# Table of Contents

What is AWS IoT? .............................................................................................................. 1
How your devices and apps access AWS IoT ...................................................................... 1
What AWS IoT can do ........................................................................................................ 2
IoT in Industry .................................................................................................................. 2
IoT in Home automation .................................................................................................... 3
How AWS IoT works .......................................................................................................... 3
The IoT universe ................................................................................................................ 3
AWS IoT services overview ............................................................................................... 5
AWS IoT Core services ....................................................................................................... 8
Learn more about AWS IoT ............................................................................................... 11
Training resources for AWS IoT ...................................................................................... 11
AWS IoT resources and guides ......................................................................................... 12
AWS IoT in social media .................................................................................................... 12
AWS services used by the AWS IoT Core rules engine ..................................................... 12
Communication protocols supported by AWS IoT Core .................................................. 13
What's new in the AWS IoT console .................................................................................. 14
Legend ............................................................................................................................... 16
Getting started with AWS IoT Core .................................................................................... 17
Connect your first device to AWS IoT Core ....................................................................... 17
Set up your AWS account .................................................................................................. 18
Sign up for an AWS account ............................................................................................. 18
Create an administrative user ........................................................................................... 19
Open the AWS IoT console ............................................................................................... 19
Try the AWS IoT Core interactive tutorial ....................................................................... 20
Connecting IoT devices ..................................................................................................... 20
Saving offline device state ............................................................................................... 21
Routing device data to services ....................................................................................... 22
Try the AWS IoT quick connect ....................................................................................... 22
Step 1. Start the tutorial .................................................................................................... 23
Step 2. Create a thing object ............................................................................................. 23
Step 3. Download files to your device ............................................................................... 26
Step 4. Run the sample ..................................................................................................... 28
Step 5. Explore further ..................................................................................................... 32
Testing connectivity with your device data endpoint ....................................................... 32
Explore AWS IoT Core services in hands-on tutorial ...................................................... 36
Which device option is best for you? ............................................................................... 37
Create AWS IoT resources ............................................................................................... 38
Configure your device ....................................................................................................... 41
View MQTT messages with the AWS IoT MQTT client ................................................... 67
Viewing MQTT messages in the MQTT client .................................................................. 68
Publishing MQTT messages from the MQTT client ......................................................... 69
Testing Shared Subscriptions in the MQTT client ............................................................ 71
Connecting to AWS IoT Core ............................................................................................ 73
AWS IoT Core - control plane endpoints ......................................................................... 73
AWS IoT device endpoints ............................................................................................... 74
AWS IoT Core for LoRaWAN gateways and devices ........................................................ 75
Connecting to AWS IoT Core service endpoints ............................................................ 75
AWS CLI for AWS IoT Core .............................................................................................. 76
AWS SDKs ......................................................................................................................... 76
AWS Mobile SDKs .............................................................................................................. 80
REST APIs of the AWS IoT Core services ....................................................................... 81
Connecting devices to AWS IoT ....................................................................................... 81
AWS IoT device data and service endpoints .................................................................... 82
AWS IoT Device SDKs ....................................................................................................... 83
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device communication protocols</td>
<td>85</td>
</tr>
<tr>
<td>MQTT topics</td>
<td>109</td>
</tr>
<tr>
<td>Configurable endpoints</td>
<td>123</td>
</tr>
<tr>
<td>Connecting to AWS IoT FIPS endpoints</td>
<td>131</td>
</tr>
<tr>
<td>AWS IoT Core - control plane endpoints</td>
<td>131</td>
</tr>
<tr>
<td>AWS IoT Core - data plane endpoints</td>
<td>131</td>
</tr>
<tr>
<td>AWS IoT Device Management - jobs data endpoints</td>
<td>132</td>
</tr>
<tr>
<td>AWS IoT Device Management - Fleet Hub endpoints</td>
<td>132</td>
</tr>
<tr>
<td>AWS IoT Device Management - secure tunneling endpoints</td>
<td>132</td>
</tr>
<tr>
<td>AWS IoT tutorials</td>
<td>133</td>
</tr>
<tr>
<td>Building demos with the AWS IoT Device Client</td>
<td>133</td>
</tr>
<tr>
<td>Prerequisites to building demos with the AWS IoT Device Client</td>
<td>133</td>
</tr>
<tr>
<td>Preparing your devices for the AWS IoT Device Client</td>
<td>135</td>
</tr>
<tr>
<td>Installing and configuring the AWS IoT Device Client</td>
<td>145</td>
</tr>
<tr>
<td>Demonstrate MQTT message communication with the AWS IoT Device Client</td>
<td>153</td>
</tr>
<tr>
<td>Demonstrate remote actions (jobs) with the AWS IoT Device Client</td>
<td>167</td>
</tr>
<tr>
<td>Cleaning up</td>
<td>176</td>
</tr>
<tr>
<td>Building solutions with the AWS IoT Device SDKs</td>
<td>183</td>
</tr>
<tr>
<td>Start building solutions with the AWS IoT Device SDK</td>
<td>183</td>
</tr>
<tr>
<td>Connecting a device to AWS IoT Core by using the AWS IoT Device SDK</td>
<td>183</td>
</tr>
<tr>
<td>Creating AWS IoT rules to route device data to other services</td>
<td>199</td>
</tr>
<tr>
<td>Retaining device state while the device is offline with Device Shadows</td>
<td>228</td>
</tr>
<tr>
<td>Creating a custom authorizer for AWS IoT Core</td>
<td>248</td>
</tr>
<tr>
<td>Monitoring soil moisture with AWS IoT and Raspberry Pi</td>
<td>259</td>
</tr>
<tr>
<td>Managing devices with AWS IoT</td>
<td>269</td>
</tr>
<tr>
<td>How to manage things with the registry</td>
<td>269</td>
</tr>
<tr>
<td>Create a thing</td>
<td>269</td>
</tr>
<tr>
<td>List things</td>
<td>270</td>
</tr>
<tr>
<td>Describe things</td>
<td>271</td>
</tr>
<tr>
<td>Update a thing</td>
<td>272</td>
</tr>
<tr>
<td>Delete a thing</td>
<td>272</td>
</tr>
<tr>
<td>Attach a principal to a thing</td>
<td>272</td>
</tr>
<tr>
<td>Detach a principal from a thing</td>
<td>273</td>
</tr>
<tr>
<td>Thing types</td>
<td>273</td>
</tr>
<tr>
<td>Create a thing type</td>
<td>273</td>
</tr>
<tr>
<td>List thing types</td>
<td>273</td>
</tr>
<tr>
<td>Describe a thing type</td>
<td>274</td>
</tr>
<tr>
<td>Associate a thing type with a thing</td>
<td>274</td>
</tr>
<tr>
<td>Deprecate a thing type</td>
<td>275</td>
</tr>
<tr>
<td>Delete a thing type</td>
<td>276</td>
</tr>
<tr>
<td>Static thing groups</td>
<td>276</td>
</tr>
<tr>
<td>Create a static thing group</td>
<td>276</td>
</tr>
<tr>
<td>Describe a thing group</td>
<td>277</td>
</tr>
<tr>
<td>Add a thing to a static thing group</td>
<td>278</td>
</tr>
<tr>
<td>Remove a thing from a static thing group</td>
<td>278</td>
</tr>
<tr>
<td>List things in a thing group</td>
<td>279</td>
</tr>
<tr>
<td>List thing groups</td>
<td>279</td>
</tr>
<tr>
<td>List groups for a thing</td>
<td>279</td>
</tr>
<tr>
<td>Update a static thing group</td>
<td>281</td>
</tr>
<tr>
<td>Delete a thing group</td>
<td>281</td>
</tr>
<tr>
<td>Attach a policy to a static thing group</td>
<td>282</td>
</tr>
<tr>
<td>Detach a policy from a static thing group</td>
<td>282</td>
</tr>
<tr>
<td>List the policies attached to a static thing group</td>
<td>283</td>
</tr>
<tr>
<td>List the groups for a policy</td>
<td>283</td>
</tr>
<tr>
<td>Get effective policies for a thing</td>
<td>283</td>
</tr>
<tr>
<td>Test authorization for MQTT actions</td>
<td>284</td>
</tr>
<tr>
<td>Dynamic thing groups</td>
<td>285</td>
</tr>
</tbody>
</table>
Tagging your AWS IoT resources .......................................................... 291
  Tag basics .................................................................................. 291
  Tag restrictions and limitations .................................................... 292
  Using tags with IAM policies .......................................................... 292
Billing groups ..................................................................................... 294
  Viewing cost allocation and usage data ............................................. 294
Security ............................................................................................... 296
  Security in AWS IoT ...................................................................... 296
Authentication ..................................................................................... 297
  AWS training and certification ......................................................... 297
  X.509 Certificate overview ............................................................ 297
  Server authentication ..................................................................... 298
  Client authentication ..................................................................... 300
  Custom authentication and authorization ......................................... 322
Authorization............................................................................................ 334
  AWS training and certification ......................................................... 336
  AWS IoT Core policies .................................................................. 336
  Authorizing direct calls to AWS services using AWS IoT Core credential provider ........................................................................ 379
  Cross account access with IAM ....................................................... 383
Data protection ..................................................................................... 385
  Data encryption in AWS IoT ........................................................... 385
  Transport security in AWS IoT Core .................................................. 386
  Data encryption ............................................................................ 389
Identity and access management .......................................................... 390
  Audience ................................................................................. 390
  Authenticating with IAM identities .................................................. 390
  Managing access using policies ...................................................... 392
  How AWS IoT works with IAM ....................................................... 394
  Identity-based policy examples ...................................................... 410
  AWS managed policies ................................................................. 413
  Troubleshooting ........................................................................... 423
Logging and Monitoring ...................................................................... 425
  Monitoring Tools ....................................................................... 425
Compliance validation ......................................................................... 426
Resilience ............................................................................................. 426
Using AWS IoT Core with VPC endpoints ........................................... 427
  Creating VPC endpoints for AWS IoT Core data plane ................... 427
  Creating VPC endpoints for AWS IoT Core credential provider ........ 428
  Creating an Amazon VPC interface endpoint .................................. 429
  Configuring private hosted zone .................................................... 429
  Controlling Access to AWS IoT Core over VPC endpoints ............... 431
  Limitations ................................................................................. 431
  Scaling VPC endpoints with AWS IoT Core ................................... 432
  Using custom domains with VPC endpoints ................................... 432
  Availability of VPC endpoints for AWS IoT Core .......................... 432
Infrastructure security .......................................................................... 432
Security monitoring ............................................................................ 433
Security best practices ....................................................................... 433
  Protecting MQTT connections in AWS IoT .................................... 433
  Keep your device’s clock in sync ..................................................... 435
  Validate the server certificate ......................................................... 435
  Use a single identity per device ....................................................... 436
Use a second AWS Region as backup ........................................................................................................... 436
Use just in time provisioning .......................................................................................................................... 436
Permissions to run AWS IoT Device Advisor tests .................................................................................. 436
Cross-service confused deputy prevention for Device Advisor .................................................................. 437
AWS training and certification ..................................................................................................................... 438
Monitoring AWS IoT .................................................................................................................................... 439
Configure AWS IoT logging .......................................................................................................................... 439
  Configure logging role and policy .................................................................................................................. 440
  Configure default logging in the AWS IoT (console) .................................................................................. 441
  Configure default logging in AWS IoT (CLI) .............................................................................................. 443
  Configure resource-specific logging in AWS IoT (CLI) .............................................................................. 444
Log levels ................................................................................................................................................... 445
Monitor AWS IoT alarms and metrics using Amazon CloudWatch .......................................................... 446
  Using AWS IoT metrics ............................................................................................................................... 446
  Creating CloudWatch alarms in AWS IoT .................................................................................................... 447
  AWS IoT metrics and dimensions .............................................................................................................. 450
Monitor AWS IoT using CloudWatch Logs .............................................................................................. 461
  Viewing AWS IoT logs in the CloudWatch console .................................................................................. 461
  CloudWatch Logs AWS IoT log entries ...................................................................................................... 462
Upload device-side logs to Amazon CloudWatch ...................................................................................... 484
  How it works ............................................................................................................................................ 484
  Uploading device-side logs by using AWS IoT rules .............................................................................. 485
Logging AWS IoT API calls using AWS CloudTrail .................................................................................. 492
  AWS IoT information in CloudTrail ........................................................................................................... 492
  Understanding AWS IoT log file entries .................................................................................................... 493
Rules ......................................................................................................................................................... 494
  Granting an AWS IoT rule the access it requires ....................................................................................... 495
  Pass role permissions ................................................................................................................................. 496
  Creating an AWS IoT rule ............................................................................................................................ 497
    Tagging your rules .................................................................................................................................... 500
  Viewing your rules ....................................................................................................................................... 501
  Deleting a rule ............................................................................................................................................ 501
AWS IoT rule actions .................................................................................................................................. 502
  Apache Kafka ............................................................................................................................................ 503
  CloudWatch alarms ................................................................................................................................. 511
  CloudWatch Logs .................................................................................................................................... 513
  CloudWatch metrics ................................................................................................................................. 514
  DynamoDB .................................................................................................................................................. 516
  DynamoDb2 ................................................................................................................................................ 518
  Elasticsearch ............................................................................................................................................... 519
  HTTP ......................................................................................................................................................... 521
  IoT Analytics ............................................................................................................................................... 548
  AWS IoT Events ......................................................................................................................................... 550
  AWS IoT SiteWise ....................................................................................................................................... 551
  Kinesis Data Firehose ................................................................................................................................. 555
  Kinesis Data Streams ................................................................................................................................. 557
  Lambda ....................................................................................................................................................... 558
  Location ...................................................................................................................................................... 560
  OpenSearch ............................................................................................................................................... 563
  Republish .................................................................................................................................................... 564
  S3 ............................................................................................................................................................... 566
  Salesforce IoT ............................................................................................................................................. 568
  SNS ............................................................................................................................................................ 569
  SQS ............................................................................................................................................................ 570
  Step Functions ........................................................................................................................................... 572
  Timestream ................................................................................................................................................ 573
Troubleshooting a rule ................................................................................................................................. 577
Device Shadow service ........................................... 577

Using shadows ............................................... 577
Choosing to use named or unnamed shadows ................. 577
Accessing shadows ......................................... 581
Using shadows in devices, apps, and other cloud services ... 583
Message order ............................................. 586
Trim shadow messages ................................... 590

Using shadows in apps and services .......................... 590
Initializing the app or service on connection to AWS IoT ...... 590
Processing state changes while the app or service is connected to AWS IoT .... 590
Detecting a device is connected ............................ 590

Simulating Device Shadow service communications .............. 590
Setting up the simulation .................................. 590
Initialize the device ....................................... 590
Send an update from the app ................................ 590
Respond to update in device ................................ 590
Observe the update in the app .............................. 590
Going beyond the simulation .............................. 590

Interacting with shadows .................................. 607
Protocol support .......................................... 607
Requesting and reporting state ............................... 607
Updating a shadow ......................................... 607
Retrieving a shadow document ................................ 607
Deleting shadow data ...................................... 607

Device Shadow REST API .................................. 607
GetThingShadow ............................................ 607
UpdateThingShadow ........................................ 607
DeleteThingShadow ........................................ 607

Error handling (error action) .................................. 587
Error action message format .................................. 587
Error action example ........................................ 588

Reducing messaging costs with Basic Ingest ................. 590
Using Basic Ingest ......................................... 590

AWS IoT Core Developer Guide

AWS IoT SQL reference ....................................... 590
SELECT clause ............................................... 590
FROM clause ............................................... 590
WHERE clause .............................................. 590
Data types .................................................. 590
Operators .................................................... 590
Functions .................................................... 590
Literals ....................................................... 590
Case statements ............................................ 590
JSON extensions ........................................... 590
Substitution templates ..................................... 590
Nested object queries ...................................... 590
Binary payloads ............................................ 590
SQL versions .............................................. 590

Accessing cross-account resources using AWS IoT rules ........................................... 577
Prerequisites .................................................. 577
Cross-account setup for Amazon SQS ......................... 578
Cross-account setup for Amazon SNS ......................... 579
Cross-account setup for Amazon S3 ........................ 580
Cross-account setup for AWS Lambda ......................... 581
Secure tunneling concepts ................................................................. 808
How secure tunneling works ............................................................. 809
Secure tunnel lifecycle ................................................................. 810
AWS IoT secure tunneling tutorials ....................................................... 810
  Tutorials in this section ......................................................... 811
  Open a tunnel and start SSH session to remote device .................. 811
  Open a tunnel for remote device and use browser-based SSH ...... 823
Local proxy .................................................................................. 826
  How to use the local proxy ......................................................... 827
  Configure local proxy for devices that use web proxy ............ 830
Multiplexing and simultaneous TCP connections ......................... 836
  Multiplexing multiple data streams ......................................... 836
  Using simultaneous TCP connections .................................... 839
Configuring a remote device and using IoT agent ......................... 841
  IoT agent snippet ................................................................. 841
Controlling access to tunnels ....................................................... 842
  Tunnel access prerequisites ................................................... 843
  Tunnel access policies ........................................................ 843
Resolving secure tunneling connectivity issues .............................. 848
  Invalid client access token error ........................................... 848
  Client token mismatch error ............................................... 848
  Remote device connectivity issues ....................................... 849
Device provisioning ..................................................................... 852
  Provisioning devices in AWS IoT .......................................... 852
Fleet provisioning APIs .................................................................. 853
  Provisioning devices that don't have device certificates using fleet provisioning ................................................................. 854
    Provisioning by claim .......................................................... 854
    Provisioning by trusted user ................................................. 856
  Using pre-provisioning hooks with the AWS CLI ...................... 857
  Provisioning devices that have device certificates .................... 859
    Single thing provisioning .................................................... 860
    Just-in-time provisioning .................................................... 860
    Bulk registration ............................................................... 865
Provisioning templates .................................................................. 865
  Parameters section ................................................................. 865
  Resources section ................................................................. 866
  Template example for bulk registration .................................. 869
  Template example for just-in-time provisioning (JITP) .......... 870
  Fleet provisioning ................................................................. 871
Pre-provisioning hooks ............................................................... 874
  Pre-provision hook input ......................................................... 874
  Pre-provision hook return value ............................................ 874
  Pre-provisioning hook Lambda example .................................. 875
Creating IAM policies and roles for a user installing a device .......... 877
  Creating an IAM policy for the user who will install a device .... 877
  Creating an IAM role for the user who will install a device ....... 878
  Updating an existing policy to authorize a new template .......... 878
Device provisioning MQTT API ...................................................... 879
  CreateCertificateFromCsr ...................................................... 880
  CreateKeysAndCertificate ..................................................... 881
  RegisterThing ........................................................................ 883
Fleet indexing .............................................................................. 885
  Managing index updates ........................................................ 885
  Searching across data sources ............................................. 885
  Querying for aggregate data .................................................. 885
  Monitoring aggregate data and creating alarms by using fleet metrics ......................................................... 885
  Managing fleet indexing ........................................................ 886
Default version .................................................................................................................. 1170
Version attributes ........................................................................................................... 1170
Enabling AWS IoT fleet indexing .................................................................................... 1171
Reserved named shadow ................................................................................................. 1171
Deleting a software package ........................................................................................... 1172
Preparing security ........................................................................................................... 1172
Resource-based authentication ....................................................................................... 1172
AWS IoT Job rights to deploy package versions ............................................................... 1173
AWS IoT Job rights to update the reserved named shadow ............................................... 1174
AWS IoT Jobs permissions to download from Amazon S3 ............................................. 1176
Preparing fleet indexing .................................................................................................. 1176
Setting the $package shadow as a data source ............................................................... 1176
Metrics displayed in the console ..................................................................................... 1176
Query patterns .................................................................................................................. 1177
Collecting package version distribution through getBucketsAggregation .................. 1179
Preparing AWS IoT Jobs ................................................................................................. 1179
Substitution parameters for AWS IoT jobs ...................................................................... 1179
Preparing the job document and package version for deployment ............................... 1180
Naming the packages and versions when deploying ....................................................... 1181
Targeting jobs through AWS IoT dynamic thing groups ............................................... 1181
Reserved named shadow and package versions .............................................................. 1181
Uninstalling a software package ..................................................................................... 1182
Getting started ............................................................................................................... 1182
Creating a package and version ..................................................................................... 1183
Deploying a package version ......................................................................................... 1184
Associating a package version ....................................................................................... 1185
AWS IoT Core Device Location ...................................................................................... 1187
Measurement types and solvers ..................................................................................... 1187
How AWS IoT Core Device Location works ................................................................. 1188
How to use AWS IoT Core Device Location ................................................................. 1189
Resolving location of IoT devices .................................................................................. 1189
Resolving device location (console) ............................................................................... 1190
Resolving device location (API) .................................................................................... 1192
Troubleshooting errors when resolving the location ..................................................... 1193
Resolving device location using MQTT topics .............................................................. 1194
Format of device location MQTT topics ....................................................................... 1194
Policy for device location MQTT topics ....................................................................... 1194
Device location topics and payload ............................................................................... 1195
Location solvers and device payload ............................................................................. 1199
Wi-Fi based solver ......................................................................................................... 1199
Cellular based solver ...................................................................................................... 1200
IP reverse lookup solver ............................................................................................... 1203
GNSS solver ................................................................................................................... 1203
Event messages .............................................................................................................. 1205
How event messages are generated .............................................................................. 1205
Policy for receiving event messages ............................................................................. 1205
Enable events for AWS IoT ............................................................................................. 1205
Registry events .............................................................................................................. 1208
Thing events ................................................................................................................... 1209
Thing type events .......................................................................................................... 1210
Thing group events ....................................................................................................... 1212
Jobs events .................................................................................................................... 1216
Lifecycle events ............................................................................................................. 1219
Connect/Disconnect events ........................................................................................... 1219
Subscribe/Unsubscribe events ....................................................................................... 1222
AWS IoT Core for LoRaWAN ......................................................................................... 1224
Introduction ..................................................................................................................... 1224
How to use AWS IoT Core for LoRaWAN ................................................................. 1224
AWS IoT Core for LoRaWAN Regions and endpoints ............................................. 1225
AWS IoT Core for LoRaWAN pricing ................................................................. 1225
What is AWS IoT Core for LoRaWAN? ............................................................... 1225
What is LoRaWAN? ............................................................................................ 1226
How AWS IoT Core for LoRaWAN works ........................................................... 1226
Connecting gateways and devices to AWS IoT Core for LoRaWAN .................... 1228
  Naming conventions for your devices, gateways, profiles, and destinations .......... 1228
  Mapping of device data to service data ............................................................ 1228
  Using the console to onboard your device and gateway to AWS IoT Core for LoRaWAN ................................................................. 1228
  Describe your AWS IoT Core for LoRaWAN resources ................................... 1229
  Onboard your gateways to AWS IoT Core for LoRaWAN ................................. 1230
  Onboard your devices to AWS IoT Core for LoRaWAN ................................... 1238
Configure position information for LoRaWAN devices and gateways ................. 1249
  How positioning works for LoRaWAN devices ............................................... 1250
  Overview of positioning workflow .................................................................. 1251
  Configuring your resource position .................................................................. 1251
  Configuring the position of LoRaWAN gateways ............................................... 1251
  Configuring position of LoRaWAN devices ...................................................... 1254
Connecting to AWS IoT Core for LoRaWAN through a VPC interface endpoint ....... 1257
  Onboard AWS IoT Core for LoRaWAN control plane API endpoint ................. 1259
  Onboard AWS IoT Core for LoRaWAN data plane API endpoints .................... 1261
Managing gateways with AWS IoT Core for LoRaWAN .......................................... 1267
  LoRa Basics Station software requirement ..................................................... 1267
  Using qualified gateways from the AWS Partner Device Catalog ....................... 1267
  Using CUPS and LNS protocols ................................................................. 1268
  Configure beaconing and filtering capabilities of your LoRaWAN gateways ...... 1268
  Update gateway firmware using CUPS service with AWS IoT Core for LoRaWAN ................................................................. 1272
  Choosing gateways to receive the LoRaWAN downlink data traffic .................. 1282
Managing devices with AWS IoT Core for LoRaWAN ............................................. 1284
  Device considerations .................................................................................. 1284
  Using devices with gateways qualified for AWS IoT Core for LoRaWAN .......... 1284
  LoRaWAN version ........................................................................................... 1284
  Activation modes ......................................................................................... 1284
  Device classes ............................................................................................... 1285
  Manage communication between your LoRaWAN devices and AWS IoT ........ 1285
  Managing LoRaWAN traffic from public LoRaWAN networks (Everynet) ......... 1291
  Create multicast groups to send a downlink payload to multiple devices ......... 1298
  Firmware Updates Over-The-Air (FUOTA) for AWS IoT Core for LoRaWAN devices ................................................................. 1308
Monitoring your wireless resource fleet in real time using network analyzer .......... 1318
  Add necessary IAM role for network analyzer .............................................. 1319
  Create a network analyzer configuration and add resources ............................ 1320
  Stream network analyzer trace messages with WebSockets ............................ 1326
  View and monitor network analyzer trace message logs in real time ............... 1335
  Debug your multicast groups and FUOTA tasks using network analyzer ......... 1337
Data security with AWS IoT Core for LoRaWAN ................................................... 1339
  How data is secured throughout the system .................................................. 1339
  LoRaWAN device and gateway transport security ......................................... 1340
AWS IoT Core for Amazon Sidewalk .................................................................... 1341
  How to use AWS IoT Core for Amazon Sidewalk? .................................... 1341
  AWS IoT Core for Amazon Sidewalk Regions and endpoints ......................... 1341
  AWS IoT Core for Amazon Sidewalk pricing ............................................. 1341
  What is AWS IoT Core for Amazon Sidewalk? ......................................... 1342
  Features of AWS IoT Core for Amazon Sidewalk .................................... 1342
  What is Amazon Sidewalk? ........................................................................ 1342
  How AWS IoT Core for Amazon Sidewalk works ....................................... 1343
Getting started with AWS IoT Core for Amazon Sidewalk ................................. 1345
Connecting Sidewalk devices to AWS IoT Core for Amazon Sidewalk ................................. 1351
Prerequisites .................................................................................................................. 1352
Describing your Sidewalk resources ........................................................................... 1352
Add your Sidewalk device ......................................................................................... 1352
Add a destination for Sidewalk device ....................................................................... 1359
Connect your Sidewalk device ................................................................................... 1364
Bulk provisioning devices with AWS IoT Core for Amazon Sidewalk ...................... 1365
Amazon Sidewalk bulk provisioning workflow ....................................................... 1366
Creating device profiles with factory support ............................................................ 1369
Provisioning Sidewalk devices using import tasks ..................................................... 1372
AWS IoT Core for Amazon Sidewalk API operations ................................................. 1380
API operations for Sidewalk devices ......................................................................... 1380
API operations for Sidewalk end devices .................................................................. 1381
API operations for destinations for Sidewalk devices .............................................. 1383
API operations for bulk provisioning ....................................................................... 1384
Monitoring and events for AWS IoT Core for Amazon Sidewalk .............................. 1387
Events for Sidewalk devices ...................................................................................... 1387
Monitoring of Sidewalk devices ................................................................................. 1389
Monitoring and logging for AWS IoT Wireless using Amazon CloudWatch .......... 1390
Configure Logging for AWS IoT Wireless ................................................................. 1390
Create logging role and policy for AWS IoT Wireless .............................................. 1391
Configure logging for AWS IoT Wireless resources .................................................. 1393
Monitor AWS IoT Wireless using CloudWatch Logs ................................................. 1401
View CloudWatch AWS IoT Wireless log entries ...................................................... 1401
Use CloudWatch Insights to filter logs for AWS IoT Wireless .................................. 1407
Event notifications for AWS IoT Wireless .................................................................. 1410
How your resources can be notified of events ........................................................... 1410
Events and resource types ......................................................................................... 1410
Policy for receiving wireless event notifications ...................................................... 1410
Format of MQTT topics for wireless events ............................................................... 1411
Pricing for wireless events ......................................................................................... 1413
Enable events for wireless resources ......................................................................... 1413
Event configurations ................................................................................................... 1413
Prerequisites ................................................................................................................ 1414
Enable notifications using the AWS Management Console .................................... 1414
Enable notifications using the AWS CLI ...................................................................... 1415
Event notifications for LoRaWAN resources .............................................................. 1417
Event types for LoRaWAN resources ........................................................................ 1417
LoRaWAN join events .................................................................................................. 1417
Connection status events ............................................................................................ 1419
Event notifications for Sidewalk resources ................................................................. 1421
Event types for Sidewalk resources ........................................................................... 1421
Device registration state events ................................................................................... 1421
Proximity events .......................................................................................................... 1423
Message delivery status events .................................................................................. 1425
AWS IoT Device SDKs, Mobile SDKs, and AWS IoT Device Client ....................... 1428
AWS IoT Device SDKs ................................................................................................. 1428
AWS IoT Device SDK for Embedded C ...................................................................... 1429
Earlier AWS IoT Device SDKs versions ....................................................................... 1430
AWS Mobile SDKs ....................................................................................................... 1430
AWS IoT Device Client ................................................................................................. 1431
Troubleshooting .......................................................................................................... 1432
AWS IoT Core troubleshooting guide ......................................................................... 1432
Diagnosing connectivity issues ................................................................. 1432
Diagnosing rules issues ........................................................................... 1435
Diagnosing problems with shadows ......................................................... 1436
Diagnosing Salesforce action issues ......................................................... 1437
Diagnosing Stream Limits ...................................................................... 1438
Troubleshooting device fleet disconnects ............................................... 1438
AWS IoT Device Defender troubleshooting guide ...................................... 1439
AWS IoT Device Advisor troubleshooting guide ....................................... 1442
AWS IoT Device Management troubleshooting guide .................................. 1444
AWS IoT Jobs Troubleshooting ............................................................... 1444
Fleet indexing troubleshooting guide ....................................................... 1447
AWS IoT errors ........................................................................................ 1448
AWS IoT quotas ..................................................................................... 1450
AWS IoT Core pricing ............................................................................. 1451
What is AWS IoT?

AWS IoT provides the cloud services that connect your IoT devices to other devices and AWS cloud services. AWS IoT provides device software that can help you integrate your IoT devices into AWS IoT-based solutions. If your devices can connect to AWS IoT, AWS IoT can connect them to the cloud services that AWS provides.

For a hands-on introduction to AWS IoT, visit Getting started with AWS IoT Core (p. 17).

AWS IoT lets you select the most appropriate and up-to-date technologies for your solution. To help you manage and support your IoT devices in the field, AWS IoT Core supports these protocols:

- MQTT (Message Queuing and Telemetry Transport) (p. 88)
- MQTT over WSS (Websockets Secure) (p. 88)
- HTTPS (Hypertext Transfer Protocol - Secure) (p. 106)
- LoRaWAN (Long Range Wide Area Network) (p. 1224)

The AWS IoT Core message broker supports devices and clients that use MQTT and MQTT over WSS protocols to publish and subscribe to messages. It also supports devices and clients that use the HTTPS protocol to publish messages.

AWS IoT Core for LoRaWAN helps you connect and manage wireless LoRaWAN (low-power long-range Wide Area Network) devices. AWS IoT Core for LoRaWAN replaces the need for you to develop and operate a LoRaWAN Network Server (LNS).

If you don't require AWS IoT features such as device communications, rules (p. 494), or jobs (p. 704), see AWS Messaging for information about other AWS IoT messaging services that might better fit your requirements.

How your devices and apps access AWS IoT

AWS IoT provides the following interfaces for AWS IoT tutorials (p. 133):
What AWS IoT can do

This topic describes some of the solutions that you might need that AWS IoT supports.

**IoT in Industry**

These are some examples of AWS IoT solutions for industrial use cases that apply IoT technologies to improve the performance and productivity of industrial processes.

**Solutions for industrial use cases**

- **Use AWS IoT to build predictive quality models in industrial operations**
  
  See how AWS IoT can collect and analyze data from industrial operations to build predictive quality models. Learn more

- **Use AWS IoT to support predictive maintenance in industrial operations**
  
  See how AWS IoT can help plan preventive maintenance to reduce unplanned downtime. Learn more
IoT in Home automation

These are some examples of AWS IoT solutions for home automation use cases that apply IoT technologies to build scalable IoT applications that automate household activities using connected home devices.

Solutions for home automation

- **Use AWS IoT in your connected home**
  
  See how AWS IoT can provide integrated home automation solutions.

- **Use AWS IoT to provide home security and monitoring**
  
  See how AWS IoT can apply machine learning and edge computing to your home automation solution.

For a list of solutions for industrial, consumer, and commercial use cases, see the AWS IoT Solution Repository.

How AWS IoT works

AWS IoT provides cloud services and device support that you can use to implement IoT solutions. AWS provides many cloud services to support IoT-based applications. So to help you understand where to start, this section provides a diagram and definition of essential concepts to introduce you to the IoT universe.

The IoT universe

In general, the Internet of Things (IoT) consists of the key components shown in this diagram.
Apps

Apps give end users access to IoT devices and the features provided by the cloud services to which those devices are connected.

Cloud services

Cloud services are distributed, large-scale data storage and processing services that are connected to the internet. Examples include:

- IoT connection and management services

  *AWS IoT is an example of an IoT connection and management service.*
- Compute services, such as Amazon Elastic Compute Cloud and AWS Lambda
- Database services, such as Amazon DynamoDB

Communications

Devices communicate with cloud services by using various technologies and protocols. Examples include:

- Wi-Fi/Broadband internet
- Broadband cellular data
- Narrow-band cellular data
- Long-range Wide Area Network (LoRaWAN)
- Proprietary RF communications
Devices
A device is a type of hardware that manages interfaces and communications. Devices are usually located in close proximity to the real-world interfaces they monitor and control. Devices can include computing and storage resources, such as microcontrollers, CPU, memory. Examples include:

- Raspberry Pi
- Arduino
- Voice-interface assistants
- LoRaWAN and devices
- Amazon Sidewalk devices
- Custom IoT devices

Interfaces
An interface is a component that connects a device to the physical world.

- User interfaces
  Components that allow devices and users to communicate with each other.
  - Input interfaces
    Enable a user to communicate with a device
    Examples: keypad, button
  - Output interfaces
    Enable a device to communicate with a user
    Examples: Alpha-numeric display, graphical display, indicator light, alarm bell
- Sensors
  Input components that measure or sense something in the outside world in a way that a device understands. Examples include:
  - Temperature sensor (converts temperature to an analog or digital signal)
  - Humidity sensor (converts relative humidity to an analog or digital signal)
  - Analog to digital convertor (converts an analog voltage to a numeric value)
  - Ultrasonic distance measuring unit (converts a distance to a numeric value)
  - Optical sensor (converts a light level to a numeric value)
  - Camera (converts image data to digital data)
- Actuators
  Output components that the device can use to control something in the outside world. Examples include:
  - Stepper motors (convert electric signals to movement)
  - Relays (control high electric voltages and currents)

AWS IoT services overview
In the IoT universe, AWS IoT provides the services that support the devices that interact with the world and the data that passes between them and AWS IoT. AWS IoT is made up of the services that are shown in this illustration to support your IoT solution.
AWS IoT device software

AWS IoT provides this software to support your IoT devices.

AWS IoT Device SDKs

The AWS IoT Device and Mobile SDKs (p. 1428) help you efficiently connect your devices to AWS IoT. The AWS IoT Device and Mobile SDKs include open-source libraries, developer guides with samples, and porting guides so that you can build innovative IoT products or solutions on your choice of hardware platforms.

AWS IoT Device Tester

AWS IoT Device Tester for FreeRTOS and AWS IoT Greengrass is a test automation tool for microcontrollers. AWS IoT Device Tester tests your device to determine if it will run FreeRTOS or AWS IoT Greengrass and interoperate with AWS IoT services.

AWS IoT ExpressLink

AWS IoT ExpressLink powers a range of hardware modules developed and offered by AWS Partners. The connectivity modules include AWS-validated software, making it faster and easier for you to securely connect devices to the cloud and seamlessly integrate with a range of AWS services. For more information, visit the AWS IoT ExpressLink overview page or see the AWS IoT ExpressLink Programmer's Guide.

AWS IoT Greengrass

AWS IoT Greengrass extends AWS IoT to edge devices so they can act locally on the data they generate, run predictions based on machine learning models, and filter and aggregate device data. AWS IoT Greengrass enables your devices to collect and analyze data closer to where that data is generated, react autonomously to local events, and communicate securely with other devices on the local network. You can use AWS IoT Greengrass to build edge applications using pre-built software modules, called components, that can connect your edge devices to AWS services or third-party services.
FreeRTOS

FreeRTOS is an open source, real-time operating system for microcontrollers that lets you include small, low-power edge devices in your IoT solution. FreeRTOS includes a kernel and a growing set of software libraries that support many applications. FreeRTOS systems can securely connect your small, low-power devices to AWS IoT and support more powerful edge devices running AWS IoT Greengrass.

AWS IoT control services

Connect to the following AWS IoT services to manage the devices in your IoT solution.

AWS IoT Core

AWS IoT Core is a managed cloud service that enables connected devices to securely interact with cloud applications and other devices. AWS IoT Core can support many devices and messages, and it can process and route those messages to AWS IoT endpoints and other devices. With AWS IoT Core, your applications can interact with all of your devices even when they aren't connected.

AWS IoT Core Device Advisor

AWS IoT Core Device Advisor is a cloud-based, fully managed test capability for validating IoT devices during device software development. Device Advisor provides pre-built tests that you can use to validate IoT devices for reliable and secure connectivity with AWS IoT Core, before deploying devices to production.

AWS IoT Device Defender

AWS IoT Device Defender helps you secure your fleet of IoT devices. AWS IoT Device Defender continuously audits your IoT configurations to make sure that they aren't deviating from security best practices. AWS IoT Device Defender sends an alert when it detects any gaps in your IoT configuration that might create a security risk, such as identity certificates being shared across multiple devices or a device with a revoked identity certificate trying to connect to AWS IoT Core.

AWS IoT Device Management

AWS IoT Device Management services help you track, monitor, and manage the plethora of connected devices that make up your device fleets. AWS IoT Device Management services help you ensure that your IoT devices work properly and securely after they have been deployed. They also provide secure tunneling to access your devices, monitor their health, detect and remotely troubleshoot problems, as well as services to manage device software and firmware updates.

AWS IoT data services

Analyze the data from the devices in your IoT solution and take appropriate action by using the following AWS IoT services.

Amazon Kinesis Video Streams

Amazon Kinesis Video Streams allows you to stream live video from devices to the AWS Cloud, where it is durably stored, encrypted, and indexed, allowing you to access your data through easy-to-use APIs. You can use Amazon Kinesis Video Streams to capture massive amounts of live video data from millions of sources, including smartphones, security cameras, webcams, cameras embedded in cars, drones, and other sources. Amazon Kinesis Video Streams enables you to play back video for live and on-demand viewing, and quickly build applications that take advantage of computer vision and video analytics through integration with Amazon Rekognition Video, and libraries for ML frameworks. You can also send non-video time-serialized data such as audio data, thermal imagery, depth data, RADAR data, and more.
Amazon Kinesis Video Streams with WebRTC

Amazon Kinesis Video Streams with WebRTC provides a standards-compliant WebRTC implementation as a fully managed capability. You can use Amazon Kinesis Video Streams with WebRTC to securely live stream media or perform two-way audio or video interaction between any camera IoT device and WebRTC-compliant mobile or web players. As a fully managed capability, you don't have to build, operate, or scale any WebRTC-related cloud infrastructure, such as signaling or media relay servers to securely stream media across applications and devices. Using Amazon Kinesis Video Streams with WebRTC, you can easily build applications for live peer-to-peer media streaming, or real-time audio or video interactivity between camera IoT devices, web browsers, and mobile devices for a variety of use cases.

AWS IoT Analytics

AWS IoT Analytics lets you efficiently run and operationalize sophisticated analytics on massive volumes of unstructured IoT data. AWS IoT Analytics automates each difficult step that is required to analyze data from IoT devices. AWS IoT Analytics filters, transforms, and enriches IoT data before storing it in a time-series data store for analysis. You can analyze your data by running one-time or scheduled queries using the built-in SQL query engine or machine learning.

AWS IoT Events

AWS IoT Events detects and responds to events from IoT sensors and applications. Events are patterns of data that identify more complicated circumstances than expected, such as motion detectors using movement signals to activate lights and security cameras. AWS IoT Events continuously monitors data from multiple IoT sensors and applications, and integrates with other services, such as AWS IoT Core, IoT SiteWise, DynamoDB, and others to enable early detection and unique insights.

AWS IoT FleetWise

AWS IoT FleetWise is a managed service that you can use to collect and transfer vehicle data to the cloud in near-real time. With AWS IoT FleetWise, you can easily collect and organize data from vehicles that use different protocols and data formats. AWS IoT FleetWise helps to transform low-level messages into human-readable values and standardize the data format in the cloud for data analyses. You can also define data collection schemes to control what data to collect in vehicles and when to transfer it to the cloud.

AWS IoT SiteWise

AWS IoT SiteWise collects, stores, organizes, and monitors data passed from industrial equipment by MQTT messages or APIs at scale by providing software that runs on a gateway in your facilities. The gateway securely connects to your on-premises data servers and automates the process of collecting and organizing the data and sending it to the AWS Cloud.

AWS IoT TwinMaker

AWS IoT TwinMaker builds operational digital twins of physical and digital systems. AWS IoT TwinMaker creates digital visualizations using measurements and analysis from a variety of real-world sensors, cameras, and enterprise applications to help you keep track of your physical factory, building, or industrial plant. You can use real-world data to monitor operations, diagnose and correct errors, and optimize operations.

AWS IoT Core services

AWS IoT Core provides the services that connect your IoT devices to the AWS Cloud so that other cloud services and applications can interact with your internet-connected devices.
The next section describes each of the AWS IoT Core services shown in the illustration.

**AWS IoT Core messaging services**

The AWS IoT Core connectivity services provide secure communication with the IoT devices and manage the messages that pass between them and AWS IoT.

**Device gateway**

Enables devices to securely and efficiently communicate with AWS IoT. Device communication is secured by secure protocols that use X.509 certificates.

**Message broker**

Provides a secure mechanism for devices and AWS IoT applications to publish and receive messages from each other. You can use either the MQTT protocol directly or MQTT over WebSocket to publish and subscribe. For more information about the protocols that AWS IoT supports, see the section called “Device communication protocols” (p. 85). Devices and clients can also use the HTTP REST interface to publish data to the message broker.

The message broker distributes device data to devices that have subscribed to it and to other AWS IoT Core services, such as the Device Shadow service and the rules engine.

**AWS IoT Core for LoRaWAN**

AWS IoT Core for LoRaWAN makes it possible to set up a private LoRaWAN network by connecting your LoRaWAN devices and gateways to AWS without the need to develop and operate a LoRaWAN Network Server (LNS). Messages received from LoRaWAN devices are sent to the rules engine where they can be formatted and sent to other AWS IoT services.

**Rules engine**

The Rules engine connects data from the message broker to other AWS IoT services for storage and additional processing. For example, you can insert, update, or query a DynamoDB table or invoke a Lambda function based on an expression that you defined in the Rules engine. You can use an SQL-based language to select data from message payloads, and then process and send the data to other services, such as Amazon Simple Storage Service (Amazon S3), Amazon DynamoDB, and AWS Lambda. You can also create rules that republish messages to the message broker and on to other subscribers. For more information, see Rules for AWS IoT (p. 494).
AWS IoT Core control services

The AWS IoT Core control services provide device security, management, and registration features.

Custom Authentication service

You can define custom authorizers that allow you to manage your own authentication and authorization strategy using a custom authentication service and a Lambda function. Custom authorizers allow AWS IoT to authenticate your devices and authorize operations using bearer token authentication and authorization strategies.

Custom authorizers can implement various authentication strategies; for example, JSON Web Token verification or OAuth provider callout. They must return policy documents that are used by the device gateway to authorize MQTT operations. For more information, see Custom authentication and authorization (p. 322).

Device Provisioning service

Allows you to provision devices using a template that describes the resources required for your device: a thing object, a certificate, and one or more policies. A thing object is an entry in the registry that contains attributes that describe a device. Devices use certificates to authenticate with AWS IoT. Policies determine which operations a device can perform in AWS IoT.

The templates contain variables that are replaced by values in a dictionary (map). You can use the same template to provision multiple devices just by passing in different values for the template variables in the dictionary. For more information, see Device provisioning (p. 852).

Group registry

Groups allow you to manage several devices at once by categorizing them into groups. Groups can also contain groups—you can build a hierarchy of groups. Any action that you perform on a parent group will apply to its child groups. The same action also applies to all the devices in the parent group and all devices in the child groups. Permissions granted to a group will apply to all devices in the group and in all of its child groups. For more information, see Managing devices with AWS IoT (p. 269).

Jobs service

Allows you to define a set of remote operations that are sent to and run on one or more devices connected to AWS IoT. For example, you can define a job that instructs a set of devices to download and install application or firmware updates, reboot, rotate certificates, or perform remote troubleshooting operations.

To create a job, you specify a description of the remote operations to be performed and a list of targets that should perform them. The targets can be individual devices, groups or both. For more information, see Jobs (p. 704).

Registry

Organizes the resources associated with each device in the AWS Cloud. You register your devices and associate up to three custom attributes with each one. You can also associate certificates and MQTT client IDs with each device to improve your ability to manage and troubleshoot them. For more information, see Managing devices with AWS IoT (p. 269).

Security and Identity service

Provides shared responsibility for security in the AWS Cloud. Your devices must keep their credentials safe to securely send data to the message broker. The message broker and rules engine use AWS security features to send data securely to devices or other AWS services. For more information, see Authentication (p. 297).
AWS IoT Core data services

The AWS IoT Core data services help your IoT solutions provide a reliable application experience even with devices that are not always connected.

Device shadow

A JSON document used to store and retrieve current state information for a device.

Device Shadow service

The Device Shadow service maintains a device's state so that applications can communicate with a device whether the device is online or not. When a device is offline, the Device Shadow service manages its data for connected applications. When the device reconnects, it synchronizes its state with that of its shadow in the Device Shadow service. Your devices can also publish their current state to a shadow for use by applications or other devices that might not be connected all the time. For more information, see AWS IoT Device Shadow service (p. 657).

AWS IoT Core support service

Amazon Sidewalk Integration for AWS IoT Core

Amazon Sidewalk is a shared network that improves connectivity options to help devices work together better. Amazon Sidewalk supports a wide range of customer devices such as those that locate pets or valuables, those that provide smart home security and lighting control, and those that provide remote diagnostics for appliances and tools. Amazon Sidewalk Integration for AWS IoT Core makes it possible for device manufacturers to add their Sidewalk device fleet to the AWS IoT Cloud.

For more information, see AWS IoT Core for Amazon Sidewalk (p. 1341)

Learn more about AWS IoT

This topic helps you get familiar with the world of AWS IoT. You can get general information about how IoT solutions are applied in various use cases, training resources, links to social media for AWS IoT and all other AWS services, and a list of services and communication protocols that AWS IoT uses.

Training resources for AWS IoT

We provide these training courses to help you learn about AWS IoT and how to apply them to your solution design.

- **Introduction to AWS IoT**
  
  A video overview of AWS IoT and its core services.

- **Deep Dive into AWS IoT Authentication and Authorization**
  
  An advanced course that explores the concepts of AWS IoT authentication and authorization. You will learn how to authenticate and authorize clients to access the AWS IoT control plane and data plane APIs.

- **Internet of Things Foundation Series**
  
  A learning path of IoT eLearning modules on different IoT technologies and features.
AWS IoT resources and guides

These are in-depth technical resources on specific aspects of AWS IoT.

- **IoT Lens – AWS IoT Well-Architected Framework**
  
  A document that describes the best practices for architecting your IoT applications on AWS.

- **Designing MQTT Topics for AWS IoT Core**
  
  A whitepaper that describes the best practices for designing MQTT topics in AWS IoT Core and leveraging AWS IoT Core features with MQTT.

- **Abstract and introduction**
  
  A PDF document that describes the different ways that AWS IoT provides to provision large fleets of devices.

- **AWS IoT Core Device Advisor**
  
  AWS IoT Core Device Advisor provides pre-built tests that you can use to validate IoT devices for reliable and secure connectivity best practices with AWS IoT Core, before deploying devices to production.

- **AWS IoT Resources**
  
  IoT-specific resources, such as Technical Guides, Reference Architectures, eBooks, and curated blog posts, presented in a searchable index.

- **IoT Atlas**
  
  Overviews on how to solve common IoT design problems. The *IoT Atlas* provides in-depth looks into the design challenges that you are likely to encounter while developing your IoT solution.

- **AWS Whitepapers & Guides**
  
  Our current collection of whitepapers and guides on AWS IoT and other AWS technologies.

AWS IoT in social media

These social media channels provide information about AWS IoT and AWS-related topics.

- **The Internet of Things on AWS IoT – Official Blog**
- **AWS IoT videos in the Amazon Web Services channel on YouTube**

These social media accounts cover all AWS services, including AWS IoT

- **The Amazon Web Services channel on YouTube**
- **Amazon Web Services on Twitter**
- **Amazon Web Services on Facebook**
- **Amazon Web Services on Instagram**
- **Amazon Web Services on LinkedIn**

AWS services used by the AWS IoT Core rules engine

The AWS IoT Core rules engine can connect to these AWS services.

- **Amazon DynamoDB**
Amazon DynamoDB is a scalable, NoSQL database service that provides fast and predictable database performance.

- **Amazon Kinesis**

Amazon Kinesis makes it easy to collect, process, and analyze real-time, streaming data so you can get timely insights and react quickly to new information. Amazon Kinesis can ingest real-time data such as video, audio, application logs, website clickstreams, and IoT telemetry data for machine learning, analytics, and other applications.

- **AWS Lambda**

AWS Lambda lets you run code without provisioning or managing servers. You can set up your code to automatically trigger from AWS IoT data and events or call it directly from a web or mobile app.

- **Amazon Simple Storage Service**

Amazon Simple Storage Service (Amazon S3) can store and retrieve any amount of data at any time, from anywhere on the web. AWS IoT rules can send data to Amazon S3 for storage.

- **Amazon Simple Notification Service**

Amazon Simple Notification Service (Amazon SNS) is a web service that enables applications, end users, and devices to send and receive notifications from the cloud.

- **Amazon Simple Queue Service**

Amazon Simple Queue Service (Amazon SQS) is a message queuing service that decouples and scales microservices, distributed systems, and serverless applications.

- **Amazon OpenSearch Service**

Amazon OpenSearch Service (OpenSearch Service) is a managed service that makes it easy to deploy, operate, and scale OpenSearch, a popular open-source search and analytics engine.

- **Amazon SageMaker**

Amazon SageMaker can create machine learning (ML) models by finding patterns in your IoT data. The service uses these models to process new data and generate predictions for your application.

- **Amazon CloudWatch**

Amazon CloudWatch provides a reliable, scalable, and flexible monitoring solution to help set up, manage, and scale your own monitoring systems and infrastructure.

### Communication protocols supported by AWS IoT Core

These topics provide more information about the communication protocols used by AWS IoT. For more information about the protocols used by AWS IoT and connecting devices and services to AWS IoT, see [Connecting to AWS IoT Core](p. 73).

- **MQTT (Message Queuing Telemetry Transport)**

The home page of the MQTT.org site where you can find the MQTT protocol specifications. For more information about how AWS IoT supports MQTT, see [MQTT](p. 88).

- **HTTPS (Hypertext Transfer Protocol - Secure)**

Devices and apps can access AWS IoT services by using HTTPS.

- **LoRaWAN (Long Range Wide Area Network)**
LoRaWAN devices and gateways can connect to AWS IoT Core by using AWS IoT Core for LoRaWAN.

- **TLS (Transport Layer Security) v1.2**

  The specification of the TLS v1.2 (RFC 5246). AWS IoT uses TLS v1.2 to establish secure connections between devices and AWS IoT.

## What's new in the AWS IoT console

We're in the process of updating the user interface of the AWS IoT console to a new experience. We're updating the user interface in stages, so some pages in the console will have a new experience, some might have both the original and the new experience, and some might have only the original experience.

This table displays the state of individual areas of the AWS IoT console user interface as of January 27, 2022.

### AWS IoT console user interface status

<table>
<thead>
<tr>
<th>Console page</th>
<th>Original experience</th>
<th>New experience</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor</td>
<td>Not available</td>
<td>Available</td>
<td></td>
</tr>
<tr>
<td>Activity</td>
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<td>Available</td>
<td></td>
</tr>
<tr>
<td>Onboard - Get started</td>
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<td>Available</td>
<td>Not available in CN Regions</td>
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<tr>
<td>Onboard - Fleet provisioning templates</td>
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<tr>
<td>Manage - Things</td>
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<td>Available</td>
<td></td>
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<tr>
<td>Manage - Types</td>
<td>Available</td>
<td>Available</td>
<td></td>
</tr>
<tr>
<td>Manage - Thing groups</td>
<td>Available</td>
<td>Available</td>
<td></td>
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<tr>
<td>Manage - Billing groups</td>
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<td>Available</td>
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<tr>
<td>Manage - Jobs</td>
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<tr>
<td>Manage - Job templates</td>
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<tr>
<td>Manage - Tunnels</td>
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<td></td>
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<td>Available</td>
<td>Not available in all AWS Regions</td>
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<tr>
<td>Fleet Hub - Applications</td>
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<td>Not available in all AWS Regions</td>
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<tr>
<td>Greengrass - Getting started</td>
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</tbody>
</table>
## What's new in the AWS IoT console

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<th>Original experience</th>
<th>New experience</th>
<th>Comments</th>
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<td><strong>Wireless connectivity - Devices</strong></td>
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<td>Available</td>
<td>Not available in all AWS Regions</td>
</tr>
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<td><strong>Wireless connectivity - Profiles</strong></td>
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</tr>
<tr>
<td><strong>Wireless connectivity - Destinations</strong></td>
<td>Not available</td>
<td>Available</td>
<td>Not available in all AWS Regions</td>
</tr>
<tr>
<td><strong>Secure - Certificates</strong></td>
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<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Secure - Policies</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Secure - CAs</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Secure - Role Aliases</strong></td>
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<td>Available</td>
<td></td>
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<tr>
<td><strong>Secure - Authorizers</strong></td>
<td>Available</td>
<td>Available</td>
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</tr>
<tr>
<td><strong>Defend - Intro</strong></td>
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<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Defend - Audit</strong></td>
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<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Defend - Detect</strong></td>
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<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Defend - Mitigation actions</strong></td>
<td>Not available</td>
<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Defend - Settings</strong></td>
<td>Not available</td>
<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Act - Rules</strong></td>
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<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Act - Destinations</strong></td>
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</tr>
<tr>
<td><strong>Test - Device Advisor</strong></td>
<td>Available</td>
<td>Available</td>
<td>Not available in all AWS Regions</td>
</tr>
<tr>
<td><strong>Test - MQTT test client</strong></td>
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<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Software</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Settings</strong></td>
<td>Not available</td>
<td>Available</td>
<td></td>
</tr>
<tr>
<td><strong>Learn</strong></td>
<td>Available</td>
<td>Not available yet</td>
<td></td>
</tr>
</tbody>
</table>
Legend

Status values

- **Available**
  This user interface experience can be used.

- **Not available**
  This user interface experience can't be used.

- **Not available yet**
  The new user interface experience is being worked on, but it's not ready, yet.

- **In progress**
  The new user interface experience is in the process of being updated. Some pages might still have the original user experience, however.
Getting started with AWS IoT Core

Whether you’re new to IoT or you have years of experience, these resources present the AWS IoT concepts and terms that will help you start using AWS IoT.

- **Look** inside AWS IoT and its components in *How AWS IoT works* (p. 3).
- **Learn more about AWS IoT** (p. 11) from our collection of training materials and videos. This topic also includes a list of services that AWS IoT can connect to, social media links, and links to communication protocol specifications.
- **the section called “Connect your first device to AWS IoT Core”** (p. 17).
- **Develop** your IoT solutions by *Connecting to AWS IoT Core* (p. 73) and exploring the *AWS IoT tutorials* (p. 133).
- **Test and validate** your IoT devices for secure and reliable communication by using the *Device Advisor* (p. 1103).
- **Manage** your solution by using AWS IoT Core management services such as *Fleet indexing* (p. 885), *Jobs* (p. 704), and *AWS IoT Device Defender* (p. 929).
- **Analyze** the data from your devices by using the *AWS IoT data services* (p. 7).

Connect your first device to AWS IoT Core

AWS IoT Core services connect IoT devices to AWS IoT services and other AWS services. AWS IoT Core includes the device gateway and the message broker, which connect and process messages between your IoT devices and the cloud.

Here’s how you can get started with AWS IoT Core and AWS IoT.

![Flowchart](chart.png)

This section presents a tour of the AWS IoT Core to introduce its key services and provides several examples of how to connect a device to AWS IoT Core and pass messages between them. Passing messages between devices and the cloud is fundamental to every IoT solution and is how your devices can interact with other AWS services.

- **Set up your AWS account** (p. 18)
Before you can use AWS IoT services, you must set up an AWS account. If you already have an AWS account and an IAM user for yourself, you can use them and skip this step.

- **Try the interactive tutorial (p. 20)**
  
  This demo is best if you want to see what a basic AWS IoT solution can do without connecting a device or downloading any software. The interactive tutorial presents a simulated solution built on AWS IoT Core services that illustrates how they interact.

- **Try the quick connect tutorial (p. 22)**
  
  This tutorial is best if you want to quickly get started with AWS IoT and see how it works in a limited scenario. In this tutorial, you'll need a device and you'll install some AWS IoT software on it. If you don't have an IoT device, you can use your Windows, Linux, or macOS personal computer as a device for this tutorial. If you want to try AWS IoT, but you don't have a device, try the next option.

- **Explore AWS IoT Core services with a hands-on tutorial (p. 36)**
  
  This tutorial is best for developers who want to get started with AWS IoT so they can continue to explore other AWS IoT Core features such as the rules engine and shadows. This tutorial follows a process similar to the quick connect tutorial, but provides more details on each step to enable a smoother transition to the more advanced tutorials.

- **View MQTT messages with the AWS IoT MQTT client (p. 67)**
  
  Learn how to use the MQTT test client to watch your first device publish MQTT messages to AWS IoT. The MQTT test client is a useful tool to monitor and troubleshoot device connections.

**Note**

If you want to try more than one of these getting started tutorials or repeat the same tutorial, you should delete the thing object that you created from an earlier tutorial before you start another one. If you don't delete the thing object from an earlier tutorial, you will need to use a different thing name for subsequent tutorials. This is because the thing name must be unique in your account and AWS Region.

For more information about AWS IoT Core, see [What Is AWS IoT Core (p. 1)]?

---

**Set up your AWS account**

Before you use AWS IoT Core for the first time, complete the following tasks:

**Topics**

- [Sign up for an AWS account (p. 18)]
- [Create an administrative user (p. 19)]
- [Open the AWS IoT console (p. 19)]

**Sign up for an AWS account**

If you do not have an AWS account, complete the following steps to create one.

**To sign up for an AWS account**

2. Follow the online instructions.
Part of the sign-up procedure involves receiving a phone call and entering a verification code on the phone keypad.

When you sign up for an AWS account, an *AWS account root user* is created. The root user has access to all AWS services and resources in the account. As a security best practice, assign *administrative access to an administrative user*, and use only the root user to perform *tasks that require root user access*.

AWS sends you a confirmation email after the sign-up process is complete. At any time, you can view your current account activity and manage your account by going to [https://aws.amazon.com/](https://aws.amazon.com/) and choosing **My Account**.

### Create an administrative user

After you sign up for an AWS account, create an administrative user so that you don't use the root user for everyday tasks.

#### Secure your AWS account root user

1. Sign in to the *AWS Management Console* as the account owner by choosing **Root user** and entering your AWS account email address. On the next page, enter your password.

   For help signing in by using root user, see *Signing in as the root user* in the *AWS Sign-In User Guide*.

2. Turn on multi-factor authentication (MFA) for your root user.

   For instructions, see *Enable a virtual MFA device for your AWS account root user (console)* in the *IAM User Guide*.

#### Create an administrative user

- For your daily administrative tasks, grant administrative access to an administrative user in AWS IAM Identity Center.

  For instructions, see *Getting started* in the *AWS IAM Identity Center User Guide*.

#### Sign in as the administrative user

- To sign in with your IAM Identity Center user, use the sign-in URL that was sent to your email address when you created the IAM Identity Center user.

  For help signing in using an IAM Identity Center user, see *Signing in to the AWS access portal* in the *AWS Sign-In User Guide*.

- [Open the AWS IoT console (p. 19)]

If you already have an AWS account and a user for yourself, you can use them and skip ahead to the section called “Open the AWS IoT console” (p. 19).

### Open the AWS IoT console

Most of the console-oriented topics in this section start from the *AWS IoT console*. If you aren't already signed in to your AWS account, sign in, then open the *AWS IoT console* and continue to the next section to continue getting started with AWS IoT.
Try the AWS IoT Core interactive tutorial

The interactive tutorial shows the components of a simple IoT solution built on AWS IoT. The tutorial's animations show how IoT devices interact with AWS IoT Core services. This topic provides a preview of the AWS IoT Core interactive tutorial. The images in the console include animations that don't appear in the images in this tutorial.

To run the demo, you must first the section called “Set up your AWS account” (p. 18). The tutorial, however, doesn't require any AWS IoT resources, additional software, or any coding.

Expect to spend approximately 5-10 minutes on this demo. Giving yourself 10 minutes will allow more time to comprehend each of the steps.

To run the AWS IoT Core interactive tutorial
1. Open the AWS IoT home page in the AWS IoT console.

On the AWS IoT home page, in the Learning resources window pane, choose Start tutorial.

2. In the AWS IoT Console Tutorial page, review the tutorial sections and choose Start section when you're ready to continue.

The following sections describe how the AWS IoT Console Tutorial presents these AWS IoT Core features:

- Connecting IoT devices (p. 20)
- Saving offline device state (p. 21)
- Routing device data to services (p. 22)

Connecting IoT devices

Learn how IoT devices communicate with AWS IoT Core.
Saving offline device state

Learn how AWS IoT Core saves device state for while a device or app is offline.

The animation in this step shows how the Device Shadow service in AWS IoT Core saves device state information for the control device and the smart lamp. While the smart lamp is offline, the Device Shadow saves commands from the control device.
When the smart lamp reconnects to AWS IoT Core, it retrieves those commands. When the control device is offline, the Device Shadow saves state information from the smart lamp. When the control device reconnects, it retrieves the current state of the smart lamp to update its display.

For more information about Device Shadows, see AWS IoT Device Shadow service (p. 657).

Routing device data to services

Learn how AWS IoT Core sends device state to other AWS services.

The animation in this step shows how AWS IoT Core sends data from the devices to other AWS services by using AWS IoT rules. AWS IoT rules subscribe to specific messages from the devices, interpret the data in those messages, and route the interpreted data to other services. In this example, an AWS IoT rule interprets data from a motion sensor and sends commands to a Device Shadow, which then sends them to the smart bulb. As in the previous example, the Device Shadow stores the device-state info for the control device.

For more information about AWS IoT rules, see Rules for AWS IoT (p. 494).

Try the AWS IoT quick connect

In this tutorial, you'll create your first thing object, connect a device to it, and watch it send MQTT messages.

You can expect to spend 15-20 minutes on this tutorial.

This tutorial is best for people who want to quickly get started with AWS IoT to see how it works in a limited scenario. If you're looking for an example that will get you started so that you can explore more features and services, try Explore AWS IoT Core services in hands-on tutorial (p. 36).

In this tutorial, you'll download and run software on a device that connects to a thing resource in AWS IoT Core as part of a very small IoT solution. The device can be an IoT device, such as a Raspberry Pi, or it can also be a computer that is running Linux, OS and OSX, or Windows. If you're looking to connect a Long Range WAN (LoRaWAN) device to AWS IoT, refer to the tutorial Connecting devices and gateways to AWS IoT Core for LoRaWAN (p. 1224).
If your device supports a browser that can run the AWS IoT console, we recommend you complete this tutorial on that device.

**Note**
If your device doesn’t have a compatible browser, follow this tutorial on a computer. When the procedure asks you to download the file, download it to your computer, and then transfer the downloaded file to your device by using Secure Copy (SCP) or a similar process.

The tutorial requires your IoT device to communicate with port 8443 on your AWS account’s device data endpoint. To test whether it can access that port, try the procedures in Testing connectivity with your device data endpoint (p. 32).

**Step 1. Start the tutorial**

If possible, complete this procedure on your device; otherwise, be ready to transfer a file to your device later in this procedure.

To start the tutorial, sign in to the AWS IoT console. In the AWS IoT console home page, on the left, choose Connect and then choose Connect one device.

**Step 2. Create a thing object**

1. In the Prepare your device section, follow the on-screen instructions to prepare your device for connecting to AWS IoT.
2. In the Register and secure your device section, choose Create a new thing or Choose an existing thing. In the Thing name field, enter the name for your thing object. The thing name used in this example is **TutorialTestThing**

   **Important**
   Double-check your thing name before you continue.
   A thing name can't be changed after the thing object is created. If you want to change a thing name, you must create a new thing object with the correct thing name and then delete the one with the incorrect name.

In the Additional configurations section, customize your thing resource further using the optional configurations listed.

After you provide your thing object a name and select any additional configurations, choose **Next**.
3. In the **Choose platform and SDK** section, choose the platform and the language of the AWS IoT Device SDK that you want to use. This example uses the Linux/OSX platform and the Python SDK. Make sure that you have python3 and pip3 installed on your target device before you continue to the next step.

**Note**

Be sure to check the list of prerequisite software required by your chosen SDK at the bottom of the console page.

You must have the required software installed on your target computer before you continue to the next step.

After you choose the platform and device SDK language, choose **Next**.
Step 3. Download files to your device

This page appears after AWS IoT has created the connection kit, which includes the following files and resources that your device requires:

- The thing's certificate files used to authenticate the device
- A policy resource to authorize your thing object to interact with AWS IoT
- The script to download the AWS Device SDK and run the sample program on your device

1. When you’re ready to continue, choose the **Download connection kit for** button to download the connection kit for the platform that you chose earlier.
2. If you're running this procedure on your device, save the connection kit file to a directory from which you can run command line commands.

   If you're not running this procedure on your device, save the connection kit file to a local directory and then transfer the file to your device.

3. In the **Unzip connection kit on your device** section, enter `unzip connect_device_package.zip` in the directory where the connection kit files are located.

   If you're using a Windows PowerShell command window and the `unzip` command doesn't work, replace `unzip` with `expand-archive`, and try the command line again.

4. After you have the connection kit file on the device, continue the tutorial by choosing **Next**.
Step 4. Run the sample

You do this procedure in a terminal or command window on your device while you follow the directions displayed in the console. The commands you see in the console are for the operating system you chose in the section called “Step 2. Create a thing object” (p. 23). Those shown here are for the Linux/OSX operating systems.

1. In a terminal or command window on your device, in the directory with the connection kit file, perform the steps shown in the AWS IoT console.
2. After you enter the command from Step 2 in the console, you should see an output in the device's terminal or command window that is similar to the following. This output is from the messages the program is sending to and then receiving back from AWS IoT Core.

```
Running pub/sub sample application...
Connecting to aiShivateyeksaski.ee-east-1.amazonaws.com with client ID 'basicPubSub'... Connected!
Subscribing to topic 'sdk/test/Python'...
Subscribed with QoS AT_LEAST_ONCE
Sending messages until program killed
Publishing message to topic 'sdk/test/Python': Hello World! [1]
Received message from topic 'sdk/test/Python': b'Hello World! [1]'"
Publishing message to topic 'sdk/test/Python': Hello World! [2]
Received message from topic 'sdk/test/Python': b'Hello World! [2]'"
Publishing message to topic 'sdk/test/Python': Hello World! [3]
Received message from topic 'sdk/test/Python': b'Hello World! [3]'"
```

While the sample program is running, the test message Hello World! will appear as well. The test message appears in the terminal or command window on your device.

**Note**
For more information about topic subscription and publish, see the example code of your chosen SDK.
3. To run the sample program again, you can repeat the commands from Step 2 in the console of this procedure.

4. (Optional) If you want to see the messages from your IoT client in the AWS IoT console, open the MQTT test client on the Test page of the AWS IoT console. If you chose Python SDK, then in the MQTT test client, in Topic filter, enter the topic, such as `sdk/test/python` to subscribe to the messages from your device. The topic filters are case sensitive and depend on the programming language of the SDK you chose in Step 1. For more information about topic subscription and publish, see the code example of your chosen SDK.

5. After you subscribe to the test topic, run `./start.sh` on your device. For more information, see the section called “View MQTT messages with the AWS IoT MQTT client” (p. 67).

After you run `./start.sh`, messages appear in the MQTT client, similar to the following:

```json
{
    "message": "Hello World!" [1]
}
```

The sequence number encased in `[]` increments by one each time a new `Hello World!` message is received and stops when you end the program.

6. To finish the tutorial and see a summary, in the AWS IoT console, choose Continue.
A summary of your AWS IoT quick connect tutorial will now appear.
Step 5. Explore further

Here are some ideas to explore AWS IoT further after you complete the quick start.

- **View MQTT messages in the MQTT test client**

  From the AWS IoT console, you can open the MQTT test client on the Test page of the AWS IoT console. In the MQTT test client, subscribe to #, and then, on your device, run the program ./start.sh as described in the previous step. For more information, see the section called “View MQTT messages with the AWS IoT MQTT client” (p. 67).

- **Run tests on your devices with Device Advisor**

  Use Device Advisor to test if your devices can securely and reliably connect to, and interact with, AWS IoT.

- **the section called “Try the AWS IoT Core interactive tutorial” (p. 20)**

  To start the interactive tutorial, from the Learn page of the AWS IoT console, in the See how AWS IoT works tile, choose Start the tutorial.

- **Get ready to explore more tutorials (p. 36)**

  This quick start gives you just a sample of AWS IoT. If you want to explore AWS IoT further and learn about the features that make it a powerful IoT solution platform, start preparing your development platform by Explore AWS IoT Core services in hands-on tutorial (p. 36).

Testing connectivity with your device data endpoint

This topic describes how to test a device’s connection with your account’s device data endpoint, the endpoint that your IoT devices use to connect to AWS IoT.

Perform these procedures on the device that you want to test or by using an SSH terminal session connected to the device you want to test.

To test a device’s connectivity with your device data endpoint.

- **Find your device data endpoint (p. 32)**
- **Test the connection quickly (p. 33)**
- **Get the app to test the connection to your device data endpoint and port (p. 33)**
- **Test the connection to your device data endpoint and port (p. 36)**

Find your device data endpoint

**To find your device data endpoint**

1. In the AWS IoT console, near the bottom of the navigation pane, choose Settings.
2. In the Settings page, in the Device data endpoint container, locate the Endpoint value and copy it. Your endpoint value is unique to your AWS account and is similar to this example: a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com.
3. Save your device data endpoint to use in the following procedures.
Test the connection quickly

This procedure tests general connectivity with your device data endpoint, but it doesn't test the specific port that your devices will use. This test uses a common program and is usually sufficient to find out if your devices can connect to AWS IoT.

If you want to test connectivity with the specific port that your devices will use, skip this procedure and continue to Get the app to test the connection to your device data endpoint and port (p. 33).

To test the device data endpoint quickly

1. In a terminal or command line window on your device, replace the sample device data endpoint (a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com) with the device data endpoint for your account, and then enter this command.

   Linux
   ```
   ping -c 5 a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com
   ```

   Windows
   ```
   ping -n 5 a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com
   ```

2. If ping displays an output similar to the following, it connected to your device data endpoint successfully. While it didn't communicate with AWS IoT directly, it did find the server and it's likely that AWS IoT is available through this endpoint.

   ```plaintext
   PING a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com (xx.xx.xxx.xxx) 56(84) bytes of data.
   64 bytes from ec2-EXAMPLE-218.eu-west-1.compute.amazonaws.com (xx.xx.xxx.xxx):
     icmp_seq=1 ttl=231 time=127 ms
   64 bytes from ec2-EXAMPLE-218.eu-west-1.compute.amazonaws.com (xx.xx.xxx.xxx):
     icmp_seq=2 ttl=231 time=127 ms
   64 bytes from ec2-EXAMPLE-218.eu-west-1.compute.amazonaws.com (xx.xx.xxx.xxx):
     icmp_seq=3 ttl=231 time=127 ms
   64 bytes from ec2-EXAMPLE-218.eu-west-1.compute.amazonaws.com (xx.xx.xxx.xxx):
     icmp_seq=4 ttl=231 time=127 ms
   64 bytes from ec2-EXAMPLE-218.eu-west-1.compute.amazonaws.com (xx.xx.xxx.xxx):
     icmp_seq=5 ttl=231 time=127 ms
   ```

   If you are satisfied with this result, you can stop testing here.

   If you want to test the connectivity with the specific port used by AWS IoT, continue to Get the app to test the connection to your device data endpoint and port (p. 33).

3. If ping didn't return a successful output, check the endpoint value to make sure you have the correct endpoint and check the device's connection with the internet.

Get the app to test the connection to your device data endpoint and port

A more thorough connectivity test can be performed by using nmap. This procedure tests to see if nmap is installed on your device.
To check for nmap on the device

1. In a terminal or command line window on the device you want to test, enter this command to see if nmap is installed.

   nmap --version

2. If you see an output similar to the following, nmap is installed and you can continue to the section called “Test the connection to your device data endpoint and port” (p. 36).

   Nmap version 6.40 ( http://nmap.org )
   Platform: x86_64-koji-linux-gnu
   Compiled with: nmap-liblua-5.2.2 openssl-1.0.2k libpcre-8.32 libpcap-1.5.3 nmap-libdnet-1.12 ipv6
   Compiled without:
   Available nsock engines: epoll poll select

3. If you don't see a response similar to the one shown in the preceding step, you must install nmap on the device. Choose the procedure for your device's operating system.

Linux

This procedure requires that you have permission to install software on the computer.

To install nmap on your Linux computer

1. In a terminal or command line window on your device, enter the command that corresponds to the version of Linux it's running.

   a. Debian or Ubuntu:

      sudo apt install nmap

   b. CentOS or RHEL:

      sudo yum install nmap

2. Test the installation with this command:

   nmap --version

3. If you see an output similar to the following, nmap is installed and you can continue to the section called “Test the connection to your device data endpoint and port” (p. 36).

   Nmap version 6.40 ( http://nmap.org )
   Platform: x86_64-koji-linux-gnu
   Compiled with: nmap-liblua-5.2.2 openssl-1.0.2k libpcre-8.32 libpcap-1.5.3 nmap-libdnet-1.12 ipv6
   Compiled without:
   Available nsock engines: epoll poll select

macOS

This procedure requires that you have permission to install software on the computer.
To install nmap on your macOS computer

1. In a browser, open https://nmap.org/download#macosx and download the latest stable installer.

   When prompted, select Open with DiskImageInstaller.

2. In the installation window, move the package to the Applications folder.

3. In the Finder, locate the nmap-xxxx.mpkg package in the Applications folder. Ctrl-click the on package and select Open to open the package.

4. Review the security dialog box. If you are ready to install nmap, choose Open to install nmap.

5. In Terminal, test the installation with this command.

   nmap --version

6. If you see an output similar to the following, nmap is installed and you can continue to the section called “Test the connection to your device data endpoint and port” (p. 36).

   Nmap version 7.92 (https://nmap.org)
   Platform: x86_64-apple-darwin17.7.0
   Compiled with: nmap-liblua-5.3.5 openssl-1.1.1k nmap-libssh2-1.9.0 libz-1.2.11
   nmap-libpcre-7.6 nmap-libpcap-1.9.1 nmap-libdnet-1.12 ipv6
   Compiled without:
   Available nsock engines: kqueue poll select

Windows

This procedure requires that you have permission to install software on the computer.

To install nmap on your Windows computer

1. In a browser, open https://nmap.org/download#windows and download the latest stable release of the setup program.

   If prompted, choose Save file. After the file is downloaded, open it from the downloads folder.

2. After the setup file finishes downloading, open downloaded nmap-xxxx-setup.exe to install the app.

3. Accept the default settings as the program installs.

   You don't need the Npcap app for this test. You can deselect that option if you don't want to install it.

4. In Command, test the installation with this command.

   nmap --version

5. If you see an output similar to the following, nmap is installed and you can continue to the section called “Test the connection to your device data endpoint and port” (p. 36).

   Nmap version 7.92 (https://nmap.org)
   Platform: i686-pc-windows-windows
   Compiled with: nmap-liblua-5.3.5 openssl-1.1.1k nmap-libssh2-1.9.0 nmap-libz-1.2.11
   nmap-libpcre-7.6 Npcap-1.50 nmap-libdnet-1.12 ipv6
   Compiled without:
   Available nsock engines: iocp poll select
Test the connection to your device data endpoint and port

To test your device data endpoint and port

1. In a terminal or command line window on your device, replace the sample device data endpoint (a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com) with the device data endpoint for your account, and then enter this command.

   ```
   nmap -p 8443 a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com
   ```

2. If nmap displays an output similar to the following, nmap was able to connect successfully to your device data endpoint at the selected port.

   ```
   Starting Nmap 7.92 ( https://nmap.org ) at 2022-02-18 16:23 Pacific Standard Time
   Nmap scan report for a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com (xx.xxx.147.160)
   Host is up (0.036s latency).
   Other addresses for a3qEXAMPLEsffp-ats.iot.eu-west-1.amazonaws.com (not scanned):
   xx.xxx.127.126
   rDNS record for xx.xxx.147.160: ec2-EXAMPLE-160.eu-west-1.compute.amazonaws.com

   PORT     STATE SERVICE
   8443/tcp open  https-alt
   MAC Address: 00:11:22:33:44:55 (Cimsys)
   
   Nmap done: 1 IP address (1 host up) scanned in 0.91 seconds
   ```

3. If nmap didn't return a successful output, check the endpoint value to make sure you have the correct endpoint and check your device's connection with the internet.

   You can test other ports on your device data endpoint, such as port 443, the primary HTTPS port, by replacing the port used in step 1, 8443, with the port that you want to test.

Explore AWS IoT Core services in hands-on tutorial

In this tutorial, you'll install the software and create the AWS IoT resources necessary to connect a device to AWS IoT Core so that it can send and receive MQTT messages with AWS IoT Core. You'll see the messages in the MQTT client in the AWS IoT console.

You can expect to spend 20-30 minutes on this tutorial. If you are using an IoT device or a Raspberry Pi, this tutorial might take longer if, for example, you need to install the operating system and configure the device.
This tutorial is best for developers who want to get started with AWS IoT Core so they can continue to explore more advanced features, such as the rules engine and shadows. This tutorial prepares you to continue learning about AWS IoT Core and how it interacts with other AWS services by explaining the steps in greater detail than the quick start tutorial (p. 22). If you are looking for just a quick, Hello World, experience, try the Try the AWS IoT quick connect (p. 22).

After setting up your AWS account and AWS IoT console, you'll follow these steps to see how to connect a device and have it send messages to AWS IoT Core.

**Next steps**

- Choose which device option is the best for you (p. 37)
- the section called “Create AWS IoT resources” (p. 38) if you are not going to create a virtual device with Amazon EC2
- the section called “Configure your device” (p. 41)
- the section called “View MQTT messages with the AWS IoT MQTT client” (p. 67)

For more information about AWS IoT Core, see What Is AWS IoT Core (p. 1)?

**Which device option is best for you?**

If you're not sure which option to pick, use the following list of each option's advantages and disadvantages to help you decide which one is best for you.

<table>
<thead>
<tr>
<th>Option</th>
<th>This might be a good option if:</th>
<th>This might not be a good option if:</th>
</tr>
</thead>
</table>
| the section called “Create a virtual device with Amazon EC2” (p. 41) | - You don't have your own device to test.  
- You don't want to install any software on your own system.  
- You want to test on a Linux OS. | - You're not comfortable using command-line commands.  
- You don't want to incur any additional AWS charges.  
- You don't want to test on a Linux OS. |
| the section called “Use your Windows or Linux PC or Mac as an AWS IoT device” (p. 49) | - You don't want to incur any additional AWS charges. | - You don't want to install any software on your personal computer. |
Create AWS IoT resources

In this tutorial, you'll create the AWS IoT resources that a device requires to connect to AWS IoT Core and exchange messages.

1. Create an AWS IoT policy document, which will authorize your device to interact with AWS IoT services.

2. Create a thing object in AWS IoT and its X.509 device certificate, and then attach the policy document. The thing object is the virtual representation of your device in the AWS IoT registry. The certificate authenticates your device to AWS IoT Core, and the policy document authorizes your device to interact with AWS IoT.

Note
If you are planning to the section called "Create a virtual device with Amazon EC2" (p. 41), you can skip this page and continue to the section called "Configure your device" (p. 41). You will create these resources when you create your virtual thing.
Create an AWS IoT policy

Devices use an X.509 certificate to authenticate with AWS IoT Core. The certificate has AWS IoT policies attached to it. These policies determine which AWS IoT operations, such as subscribing or publishing to MQTT topics, the device is permitted to perform. Your device presents its certificate when it connects and sends messages to AWS IoT Core.

Follow the steps to create a policy that allows your device to perform the AWS IoT operations necessary to run the example program. You must create the AWS IoT policy before you can attach it to the device certificate, which you’ll create later.

To create an AWS IoT policy

1. In the AWS IoT console, in the left menu, choose Security and then choose Policies.
2. On the You don’t have a policy yet page, choose Create policy.
3. If your account has existing policies, choose Create policy.
4. On the Create policy page:
   1. In the Policy properties section, in the Policy name field, enter a name for the policy (for example, My_Iot_Policy). Don’t use personally identifiable information in your policy names.
   2. In the Policy document section, create the policy statements that grant or deny resources access to AWS IoT Core operations. To create a policy statement that grants all clients to perform iot:Connect, follow these steps:
      • In the Policy effect field, choose Allow. This allows all clients that have this policy attached to their certificate to perform the action listed in the Policy action field.
      • In the Policy action field, choose a policy action such as iot:Connect. Policy actions are the actions that your device needs permission to perform when it runs the example program from the Device SDK.
      • In the Policy resource field, enter a resource Amazon Resource Name (ARN) or *. A * to select any client (device).

To create the policy statements for iot:Receive, iot:Publish, and iot:Subscribe, choose Add new statement and repeat the steps.

<table>
<thead>
<tr>
<th>Policy effect</th>
<th>Policy action</th>
<th>Policy resource</th>
<th>Remove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow</td>
<td>iot:Connect</td>
<td>*</td>
<td>Remove</td>
</tr>
<tr>
<td>Allow</td>
<td>iot:Receive</td>
<td>*</td>
<td>Remove</td>
</tr>
<tr>
<td>Allow</td>
<td>iot:Publish</td>
<td>*</td>
<td>Remove</td>
</tr>
<tr>
<td>Allow</td>
<td>iot:Subscribe</td>
<td>*</td>
<td>Remove</td>
</tr>
</tbody>
</table>

Note
In this quick start, the wildcard (*) character is used for simplicity. For higher security, you should restrict which clients (devices) can connect and publish messages by specifying a client ARN instead of the wildcard character as the resource. Client ARNs follow this format: arn:aws:iot:your-region:your-aws-account:client/my-client-id. However, you must first create the resource (such as a client device or thing shadow) before you can assign its ARN to a policy. For more information, see AWS IoT Core action resources.
4. After you've entered the information for your policy, choose Create.

For more information, see How AWS IoT works with IAM (p. 394).

Create a thing object

Devices connected to AWS IoT Core are represented by thing objects in the AWS IoT registry. A thing object represents a specific device or logical entity. It can be a physical device or sensor (for example, a light bulb or a light switch on the wall). It can also be a logical entity, like an instance of an application or physical entity that doesn't connect to AWS IoT, but is related to other devices that do (for example, a car that has engine sensors or a control panel).

To create a thing in the AWS IoT console

1. In the AWS IoT console, in the left menu, choose All devices and then choose Things.
2. On the Things page, choose Create things.
3. On the Create things page, choose Create a single thing, then choose Next.
4. On the Specify thing properties page, for Thing name, enter a name for your thing, such as MyIotThing.

Choose thing names carefully, because you can't change a thing name later.

To change a thing's name, you must create a new thing, give it the new name, and then delete the old thing.

**Note**
Do not use personally identifiable information in your thing name. The thing name can appear in unencrypted communications and reports.

5. Keep the rest of the fields on this page empty. Choose Next.
7. On the Attach policies to certificate - optional page, select the policy you created in the previous section. In that section, the policy was named, My_Iot_Policy. Choose Create thing.
8. On the Download certificates and keys page:

1. Download each of the certificate and key files and save them for later. You'll need to install these files on your device.

When you save your certificate files, give them the names in the following table. These are the file names used in later examples.

**Certificate file names**

<table>
<thead>
<tr>
<th>File</th>
<th>File path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private key</td>
<td>private.pem.key</td>
</tr>
<tr>
<td>Public key</td>
<td>(not used in these examples)</td>
</tr>
<tr>
<td>Device certificate</td>
<td>device.pem.crt</td>
</tr>
<tr>
<td>Root CA certificate</td>
<td>Amazon-root-CA-1.pem</td>
</tr>
</tbody>
</table>

2. To download the root CA file for these files, choose the Download link of the root CA certificate file that corresponds to the type of data endpoint and cipher suite you're using. In this tutorial, choose Download to the right of RSA 2048 bit key: Amazon Root CA 1 and download the RSA 2048 bit key: Amazon Root CA 1 certificate file.
Configure your device

This section describes how to configure your device to connect to AWS IoT Core. If you'd like to get started with AWS IoT Core but don't have a device yet, you can create a virtual device by using Amazon EC2 or you can use your Windows PC or Mac as an IoT device.

Select the best device option for you to try AWS IoT Core. Of course, you can try all of them, but try only one at a time. If you're not sure which device option is best for you, read about how to choose which device option is the best (p. 37), and then return to this page.

Device options

- Create a virtual device with Amazon EC2 (p. 41)
- Use your Windows or Linux PC or Mac as an AWS IoT device (p. 49)
- Connect a Raspberry Pi or other device (p. 58)

Create a virtual device with Amazon EC2

In this tutorial, you'll create an Amazon EC2 instance to serve as your virtual device in the cloud.

To complete this tutorial, you need an AWS account. If you don't have one, complete the steps described in Set up your AWS account (p. 18) before you continue.

In this tutorial, you'll:

- Set up an Amazon EC2 instance (p. 41)
- Install Git, Node.js and configure the AWS CLI (p. 42)
- Create AWS IoT resources for your virtual device (p. 44)
- Install the AWS IoT Device SDK for JavaScript (p. 47)
- Run the sample application (p. 47)
- View messages from the sample app in the AWS IoT console (p. 49)

Set up an Amazon EC2 instance

The following steps show you how to create an Amazon EC2 instance that will act as your virtual device in place of a physical device.

If this is the first time you've created an Amazon EC2 instance, you might find the instructions in Get started with Amazon EC2 Linux instances to be more helpful.

To launch an instance

1. Open the Amazon EC2 console at https://console.aws.amazon.com/ec2/.
2. From the console menu on the left, expand **Instances** section and choose **Instances**. From the **Instances** dashboard, choose **Launch instances** on the right to display a list of basic configurations.

3. In the **Name and tags** section, enter a name for the instance and optionally add tags.

4. In the **Application and OS Images (Amazon Machine Image)** section, choose an AMI template for your instance, such as **Amazon Linux 2 AMI (HVM)**. Notice that this AMI is marked "Free tier eligible."

5. In the **Instance type** section, you can select the hardware configuration of your instance. Select the **t2.micro** type, which is selected by default. Notice that this instance type is eligible for the free tier.

6. In the **Key pair (login)** section, choose a key pair name from the drop-down list or choose **Create a new key pair** to create a new one. When creating a new key pair, make sure you download the private key file and save it in a safe place, because this is your only chance to download and save it. You’ll need to provide the name of your key pair when you launch an instance and the corresponding private key each time you connect to the instance.

   **Warning**
   Don't choose the **Proceed without a key pair** option. If you launch your instance without a key pair, then you can't connect to it.

7. In the **Network settings** section and the **Configure storage** section, you can keep the default settings. When you are ready, choose **Launch instances**.

8. A confirmation page lets you know that your instance is launching. Choose **View Instances** to close the confirmation page and return to the console.

9. On the **Instances** screen, you can view the status of the launch. It takes a short time for an instance to launch. When you launch an instance, its initial state is pending. After the instance starts, its state changes to running and it receives a public DNS name. (If the **Public DNS (IPv4)** column is hidden, choose **Show/Hide Columns** (the gear-shaped icon) in the top right corner of the page and then select **Public DNS (IPv4)**.)

10. It can take a few minutes for the instance to be ready so that you can connect to it. Check that your instance has passed its status checks; you can view this information in the **Status Checks** column.

    After your new instance has passed its status checks, continue to the next procedure and connect to it.

**To connect to your instance**

You can connect to an instance using the browser-based client by selecting the instance from the Amazon EC2 console and choosing to connect using Amazon EC2 Instance Connect. Instance Connect handles the permissions and provides a successful connection.

1. Open the Amazon EC2 console at [https://console.aws.amazon.com/ec2/](https://console.aws.amazon.com/ec2/).
2. On the left menu, choose **Instances**.
3. Select the instance and choose **Connect**.
4. Choose **Amazon EC2 Instance Connect** , **Connect**.

You should now have an **Amazon EC2 Instance Connect** window that is logged into your new Amazon EC2 instance.

**Install Git, Node.js and configure the AWS CLI**

In this section, you'll install Git and Node.js on your Linux instance.

**To install Git**

1. In your **Amazon EC2 Instance Connect** window, update your instance by using the following command.
`sudo yum update -y`

2. In your **Amazon EC2 Instance Connect** window, install Git by using the following command.

`sudo yum install git -y`

3. To check if Git has been installed and the current version of Git, run the following command:

`git --version`

**To install Node.js**

1. In your **Amazon EC2 Instance Connect** window, install node version manager (nvm) by using the following command.

```
curl -o- https://raw.githubusercontent.com/nvm-sh/nvm/v0.34.0/install.sh | bash
```

We will use nvm to install Node.js because nvm can install multiple versions of Node.js and allow you to switch between them.

2. In your **Amazon EC2 Instance Connect** window, activate nvm by using this command.

```
. ~/.nvm/nvm.sh
```

3. In your **Amazon EC2 Instance Connect** window, use nvm to install the latest version of Node.js by using this command.

```
nvm install 16
```

**Note**

This installs the latest LTS release of Node.js.

Installing Node.js also installs the Node Package Manager (npm) so you can install additional modules as needed.

4. In your **Amazon EC2 Instance Connect** window, test that Node.js is installed and running correctly by using this command.

```
node -e "console.log('Running Node.js ' + process.version)"
```

This tutorial requires Node v10.0 or later. For more information, see *Tutorial: Setting Up Node.js on an Amazon EC2 Instance*.

**To configure AWS CLI**

Your Amazon EC2 instance comes preloaded with the AWS CLI. However, you must complete your AWS CLI profile. For more information on how to configure your CLI, see *Configuring the AWS CLI*.

1. The following example shows sample values. Replace them with your own values. You can find these values in your **AWS console in your account info under Security credentials**.

   In your **Amazon EC2 Instance Connect** window, enter this command:
Configure your device

aws configure

Then enter the values from your account at the prompts displayed.

<table>
<thead>
<tr>
<th>AWS Access Key ID [None]:</th>
<th>AKIAI0SFODNN7EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS Secret Access Key [None]:</td>
<td>wJalrXUttnFEMI/K7MDENG/bPxRfipFYEXAMPLEKEY</td>
</tr>
<tr>
<td>Default region name [None]:</td>
<td>us-west-2</td>
</tr>
<tr>
<td>Default output format [None]:</td>
<td>json</td>
</tr>
</tbody>
</table>

2. You can test your AWS CLI configuration with this command:

aws iot describe-endpoint --endpoint-type iot:Data-ATS

If your AWS CLI is configured correctly, the command should return an endpoint address from your AWS account.

Create AWS IoT resources for your virtual device

This section describes how to use the AWS CLI to create the thing object and its certificate files directly on the virtual device. This is done directly on the device to avoid the potential complication that might arise from copying them to the device from another computer. In this section, you will create the following resources for your virtual device:

- A thing object to represent your virtual device in AWS IoT.
- A certificate to authenticate your virtual device.
- A policy document to authorize your virtual device to connect to AWS IoT, and to publish, receive, and subscribe to messages.

To create an AWS IoT thing object in your Linux instance

Devices connected to AWS IoT are represented by thing objects in the AWS IoT registry. A thing object represents a specific device or logical entity. In this case, your thing object will represent your virtual device, this Amazon EC2 instance.

1. In your Amazon EC2 Instance Connect window, run the following command to create your thing object.

aws iot create-thing --thing-name "MyIotThing"

2. The JSON response should look like this:

```
{
"thingArn": "arn:aws:iot:your-region:your-aws-account:thing/MyIotThing",
"thingName": "MyIotThing",
"thingId": "6cf922a8-d8ea-4136-f3401EXAMPLE"
}
```

To create and attach AWS IoT keys and certificates in your Linux instance

The create-keys-and-certificate command creates client certificates signed by the Amazon Root certificate authority. This certificate is used to authenticate the identity of your virtual device.
1. In your Amazon EC2 Instance Connect window, create a directory to store your certificate and key files.

   ```
mkdir ~/certs
   ```

2. In your Amazon EC2 Instance Connect window, download a copy of the Amazon certificate authority (CA) certificate by using this command.

   ```
curl -o ~/certs/Amazon-root-CA-1.pem https://www.amazontrust.com/repository/AmazonRootCA1.pem
   ```

3. In your Amazon EC2 Instance Connect window, run the following command to create your private key, public key, and X.509 certificate files. This command also registers and activates the certificate with AWS IoT.

   ```
aws iot create-keys-and-certificate
   --set-as-active
   --certificate-pem-outfile ~/certs/device.pem.crt
   --public-key-outfile ~/certs/public.pem.key
   --private-key-outfile ~/certs/private.pem.key
   ```

   The response looks like the following. Save the certificateArn so that you can use it in subsequent commands. You'll need it to attach your certificate to your thing and to attach the policy to the certificate in a later step.

   ```
   {
     "certificateArn": "arn:aws:iot:us-west-2:123456789012:cert/9894ba17925e663f1d29c23af4582be83b7619c31f3fbd93adcb51ae54b83dc2",
     "certificateId": "9894ba17925e663f1d29c23af4582be83b7619c31f3fbd93adcb51ae54b83dc2",
     "certificatePem": "-----BEGIN CERTIFICATE-----
MIICiTCCEXAMPLE6m7oRw0uXOjANBkgtkh7G9w0BAQUFADCBIDMLMAGAIUEBhMC
VMXczAJBGNVAgEXAMPLEAwgDvQQHEwdTZWF0dGxJMQ8wDQYDVQQKEwZbbWGF6
b24fDFA5BgNVBAkTC0lBTSEXAMPLE3x1MRiwEAYDVQQDEwUZXNoQ2lsYVMyMzHz
BgkqhkiG9w0BCCQEWG5eMs25lQGfYXKMEXAMPLEb20wHhcNMTEwNDI1MjA0NTIw
NjMtNDEwMjA0NTIlMjA0NTIwWhcN
NITJbNMEXAMPLEbt7yjXjBiBDMLMAKAIUEBhMCEXAMPLEJbGNVAgTA1dMB8AwgYD
VQQHEwdTZWFQdGxJMQ8wDQYDVQQKEwZbbWGF6b24fDFAEXAMPLE3xTC0lBT5Bdb25z
b2xlMRiwEAYDVQQDEwUZXNoQ2lsYWMxMzHzdGkqkh7G9w0BCQEXAMPLE2S5lQGF
YXpbv15jZb0gwZWdDQJKoZIvcnNAQEEDBAQgYAMSIGJhAQAIAK8d+eEXAMPLE
EXAMPLEEVwSwlC3A4nB+BLyVig6k6CPiw3Z5G3vUEI03yNoH/F0wYKS89MT
zDHudUZEXAMPLEL5M43q7WgC/MbQ75QV7c7ugFFDzQBzZswY76GM68gEp
Ibbo397nzcvcQAXEMPLEW1Mm2RZvAgMAAeEAwDQJKoZIvcnNAQEFBDQgYExcelAcy
luVvXutfnlln9+h+Mg9qEXAMPLEExzyLwaxlAoo7TJHldt54J51NmzGhXFL0fb
FFbjv5fpJ1l0bzwN5Ss6GuoEEXAMPLEBjJymp5280B8us7Fllvje79LjSb
 NYjytBzEQQQuyvu2jXn1mww3rrsz1aEXAMPLE=
   ------END CERTIFICATE-----\n",
   "keyPair": {
     "PublicKey": "-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BAQUFADCBIDMLMAGAIUEBhMC
VMXczAJSByVAgEXAMPLEAwgDvQQHEwdTZWF0dGxJMQ8wDQYDVQQKEwZbbWGF6
b24fDFA5BgNVBAkTC0lBTSEXAMPLE3x1MRiwEAYDVQQDEwUZXNoQ2lsYVMyMzHz
BgkqhkiG9w0BCCQEWG5eMs25lQGfYXKMEXAMPLEb20wHhcNMTEwNDI1MjA0NTIw
NjMtNDEwMjA0NTIlMjA0NTIwWhcN
NITJbNMEXAMPLEbt7yjXjBiBDMLMAKAIUEBhMCEXAMPLEJbGNVAgTA1dMB8AwgYD
VQQHEwdTZWFQdGxJMQ8wDQYDVQQKEwZbbWGF6b24fDFAEXAMPLE3xTC0lBT5Bdb25z
b2xlMRiwEAYDVQQDEwUZXNoQ2lsYWMxMzHzdGkqkh7G9w0BCQEXAMPLE2S5lQGF
YXpbv15jZb0gwZWdDQJKoZIvcnNAQEEDBAQgYAMSIGJhAQAIAK8d+eEXAMPLE
EXAMPLEEVwSwlC3A4nB+BLyVig6k6CPiw3Z5G3vUEI03yNoH/F0wYKS89MT
zDHudUZEXAMPLEL5M43q7WgC/MbQ75QV7c7ugFFDzQBzZswY76GM68gEp
Ibbo397nzcvcQAXEMPLEW1Mm2RZvAgMAAeEAwDQJKoZIvcnNAQEFBDQgYExcelAcy
luVvXutfnlln9+h+Mg9qEXAMPLEExzyLwaxlAoo7TJHldt54J51NmzGhXFL0fb
FFbjv5fpJ1l0bzwN5Ss6GuoEEXAMPLEBjJymp5280B8us7Fllvje79LjSb
 NYjytBzEQQQuyvu2jXn1mww3rrsz1aEXAMPLE=
   ------END CERTIFICATE-----\n",
   "PrivateKey": "-----BEGIN RSA PRIVATE KEY-----
key omitted for security reasons
   --------END RSA PRIVATE KEY-----\n"
   }
   }
   ```
4. In your **Amazon EC2 Instance Connect** window, attach your thing object to the certificate you just created by using the following command and the *certificateArn* in the response from the previous command.

```bash
aws iot attach-thing-principal \
   --thing-name "MyIotThing" \ 
   --principal "certificateArn"
```

If successful, this command does not display any output.

**To create and attach a policy**

1. In your **Amazon EC2 Instance Connect** window, create the policy file by copying and pasting this policy document to a file named `~/policy.json`.

   If you don't have a favorite Linux editor, you can open **nano**, by using this command.

   ```bash
   nano ~/policy.json
   ```

   Paste the policy document for `policy.json` into it. Enter `ctrl-x` to exit the **nano** editor and save the file.

   Contents of the policy document for `policy.json`.

   ```json
   {
   "Version": "2012-10-17",
   "Statement": [
   
   
   {
   "Effect": "Allow",
   "Action": [
   "iot:Publish",
   "iot:Subscribe",
   "iot:Receive",
   "iot:Connect"
   ],
   "Resource": [
   "*
   ]
   }
   ]
   }
   ```

2. In your **Amazon EC2 Instance Connect** window, create your policy by using the following command.

   ```bash
   aws iot create-policy \
   --policy-name "MyIotThingPolicy" \ 
   --policy-document "file://~/policy.json"
   ```

   Output:

   ```json
   {
   "policyName": "MyIotThingPolicy",
   "policyArn": "arn:aws:iot:your-region:your-aws-account:policy/MyIotThingPolicy",
   "policyDocument": "{\n   "Version": "2012-10-17",
   "Statement": [{
   "Effect": "Allow",
   "Action": [
   "iot:Publish",
   "iot:Subscribe",
   "iot:Receive",
   "iot:Connect"
   ],
   "Resource": [
   "*
   ]
   }
   ]
   }
   ```
Configure your device

```json
"Action": [
  "iot:Publish",
  "iot:Receive",
  "iot:Subscribe",
  "iot:Connect"
],
"Resource": [
  "*"
]
"policyVersionId": "1"
```

3. In your Amazon EC2 Instance Connect window, attach the policy to your virtual device's certificate by using the following command.

```bash
aws iot attach-policy
   --policy-name "MyIotThingPolicy" 
   --target "certificateArn"
```

If successful, this command does not display any output.

**Install the AWS IoT Device SDK for JavaScript**

In this section, you'll install the AWS IoT Device SDK for JavaScript, which contains the code that applications can use to communicate with AWS IoT and the sample programs. For more information, see the [AWS IoT Device SDK for JavaScript GitHub repository](https://github.com/aws/aws-iot-device-sdk-js-v2).

**To install the AWS IoT Device SDK for JavaScript on your Linux instance**

1. In your Amazon EC2 Instance Connect window, clone the AWS IoT Device SDK for JavaScript repository into the `aws-iot-device-sdk-js-v2` directory of your home directory by using this command.

   ```bash
   cd ~
git clone https://github.com/aws/aws-iot-device-sdk-js-v2.git
   ```

2. Navigate to the `aws-iot-device-sdk-js-v2` directory that you created in the preceding step.

   ```bash
cd aws-iot-device-sdk-js-v2
   ```

3. Use npm to install the SDK.

   ```bash
   npm install
   ```

**Run the sample application**

The commands in the next sections assume that your key and certificate files are stored on your virtual device as shown in this table.

**Certificate file names**

<table>
<thead>
<tr>
<th>File</th>
<th>File path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private key</td>
<td>~/certs/private.pem.key</td>
</tr>
</tbody>
</table>
In this section, you'll install and run the pub-sub.js sample app found in the aws-iot-device-sdk-js-v2/samples/node directory of the AWS IoT Device SDK for JavaScript. This app shows how a device, your Amazon EC2 instance, uses the MQTT library to publish and subscribe to MQTT messages. The pub-sub.js sample app subscribes to a topic, topic_1, publishes 10 messages to that topic and displays the messages as they're received from the message broker.

To install and run the sample app

1. In your Amazon EC2 Instance Connect window, navigate to the aws-iot-device-sdk-js-v2/samples/node/pub_sub directory that the SDK created and install the sample app by using these commands.

   ```bash
cd ~/aws-iot-device-sdk-js-v2/samples/node/pub_sub
npm install
```

2. In your Amazon EC2 Instance Connect window, get your-iot-endpoint from AWS IoT by using this command.

   ```bash
aws iot describe-endpoint --endpoint-type iot:Data-ATS
```

3. In your Amazon EC2 Instance Connect window, insert your-iot-endpoint as indicated and run this command.

   ```bash
node dist/index.js --topic topic_1 --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint
```

The sample app:

1. Connects to AWS IoT Core for your account.
2. Subscribes to the message topic, topic_1, and displays the messages it receives on that topic.
3. Publishes 10 messages to the topic, topic_1.
4. Displays output similar to the following:

   ```
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":1
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":2
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":3
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":4
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":5
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":6
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":7
   Publish received. topic:"topic_1" dup:false qos:1 retain:false
   "message":"Hello world!","sequence":8
   ```
If you're having trouble running the sample app, review the section called “Troubleshooting problems with the sample app” (p. 66).

You can also add the --verbosity debug parameter to the command line so the sample app displays detailed messages about what it's doing. That information might provide you the help you need to correct the problem.

View messages from the sample app in the AWS IoT console

You can see the sample app's messages as they pass through the message broker by using the MQTT test client in the AWS IoT console.

To view the MQTT messages published by the sample app

1. Review View MQTT messages with the AWS IoT MQTT client (p. 67). This helps you learn how to use the MQTT test client in the AWS IoT console to view MQTT messages as they pass through the message broker.
2. Open the MQTT test client in the AWS IoT console.
3. In Subscribe to a topic, Subscribe to the topic, topic_1.
4. In your Amazon EC2 Instance Connect window, run the sample app again and watch the messages in the MQTT test client in the AWS IoT console.

For more information about MQTT and how AWS IoT Core supports the protocol, see MQTT.

Use your Windows or Linux PC or Mac as an AWS IoT device

In this tutorial, you'll configure a personal computer for use with AWS IoT. These instructions support Windows and Linux PCs and Macs. To accomplish this, you need to install some software on your computer. If you don't want to install software on your computer, you might try Create a virtual device with Amazon EC2 (p. 41), which installs all software on a virtual machine.

In this tutorial, you'll:

• Set up your personal computer (p. 49)
• Install Git, Python, and the AWS IoT Device SDK for Python (p. 50)
• Set up the policy and run the sample application (p. 52)
• View messages from the sample app in the AWS IoT console (p. 55)
• Run the Shared Subscription example in Python (p. 55)

Set up your personal computer

To complete this tutorial, you need a Windows or Linux PC or a Mac with a connection to the internet.

Before you continue to the next step, make sure you can open a command line window on your computer. Use cmd.exe on a Windows PC. On a Linux PC or a Mac, use Terminal.
Install Git, Python, and the AWS IoT Device SDK for Python

In this section, you'll install Python, and the AWS IoT Device SDK for Python on your computer.

Install the latest version of Git and Python

To download and install Git and Python on your computer

1. Check to see if you have Git installed on your computer. Enter this command in the command line.

```
git --version
```

If the command displays the Git version, Git is installed and you can continue to the next step.

If the command displays an error, open https://git-scm.com/download and install Git for your computer.

2. Check to see if you have already installed Python. Enter the command in the command line.

```
python -V
```

**Note**

If this command gives an error: Python was not found, it might be because your operating system calls the Python v3.x executable as Python3. In that case, replace all instances of python with python3 and continue the remainder of this tutorial.

If the command displays the Python version, Python is already installed. This tutorial requires Python v3.7 or later.

3. If Python is installed, you can skip the rest of the steps in this section. If not, continue.

4. Open https://www.python.org/downloads/ and download the installer for your computer.

5. If the download didn't automatically start to install, run the downloaded program to install Python.

6. Verify the installation of Python.

```
python -V
```

Confirm that the command displays the Python version. If the Python version isn't displayed, try downloading and installing Python again.

Install the AWS IoT Device SDK for Python

To install the AWS IoT Device SDK for Python on your computer

1. Install v2 of the AWS IoT Device SDK for Python.

```
python3 -m pip install awsiotsdk
```

2. Clone the AWS IoT Device SDK for Python repository into the aws-iot-device-sdk-python-v2 directory of your home directory. This procedure refers to the base directory for the files you're installing as home.

The actual location of the home directory depends on your operating system.

Linux/macOS

In macOS and Linux, the home directory is ~.
cd ~
git clone https://github.com/aws/aws-iot-device-sdk-python-v2.git

Windows

In Windows, you can find the `home` directory path by running this command in the cmd window.

```
echo %USERPROFILE%
cd %USERPROFILE%
git clone https://github.com/aws/aws-iot-device-sdk-python-v2.git
```

**Note**
If you're using Windows PowerShell as opposed to `cmd.exe`, then use the following command.

```
echo $home
```

For more information, see the [AWS IoT Device SDK for Python GitHub repository](https://github.com/aws/aws-iot-device-sdk-python-v2.git).

**Prepare to run the sample applications**

**To prepare your system to run the sample application**

- Create the `certs` directory. Into the `certs` directory, copy the private key, device certificate, and root CA certificate files you saved when you created and registered the thing object in the section called “Create AWS IoT resources” (p. 38). The file names of each file in the destination directory should match those in the table.

```
mkdir ~/certs
```

The commands in the next section assume that your key and certificate files are stored on your device as shown in this table.

**Linux/macOS**

Run this command to create the `certs` subdirectory that you'll use when you run the sample applications.

```
mkdir ~/certs
```

Into the new subdirectory, copy the files to the destination file paths shown in the following table.

**Certificate file names**

<table>
<thead>
<tr>
<th>File</th>
<th>File path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private key</td>
<td>~/certs/private.pem.key</td>
</tr>
<tr>
<td>Device certificate</td>
<td>~/certs/device.pem.crt</td>
</tr>
<tr>
<td>Root CA certificate</td>
<td>~/certs/Amazon-root-CA-1.pem</td>
</tr>
</tbody>
</table>
Run this command to list the files in the `certs` directory and compare them to those listed in the table.

```
ls -l ~*/certs
```

**Windows**

Run this command to create the `certs` subdirectory that you'll use when you run the sample applications.

```
mkdir %USERPROFILE%\certs
```

Into the new subdirectory, copy the files to the destination file paths shown in the following table.

<table>
<thead>
<tr>
<th>Certificate file names</th>
<th>File path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private key</td>
<td>%USERPROFILE%\certs\private.pem.key</td>
</tr>
<tr>
<td>Device certificate</td>
<td>%USERPROFILE%\certs\device.pem.crt</td>
</tr>
<tr>
<td>Root CA certificate</td>
<td>%USERPROFILE%\certs\Amazon-root-CA-1.pem</td>
</tr>
</tbody>
</table>

Run this command to list the files in the `certs` directory and compare them to those listed in the table.

```
dir %USERPROFILE%\certs
```

**Set up the policy and run the sample application**

In this section, you'll set up your policy and run the `pubsub.py` sample script found in the `aws-iot-device-sdk-python-v2/samples` directory of the AWS IoT Device SDK for Python. This script shows how your device uses the MQTT library to publish and subscribe to MQTT messages.

The `pubsub.py` sample app subscribes to a topic, `test/topic`, publishes 10 messages to that topic, and displays the messages as they're received from the message broker.

To run the `pubsub.py` sample script, you need the following information:

**Application parameter values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Where to find the value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>your-iot-endpoint</code></td>
<td>1. In the AWS IoT console, in the left menu, choose Settings.</td>
</tr>
<tr>
<td></td>
<td>2. On the Settings page, your endpoint is displayed in the Device data endpoint section.</td>
</tr>
</tbody>
</table>
The `your-iot-endpoint` value has a format of: `endpoint_id-ats.iot.region.amazonaws.com`, for example, `a3qj468EXAMPLE-ats.iot.us-west-2.amazonaws.com`.

Before running the script, make sure your thing's policy provides permissions for the sample script to connect, subscribe, publish, and receive.

**To find and review the policy document for a thing resource**

1. In the [AWS IoT console](https://console.aws.amazon.com/iot), in the **Things** list, find the thing resource that represents your device.

2. Choose the **Name** link of the thing resource that represents your device to open the **Thing details** page.

3. In the **Thing details** page, in the **Certificates** tab, choose the certificate that is attached to the thing resource. There should only be one certificate in the list. If there is more than one, choose the certificate whose files are installed on your device and that will be used to connect to AWS IoT Core.

   In the **Certificate** details page, in the **Policies** tab, choose the policy that's attached to the certificate. There should only be one. If there is more than one, repeat the next step for each to make sure that at least one policy grants the required access.

4. In the **Policy** overview page, find the JSON editor and choose **Edit policy document** to review and edit the policy document as required.

5. The policy JSON is displayed in the following example. In the "Resource" element, replace `region:account` with your AWS Region and AWS account in each of the `Resource` values.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish",
                "iot:Receive"
            ],
            "Resource": [
                "arn:aws:iot:region:account:topic/test/topic"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Subscribe"
            ],
            "Resource": [
                "arn:aws:iot:region:account:topicfilter/test/topic"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Connect"
            ],
            "Resource": [
            ]
        }
    ]
}
```
Linux/macOS

**To run the sample script on Linux/macOS**

1. In your command line window, navigate to the `~/aws-iot-device-sdk-python-v2/samples/node/pub_sub` directory that the SDK created by using these commands.

   ```bash
cd ~/aws-iot-device-sdk-python-v2/samples
   ```

2. In your command line window, replace `your-iot-endpoint` as indicated and run this command.

   ```bash
   python3 pubsub.py --endpoint your-iot-endpoint --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key
   ```

Windows

**To run the sample app on a Windows PC**

1. In your command line window, navigate to the `%USERPROFILE%\aws-iot-device-sdk-python-v2\samples` directory that the SDK created and install the sample app by using these commands.

   ```bash
cd %USERPROFILE%\aws-iot-device-sdk-python-v2\samples
   ```

2. In your command line window, replace `your-iot-endpoint` as indicated and run this command.

   ```bash
   python3 pubsub.py --endpoint your-iot-endpoint --ca_file %USERPROFILE%\certs\Amazon-root-CA-1.pem --cert %USERPROFILE%\certs\device.pem.crt --key %USERPROFILE%\certs\private.pem.key
   ```

The sample script:

1. Connects to the AWS IoT Core for your account.
2. Subscribes to the message topic, `test/topic`, and displays the messages it receives on that topic.
3. Publishes 10 messages to the topic, `test/topic`.
4. Displays output similar to the following:

   ```
   Connected!
   Subscribing to topic 'test/topic'...
   Subscribed with QoS.AT_LEAST_ONCE
   Sending 10 message(s)
   Publishing message to topic 'test/topic': Hello World! [1]
   Received message from topic 'test/topic': b"Hello World! [1]"
   Publishing message to topic 'test/topic': Hello World! [2]
   Received message from topic 'test/topic': b"Hello World! [2]"
   Publishing message to topic 'test/topic': Hello World! [3]
   Received message from topic 'test/topic': b"Hello World! [3]"
   Publishing message to topic 'test/topic': Hello World! [4]
   Received message from topic 'test/topic': b"Hello World! [4]"
   Publishing message to topic 'test/topic': Hello World! [5]
   Received message from topic 'test/topic': b"Hello World! [5]"
   Publishing message to topic 'test/topic': Hello World! [6]
   Received message from topic 'test/topic': b"Hello World! [6]"
   ```
Publishing message to topic 'test/topic': Hello World! [7]
Received message from topic 'test/topic': b'"Hello World! [7"]'
Publishing message to topic 'test/topic': Hello World! [8]
Received message from topic 'test/topic': b'"Hello World! [8"]'
Publishing message to topic 'test/topic': Hello World! [9]
Received message from topic 'test/topic': b'"Hello World! [9"]'
Publishing message to topic 'test/topic': Hello World! [10]
Received message from topic 'test/topic': b'"Hello World! [10"]'
10 message(s) received.
Disconnecting...
Disconnected!

If you're having trouble running the sample app, review the section called "Troubleshooting problems with the sample app" (p. 66).

You can also add the --verbosity Debug parameter to the command line so the sample app displays detailed messages about what it's doing. That information might help you correct the problem.

View messages from the sample app in the AWS IoT console

You can see the sample app's messages as they pass through the message broker by using the MQTT test client in the AWS IoT console.

To view the MQTT messages published by the sample app

1. Review View MQTT messages with the AWS IoT MQTT client (p. 67). This helps you learn how to use the MQTT test client in the AWS IoT console to view MQTT messages as they pass through the message broker.
2. Open the MQTT test client in the AWS IoT console.
3. In Subscribe to a topic, subscribe to the topic, test/topic.
4. In your command line window, run the sample app again and watch the messages in the MQTT client in the AWS IoT console.

Linux/macOS

```
cd ~/aws-iot-device-sdk-python-v2/samples
python3 pubsub.py --topic test/topic --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint
```

Windows

```
cd %USERPROFILE%\aws-iot-device-sdk-python-v2\samples
python3 pubsub.py --topic test/topic --ca_file %USERPROFILE%\certs\Amazon-root-CA-1.pem --cert %USERPROFILE%\certs\device.pem.crt --key %USERPROFILE%\certs\private.pem.key --endpoint your-iot-endpoint
```

For more information about MQTT and how AWS IoT Core supports the protocol, see MQTT.

Run the Shared Subscription example in Python

AWS IoT Core supports Shared Subscriptions (p. 98) for both MQTT 3 and MQTT 5. Shared Subscriptions allow multiple clients to share a subscription to a topic and only one client will receive messages published to that topic using a random distribution. To use Shared Subscriptions, clients subscribe to a Shared Subscription's topic filter: $share/{ShareName}/[TopicFilter].
To set up the policy and run the Shared Subscription example

1. To run the Shared Subscription example, you must set up your thing's policy as documented in [MQTT 5 Shared Subscription](#).
2. To run the Shared Subscription example, run the following commands.

   **Linux/macOS**

   **To run the sample script on Linux/macOS**

   1. In your command line window, navigate to the `~/aws-iot-device-sdk-python-v2/samples` directory that the SDK created by using these commands.

      ```
      cd ~/aws-iot-device-sdk-python-v2/samples
      ```

   2. In your command line window, replace `your-iot-endpoint` as indicated and run this command.

      ```
      python3 mqtt5_shared_subscription.py --endpoint your-iot-endpoint --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --group_identifier consumer
      ```

   **Windows**

   **To run the sample app on a Windows PC**

   1. In your command line window, navigate to the `%USERPROFILE%\aws-iot-device-sdk-python-v2\samples` directory that the SDK created and install the sample app by using these commands.

      ```
      cd %USERPROFILE%\aws-iot-device-sdk-python-v2\samples
      ```

   2. In your command line window, replace `your-iot-endpoint` as indicated and run this command.

      ```
      python3 mqtt5_shared_subscription.py --endpoint your-iot-endpoint --ca_file %USERPROFILE%\certs\Amazon-root-CA-1.pem --cert %USERPROFILE%\certs\device.pem.crt --key %USERPROFILE%\certs\private.pem.key --group_identifier consumer
      ```

   **Note**

   You can optionally specify a group identifier based on your needs when you run the sample (e.g., `--group_identifier consumer`). If you don't specify one, `python-sample` is the default group identifier.

3. The output in your command line can look like the following:

   ```
   Publisher]: Lifecycle Connection Success
   [Publisher]: Connected
   Subscriber One]: Lifecycle Connection Success
   [Subscriber One]: Connected
   Subscriber Two]: Lifecycle Connection Success
   [Subscriber Two]: Connected
   [Subscriber One]: Subscribed to topic 'test/topic' in shared subscription group 'consumer'.
   [Subscriber One]: Full subscribed topic is: '$share/consumer/test/topic' with SubAck code: [<SubackReasonCode.GRANTED_QOS_1: 1>]
   ```
4. Open MQTT test client in the AWS IoT console. In Subscribe to a topic, subscribe to the Shared Subscription's topic such as: $share/consumer/test/topic. You can specify a group identifier.
Configure your device

based on your needs when you run the sample (e.g., `--group_identifier consumer`). If you don't specify a group identifier, the default value is `python-sample`. For more information, see MQTT 5 Shared Subscription Python example and Shared Subscriptions (p. 98) from AWS IoT Core Developer Guide.

In your command line window, run the sample app again and watch the distribution of messages in your MQTT test client of the AWS IoT console and the command line.

Connect a Raspberry Pi or other device

In this section, we'll configure a Raspberry Pi for use with AWS IoT. If you have another device that you'd like to connect, the instructions for the Raspberry Pi include references that can help you adapt these instructions to your device.

This normally takes about 20 minutes, but it can take longer if you have many system software upgrades to install.

In this tutorial, you'll:

- Set up your device (p. 59)
- Install the required tools and libraries for the AWS IoT Device SDK (p. 59)
- Install AWS IoT Device SDK (p. 60)
- Install and run the sample app (p. 62)
- View messages from the sample app in the AWS IoT console (p. 65)

Important

Adapting these instructions to other devices and operating systems can be challenging. You'll need to understand your device well enough to be able to interpret these instructions and apply them to your device.
If you encounter difficulties while configuring your device for AWS IoT, you might try one of the other device options as an alternative, such as Create a virtual device with Amazon EC2 (p. 41) or Use your Windows or Linux PC or Mac as an AWS IoT device (p. 49).

Set up your device

The goal of this step is to collect what you'll need to configure your device so that it can start the operating system (OS), connect to the internet, and allow you to interact with it at a command line interface.

To complete this tutorial, you need the following:

- An AWS account. If you don't have one, complete the steps described in Set up your AWS account (p. 18) before you continue.
- A Raspberry Pi 3 Model B or more recent model. This might work on earlier versions of the Raspberry Pi, but they have not been tested.
- Raspberry Pi OS (32-bit) or later. We recommend using the latest version of the Raspberry Pi OS. Earlier versions of the OS might work, but they have not been tested.

To run this example, you do not need to install the desktop with the graphical user interface (GUI); however, if you're new to the Raspberry Pi and your Raspberry Pi hardware supports it, using the desktop with the GUI might be easier.
- An Ethernet or WiFi connection.
- Keyboard, mouse, monitor, cables, power supplies, and other hardware required by your device.

**Important**

Before you continue to the next step, your device must have its operating system installed, configured, and running. The device must be connected to the internet and you will need to be able to access the device by using its command line interface. Command line access can be through a directly-connected keyboard, mouse, and monitor, or by using an SSH terminal remote interface.

If you are running an operating system on your Raspberry Pi that has a graphical user interface (GUI), open a terminal window on the device and perform the following instructions in that window. Otherwise, if you are connecting to your device by using a remote terminal, such as PuTTY, open a remote terminal to your device and use that.

**Install the required tools and libraries for the AWS IoT Device SDK**

Before you install the AWS IoT Device SDK and sample code, make sure your system is up to date and has the required tools and libraries to install the SDKs.

1. **Update the operating system and install required libraries**

   Before you install an AWS IoT Device SDK, run these commands in a terminal window on your device to update the operating system and install the required libraries.

   ```bash
   sudo apt-get update
   sudo apt-get upgrade
   sudo apt-get install cmake
   sudo apt-get install libssl-dev
   ```
2. **Install Git**

If your device’s operating system doesn’t come with Git installed, you must install it to install the AWS IoT Device SDK for JavaScript.

a. Test to see if Git is already installed by running this command.

```bash
git --version
```

b. If the previous command returns the Git version, Git is already installed and you can skip to Step 3.

c. If an error is displayed when you run the `git` command, install Git by running this command.

```bash
sudo apt-get install git
```

d. Test again to see if Git is installed by running this command.

```bash
git --version
```

e. If Git is installed, continue to the next section. If not, troubleshoot and correct the error before continuing. You need Git to install the AWS IoT Device SDK for JavaScript.

---

**Install AWS IoT Device SDK**

Install the AWS IoT Device SDK.

**Python**

In this section, you’ll install Python, its development tools, and the AWS IoT Device SDK for Python on your device. These instructions are for a Raspberry Pi running the latest Raspberry Pi OS. If you have another device or are using another operating system, you might need to adapt these instructions for your device.

1. **Install Python and its development tools**

   The AWS IoT Device SDK for Python requires Python v3.5 or later to be installed on your Raspberry Pi.

   In a terminal window to your device, run these commands.

   1. Run this command to determine the version of Python installed on your device.

      ```bash
      python3 --version
      ```

      If Python is installed, it will display its version.

   2. If the version displayed is Python 3.5 or greater, you can skip to Step 2.

   3. If the version displayed is less than Python 3.5, you can install the correct version by running this command.

      ```bash
      sudo apt install python3
      ```

   4. Run this command to confirm that the correct version of Python is now installed.

      ```bash
      python3 --version
      ```
In a terminal window to your device, run these commands.

1. Run this command to see if pip3 is installed.

   pip3 --version

2. If the command returns a version number, pip3 is installed and you can skip to Step 3.

3. If the previous command returns an error, run this command to install pip3.

   sudo apt install python3-pip

4. Run this command to see if pip3 is installed.

   pip3 --version

3. Install the current AWS IoT Device SDK for Python

Install the AWS IoT Device SDK for Python and download the sample apps to your device.

On your device, run these commands.

   cd ~
   python3 -m pip install awsiotsdk

   git clone https://github.com/aws/aws-iot-device-sdk-python-v2.git

JavaScript

In this section, you'll install Node.js, the npm package manager, and the AWS IoT Device SDK for JavaScript on your device. These instructions are for a Raspberry Pi running the Raspberry Pi OS. If you have another device or are using another operating system, you might need to adapt these instructions for your device.

1. Install the latest version of Node.js

The AWS IoT Device SDK for JavaScript requires Node.js and the npm package manager to be installed on your Raspberry Pi.

a. Download the latest version of the Node repository by entering this command.

   cd ~
   curl -sL https://deb.nodesource.com/setup_12.x | sudo -E bash -

b. Install Node and npm.

   sudo apt-get install -y nodejs

c. Verify the installation of Node.

   node -v

   Confirm that the command displays the Node version. This tutorial requires Node v10.0 or later. If the Node version isn't displayed, try downloading the Node repository again.

d. Verify the installation of npm.
Configure your device

npm -v

Confirm that the command displays the npm version. If the npm version isn't displayed, try installing Node and npm again.

e. Restart the device.
sudo shutdown -r 0

Continue after the device restarts.

2. Install the AWS IoT Device SDK for JavaScript

Install the AWS IoT Device SDK for JavaScript on your Raspberry Pi.

a. Clone the AWS IoT Device SDK for JavaScript repository into the aws-iot-device-sdk-js-v2 directory of your home directory. On the Raspberry Pi, the home directory is ~/, which is used as the home directory in the following commands. If your device uses a different path for the home directory, you must replace ~/ with the correct path for your device in the following commands.

These commands create the ~/aws-iot-device-sdk-js-v2 directory and copy the SDK code into it.

    cd ~
    git clone https://github.com/aws/aws-iot-device-sdk-js-v2.git

b. Change to the aws-iot-device-sdk-js-v2 directory that you created in the preceding step and run npm install to install the SDK. The command npm install will invoke the aws-crt library build that can take a few minutes to complete.

    cd ~/aws-iot-device-sdk-js-v2
    npm install

Install and run the sample app

In this section, you'll install and run the pubsub sample app found in the AWS IoT Device SDK. This app shows how your device uses the MQTT library to publish and subscribe to MQTT messages. The sample app subscribes to a topic, topic_1, publishes 10 messages to that topic, and displays the messages as they're received from the message broker.

Install the certificate files

The sample app requires the certificate files that authenticate the device to be installed on the device.

To install the device certificate files for the sample app

1. Create a certs subdirectory in your home directory by running these commands.

    cd ~
    mkdir certs

2. Into the ~/certs directory, copy the private key, device certificate, and root CA certificate that you created earlier in the section called "Create AWS IoT resources" (p. 38).

    How you copy the certificate files to your device depends on the device and operating system and isn't described here. However, if your device supports a graphical user interface (GUI) and has
a web browser, you can perform the procedure described in the section called “Create AWS IoT resources” (p. 38) from your device's web browser to download the resulting files directly to your device.

The commands in the next section assume that your key and certificate files are stored on the device as shown in this table.

**Certificate file names**

<table>
<thead>
<tr>
<th>File</th>
<th>File path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root CA certificate</td>
<td>~/certs/Amazon-root-CA-1.pem</td>
</tr>
<tr>
<td>Device certificate</td>
<td>~/certs/device.pem.crt</td>
</tr>
<tr>
<td>Private key</td>
<td>~/certs/private.pem.key</td>
</tr>
</tbody>
</table>

To run the sample app, you need the following information:

**Application parameter values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Where to find the value</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>your-iot-endpoint</code></td>
<td>In the AWS IoT console, choose All devices, and then choose Things. Choose the IoT thing you created for your device, MyIoTThing was the name used earlier, and then choose Interact. On the thing details page, your endpoint is displayed in the HTTPS section. If you use the new AWS IoT console, choose Settings from the AWS IoT menu. Your endpoint is displayed in the Device data endpoint section.</td>
</tr>
</tbody>
</table>

The `your-iot-endpoint` value has a format of: `endpoint_id-ats.iot.region.amazonaws.com`, for example, a3qj468EXAMPLE-ats.iot.us-west-2.amazonaws.com.

**Python**

**To install and run the sample app**

1. Navigate to the sample app directory.
   
   ```
   cd ~/aws-iot-device-sdk-python-v2/samples
   ```

2. In the command line window, replace `your-iot-endpoint` as indicated and run this command.
   
   ```
   python3 pubsub.py --topic topic_1 --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint
   ```

3. Observe that the sample app:

   1. Connects to the AWS IoT service for your account.
2. Subscribes to the message topic, `topic_1`, and displays the messages it receives on that topic.
3. Publishes 10 messages to the topic, `topic_1`.
4. Displays output similar to the following:

```plaintext
Connecting to a3qEXAMPLEffp-ats.iot.us-west-2.amazonaws.com with client ID 'test-0c8ae2ff-cc87-49d2-a82a-ae7ba1d0ca5a'...
Connected!
Subscribing to topic 'topic_1'...
Subscribed with QoS.AT_LEAST_ONCE
Sending 10 message(s)
  Publishing message to topic 'topic_1': Hello World! [1]
  Received message from topic 'topic_1': b'Hello World! [1]'
  Publishing message to topic 'topic_1': Hello World! [2]
  Received message from topic 'topic_1': b'Hello World! [2]'
  Publishing message to topic 'topic_1': Hello World! [3]
  Received message from topic 'topic_1': b'Hello World! [3]'
  Publishing message to topic 'topic_1': Hello World! [4]
  Received message from topic 'topic_1': b'Hello World! [4]'
  Publishing message to topic 'topic_1': Hello World! [5]
  Received message from topic 'topic_1': b'Hello World! [5]'
  Publishing message to topic 'topic_1': Hello World! [6]
  Received message from topic 'topic_1': b'Hello World! [6]'
  Publishing message to topic 'topic_1': Hello World! [7]
  Received message from topic 'topic_1': b'Hello World! [7]'
  Publishing message to topic 'topic_1': Hello World! [8]
  Received message from topic 'topic_1': b'Hello World! [8]'
  Publishing message to topic 'topic_1': Hello World! [9]
  Received message from topic 'topic_1': b'Hello World! [9]'
  Publishing message to topic 'topic_1': Hello World! [10]
  Received message from topic 'topic_1': b'Hello World! [10]'
10 message(s) received.
Disconnecting...
Disconnected!
```

If you're having trouble running the sample app, review the section called “Troubleshooting problems with the sample app” (p. 66).

You can also add the `--verbosity Debug` parameter to the command line so the sample app displays detailed messages about what it's doing. That information might provide you the help you need to correct the problem.

**JavaScript**

**To install and run the sample app**

1. In your command line window, navigate to the `~/.aws-iot-device-sdk-js-v2/samples/node/pub_sub` directory that the SDK created and install the sample app by using these commands. The command `npm install` will invoke the `aws-crt` library build that can take a few minutes to complete.

   ```bash
cd ~/.aws-iot-device-sdk-js-v2/samples/node/pub_sub
npm install
```

2. In the command line window, replace `your-iot-endpoint` as indicated and run this command.
Configure your device

node dist/index.js --topic topic_1 --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint

3. Observe that the sample app:

1. Connects to the AWS IoT service for your account.
2. Subscribes to the message topic, **topic_1**, and displays the messages it receives on that topic.
3. Publishes 10 messages to the topic, **topic_1**.
4. Displays output similar to the following:

   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":1}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":2}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":3}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":4}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":5}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":6}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":7}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":8}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":9}
   Publish received on topic **topic_1**
   {"message":"Hello world!","sequence":10}

   If you're having trouble running the sample app, review the section called “Troubleshooting problems with the sample app” (p. 66).

   You can also add the --verbosity Debug parameter to the command line so the sample app displays detailed messages about what it's doing. That information might provide you the help you need to correct the problem.

**View messages from the sample app in the AWS IoT console**

You can see the sample app's messages as they pass through the message broker by using the **MQTT test client** in the **AWS IoT console**.

**To view the MQTT messages published by the sample app**

1. Review View MQTT messages with the AWS IoT MQTT client (p. 67). This helps you learn how to use the **MQTT test client** in the **AWS IoT console** to view MQTT messages as they pass through the message broker.
2. Open the **MQTT test client** in the **AWS IoT console**.
3. Subscribe to the topic, **topic_1**.
4. In your command line window, run the sample app again and watch the messages in the **MQTT client** in the **AWS IoT console**.
Configure your device

Python

```bash
cd ~/aws-iot-device-sdk-python-v2/samples
python3 pubsub.py --topic topic_1 --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint
```

JavaScript

```bash
cd ~/aws-iot-device-sdk-js-v2/samples/node/pub_sub
node dist/index.js --topic topic_1 --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint
```

Troubleshooting problems with the sample app

If you encounter an error when you try to run the sample app, here are some things to check.

**Check the certificate**

If the certificate is not active, AWS IoT will not accept any connection attempts that use it for authorization. When creating your certificate, it's easy to overlook the Activate button. Fortunately, you can activate your certificate from the AWS IoT console.

**To check your certificate's activation**

1. In the AWS IoT console, in the left menu, choose Secure, and then choose Certificates.
2. In the list of certificates, find the certificate you created for the exercise and check its status in the Status column.
   
   If you don't remember the certificate's name, check for any that are Inactive to see if they might be the one you're using.
   
   Choose the certificate in the list to open its detail page. In the detail page, you can see its Create date to help you identify the certificate.
3. **To activate an inactive certificate**, from the certificate's detail page, choose Actions and then choose Activate.

If you found the correct certificate and it's active, but you're still having problems running the sample app, check its policy as the next step describes.

You can also try to create a new thing and a new certificate by following the steps in the section called “Create a thing object” (p. 40). If you create a new thing, you will need to give it a new thing name and download the new certificate files to your device.

**Check the policy attached to the certificate**

Policies authorize actions in AWS IoT. If the certificate used to connect to AWS IoT does not have a policy, or does not have a policy that allows it to connect, the connection will be refused, even if the certificate is active.

**To check the policies attached to a certificate**

1. Find the certificate as described in the previous item and open its details page.
2. In the left menu of the certificate's details page, choose Policies to see the policies attached to the certificate.
3. If there are no policies attached to the certificate, add one by choosing the Actions menu, and then choosing Attach policy.

Choose the policy that you created earlier in the section called "Create AWS IoT resources" (p. 38).

4. If there is a policy attached, choose the policy tile to open its details page.

In the details page, review the Policy document to make sure it contains the same information as the one you created in the section called "Create an AWS IoT policy" (p. 39).

Check the command line

Make sure you used the correct command line for your system. The commands used on Linux and macOS systems are often different from those used on Windows systems.

Check the endpoint address

Review the command you entered and double-check the endpoint address in your command to the one in your AWS IoT console.

Check the file names of the certificate files

Compare the file names in the command you entered to the file names of the certificate files in the certs directory.

Some systems might require the file names to be in quotes to work correctly.

Check the SDK installation

Make sure that your SDK installation is complete and correct.

If in doubt, reinstall the SDK on your device. In most cases, that's a matter of finding the section of the tutorial titled Install the AWS IoT Device SDK for SDK language and following the procedure again.

If you are using the AWS IoT Device SDK for JavaScript, remember to install the sample apps before you try to run them. Installing the SDK doesn't automatically install the sample apps. The sample apps must be installed manually after the SDK has been installed.

View MQTT messages with the AWS IoT MQTT client

This section describes how to use the AWS IoT MQTT test client in the AWS IoT console to watch the MQTT messages sent and received by AWS IoT. The example used in this section relates to the examples used in Getting started with AWS IoT Core (p. 17); however, you can replace the topicName used in the examples with any topic name or topic filter (p. 109) used by your IoT solution.

Devices publish MQTT messages that are identified by topics (p. 109) to communicate their state to AWS IoT, and AWS IoT publishes MQTT messages to inform the devices and apps of changes and events. You can use the MQTT client to subscribe to these topics and watch the messages as they occur. You can also use the MQTT test client to publish MQTT messages to subscribed devices and services in your AWS account.

Contents

- Viewing MQTT messages in the MQTT client (p. 68)
To view MQTT messages in the MQTT test client

1. In the AWS IoT console, in the left menu, choose Test and then choose MQTT test client.

2. In the Subscribe to a topic tab, enter the topicName to subscribe to the topic on which your device publishes. For the getting started sample app, subscribe to #, which subscribes to all message topics.

Continuing with the getting started example, on the Subscribe to a topic tab, in the Topic filter field, enter #, and then choose Subscribe.

The topic message log page, # opens and # appears in the Subscriptions list. If the device that you configured in the section called "Configure your device" (p. 41) is running the example program, you should see the messages it sends to AWS IoT in the # message log. The message log entries will appear below the Publish section when messages with the subscribed topic are received by AWS IoT.
3. On the # message log page, you can also publish messages to a topic, but you'll need to specify the topic name. You cannot publish to the # topic.

   Messages published to subscribed topics appear in the message log as they are received, with the most recent message first.

Troubleshooting MQTT messages

Use the wild card topic filter

If your messages are not showing up in the message log as you expect, try subscribing to a wild card topic filter as described in Topic filters (p. 110). The MQTT multi-level wild card topic filter is the hash or pound sign (#) and can be used as the topic filter in the Subscription topic field.

Subscribing to the # topic filter subscribes to every topic received by the message broker. You can narrow the filter down by replacing elements of the topic filter path with a # multi-level wild card character or the '+' single-level wild-card character.

When using wild cards in a topic filter

- The multi-level wild card character must be the last character in the topic filter.
- The topic filter path can have only one single-level wild card character per topic level.

For example:

<table>
<thead>
<tr>
<th>Topic filter</th>
<th>Displays messages with</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>Any topic name</td>
</tr>
<tr>
<td>topic_1/#</td>
<td>A topic name that starts with topic_1/</td>
</tr>
<tr>
<td>topic_1/level_2/#</td>
<td>A topic name that starts with topic_1/level_2/</td>
</tr>
<tr>
<td>topic_1/+/level_3</td>
<td>A topic name that starts with topic_1/, ends with /level_3, and has one element of any value in between.</td>
</tr>
</tbody>
</table>

For more information on topic filters, see Topic filters (p. 110).

Check for topic name errors

MQTT topic names and topic filters are case sensitive. If, for example, your device is publishing messages to Topic_1 (with a capital T) instead of topic_1, the topic to which you subscribed, its messages would not appear in the MQTT test client. Subscribing to the wild card topic filter, however would show that the device is publishing messages and you could see that it was using a topic name that was not the one you expected.

Publishing MQTT messages from the MQTT client

To publish a message to an MQTT topic

1. On the MQTT test client page, in the Publish to a topic tab, in the Topic name field, enter the topicName of your message. In this example, use my/topic.
Note
Do not use personally identifiable information in topic names, whether using them in the MQTT test client or in your system implementation. Topic names can appear in unencrypted communications and reports.

2. In the message payload window, enter the following JSON:

```json
{
    "message": "Hello, world",
    "clientType": "MQTT test client"
}
```

3. Choose Publish to publish your message to AWS IoT.

Note
Make sure you are subscribed to the my/topic topic before publishing your message.

4. In the Subscriptions list, choose my/topic to see the message. You should see the message appear in the MQTT test client below the publish message payload window.

You can publish MQTT messages to other topics by changing the topicName in the Topic name field and choosing the Publish button.
Testing Shared Subscriptions in the MQTT client

This section describes how to use the AWS IoT MQTT client in the AWS IoT console to watch the MQTT messages sent and received by AWS IoT using Shared Subscriptions. Allow multiple clients to share a subscription to a topic with only one client receiving messages published to that topic using a random distribution. To simulate multiple MQTT clients (in this example, two MQTT clients) sharing the same subscription, you open the AWS IoT MQTT client in the AWS IoT console from multiple web browsers. The example used in this section doesn't relate to the examples used in Getting started with AWS IoT Core. For more information, see Shared Subscriptions.

To share a subscription to an MQTT topic

1. In the AWS IoT console, in the navigation pane, choose Test and then choose MQTT test client.
2. In the Subscribe to a topic tab, enter the topicName to subscribe to the topic on which your device publishes. To use Shared Subscriptions, subscribe to a Shared Subscription's topic filter as follows:

   \$share/{ShareName}/{TopicFilter}

   An example topic filter can be \$share/group1/topic1, which subscribes to the message topic topic1.

3. Open another web browser and repeat step 1 and step 2. In this way, you are simulating two different MQTT clients that share the same subscription \$share/group1/topic1.
4. Choose one MQTT client, in the Publish to a topic tab, in the Topic name field, enter the topicName of your message. In this example, use topic1. Try publishing the message a few times. From the Subscriptions list of both MQTT clients, you should be able to see that the clients receive the message using a random distribution. In this example, we publish the same message "Hello from AWS IoT console" three times. The MQTT client on the left received the message twice and the MQTT client on the right received the message once.
Testing Shared Subscriptions in the MQTT client

Subscribe to a topic

Topic filter: $share
The topic filter describes the topic(s) to which you want to subscribe. The topic filter can include MQTT wildcard characters.

$mshare/group/topic1

Subscribe

Additional configuration

Publish a topic

Topic filter: $share
The topic filter describes the topic(s) to which you want to publish. The topic filter can include MQTT wildcard characters.

$mshare/group/topic1

Subscribe

Additional configuration

Subscriptions

$mshare/group/topic1

Message payload

```
{
  "message": "Hello from AWS IoT console"
}
```

Publish

Additional configuration

No messages have been sent to this subscription yet. Please send a message to this subscription to see messages here.

Subscriptions

$mshare/group/topic1

Message payload

```
{
  "message": "Hello from AWS IoT console"
}
```

Publish

Additional configuration

No messages have been sent to this subscription yet. Please send a message to this subscription to see messages here.
Connecting to AWS IoT Core

AWS IoT Core supports connections with IoT devices, wireless gateways, services, and apps. Devices connect to AWS IoT Core so they can send data to and receive data from AWS IoT services and other devices. Apps and other services also connect to AWS IoT Core to control and manage the IoT devices and process the data from your IoT solution. This section describes how to choose the best way to connect and communicate with AWS IoT Core for each aspect of your IoT solution.

There are several ways to interact with AWS IoT. Apps and services can use the AWS IoT Core - control plane endpoints (p. 73) and devices can connect to AWS IoT Core by using the AWS IoT device endpoints (p. 74) or AWS IoT Core for LoRaWAN gateways and devices (p. 75).

AWS IoT Core - control plane endpoints

The AWS IoT Core - control plane endpoints provide access to functions that control and manage your AWS IoT solution.

- **Endpoints**

  The AWS IoT Core - control plane and AWS IoT Core Device Advisor control plane endpoints are Region specific and are listed in AWS IoT Core Endpoints and Quotas. The formats of the endpoints are as follows.

<table>
<thead>
<tr>
<th>Endpoint purpose</th>
<th>Endpoint format</th>
<th>Serves</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS IoT Core - control plane</td>
<td><code>iot.aws-region.amazonaws.com</code></td>
<td>AWS IoT Control Plane API</td>
</tr>
</tbody>
</table>


AWS IoT Core Developer Guide

AWS IoT device endpoints

<table>
<thead>
<tr>
<th>Endpoint purpose</th>
<th>Endpoint format</th>
<th>Serves</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS IoT Core Device Advisor - control plane</td>
<td>api.iotdeviceadvisor.aws-region.amazonaws.com</td>
<td>AWS IoT Core Device Advisor Control Plane API</td>
</tr>
</tbody>
</table>

- **SDKs and tools**

The AWS SDKs provide language-specific support for the AWS IoT Core APIs, and the APIs of other AWS services. The AWS Mobile SDKs provide app developers with platform-specific support for the AWS IoT Core API, and other AWS services on mobile devices.

The AWS CLI provides command-line access to the functions provided by the AWS IoT service endpoints. AWS Tools for PowerShell provides tools to manage AWS services and resources in the PowerShell scripting environment.

- **Authentication**

The service endpoints use IAM users and AWS credentials to authenticate users.

- **Learn more**

For more information and links to SDK references, see the section called “Connecting to AWS IoT Core service endpoints” (p. 75).

AWS IoT device endpoints

The AWS IoT device endpoints support communication between your IoT devices and AWS IoT.

- **Endpoints**

The device endpoints support AWS IoT Core and AWS IoT Device Management functions. They are specific to your AWS account and you can see what they are by using the describe-endpoint command.

<table>
<thead>
<tr>
<th>Endpoint purpose</th>
<th>Endpoint format</th>
<th>Serves</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS IoT Core - data plane</td>
<td>See ??? (p. 82).</td>
<td>AWS IoT Data Plane API</td>
</tr>
<tr>
<td>AWS IoT Device Management - jobs data</td>
<td>See ??? (p. 82).</td>
<td>AWS IoT Jobs Data Plane API</td>
</tr>
<tr>
<td>AWS IoT Device Advisor - data plane</td>
<td>See ??? (p. 1108).</td>
<td>Not applicable</td>
</tr>
<tr>
<td>AWS IoT Device Management - Fleet Hub</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
<tr>
<td>AWS IoT Device Management - secure tunneling</td>
<td>api.tunneling.iot.aws-region.amazonaws.com</td>
<td>AWS IoT Secure Tunneling API</td>
</tr>
</tbody>
</table>

For more information about these endpoints and the functions that they support, see the section called “AWS IoT device data and service endpoints” (p. 82).

- **SDKs**

The AWS IoT Device SDKs (p. 83) provide language-specific support for the Message Queueing Telemetry Transport (MQTT) and WebSocket Secure (WSS) protocols, which devices use to

74
communicate with AWS IoT. AWS Mobile SDKs (p. 80) also provide support for MQTT device communications, AWS IoT APIs, and the APIs of other AWS services on mobile devices.

- **Authentication**

  The device endpoints use X.509 certificates or AWS IAM users with credentials to authenticate users.

- **Learn more**

  For more information and links to SDK references, see the section called “AWS IoT Device SDKs” (p. 83).

## AWS IoT Core for LoRaWAN gateways and devices

AWS IoT Core for LoRaWAN connects wireless gateways and devices to AWS IoT Core.

- **Endpoints**

  AWS IoT Core for LoRaWAN manages the gateway connections to account and Region-specific AWS IoT Core endpoints. Gateways can connect to your account’s Configuration and Update Server (CUPS) endpoint that AWS IoT Core for LoRaWAN provides.

<table>
<thead>
<tr>
<th>Endpoint purpose</th>
<th>Endpoint format</th>
<th>Serves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration and Update Server (CUPS)</td>
<td><code>account-specific-prefix.cups.lorawan.aws-region.amazonaws.com:443</code></td>
<td>Gateway communication with the Configuration and Update Server provided by AWS IoT Core for LoRaWAN</td>
</tr>
<tr>
<td>LoRaWAN Network Server (LNS)</td>
<td><code>account-specific-prefix.gateway.lorawan.aws-region.amazonaws.com:443</code></td>
<td>Gateway communication with the LoRaWAN Network Server provided by AWS IoT Core for LoRaWAN</td>
</tr>
</tbody>
</table>

- **SDKs**

  The AWS IoT Wireless API that AWS IoT Core for LoRaWAN is built on is supported by the AWS SDK. For more information, see AWS SDKs and Toolkits.

- **Authentication**

  AWS IoT Core for LoRaWAN device communications use X.509 certificates to secure communications with AWS IoT.

- **Learn more**

  For more information about configuring and connecting wireless devices, see AWS IoT Core for LoRaWAN (p. 1224).

## Connecting to AWS IoT Core service endpoints

You can access the features of the AWS IoT Core - control plane by using the AWS CLI, the AWS SDK for your preferred language, or by calling the REST API directly. We recommend using the AWS CLI or an AWS SDK to interact with AWS IoT Core because they incorporate the best practices for calling AWS services. Calling the REST APIs directly is an option, but you must provide the necessary security credentials that enable access to the API.
Note
IoT devices should use AWS IoT Device SDKs (p. 83). The Device SDKs are optimized for use on devices, support MQTT communication with AWS IoT, and support the AWS IoT APIs most used by devices. For more information about the Device SDKs and the features they provide, see AWS IoT Device SDKs (p. 83).
Mobile devices should use AWS Mobile SDKs (p. 80). The Mobile SDKs provide support for AWS IoT APIs, MQTT device communications, and the APIs of other AWS services on mobile devices. For more information about the Mobile SDKs and the features they provide, see AWS Mobile SDKs (p. 80).

You can use AWS Amplify tools and resources in web and mobile applications to connect more easily to AWS IoT Core. For more information about connecting to AWS IoT Core by using Amplify, see Pub Sub Getting Started in the Amplify documentation.

The following sections describe the tools and SDKs that you can use to develop and interact with AWS IoT and other AWS services. For the complete list of AWS tools and development kits that are available to build and manage apps on AWS, see Tools to Build on AWS.

AWS CLI for AWS IoT Core

The AWS CLI provides command-line access to AWS APIs.

- **Installation**
  For information about how to install the AWS CLI, see Installing the AWS CLI.
- **Authentication**
  The AWS CLI uses credentials from your AWS account.
- **Reference**
  For information about the AWS CLI commands for these AWS IoT Core services, see:
  - AWS CLI Command Reference for IoT
  - AWS CLI Command Reference for IoT data
  - AWS CLI Command Reference for IoT jobs data
  - AWS CLI Command Reference for IoT secure tunneling

For tools to manage AWS services and resources in the PowerShell scripting environment, see AWS Tools for PowerShell.

AWS SDKs

With AWS SDKs, your apps and compatible devices can call AWS IoT APIs and the APIs of other AWS services. This section provides links to the AWS SDKs and to the API reference documentation for the APIs of the AWS IoT Core services.

The AWS SDKs support these AWS IoT Core APIs

- AWS IoT
- AWS IoT Data Plane
- AWS IoT Jobs Data Plane
- AWS IoT Secure Tunneling
- AWS IoT Wireless
C++

To install the **AWS SDK for C++** and use it to connect to AWS IoT:

1. Follow the instructions in **Getting Started Using the AWS SDK for C++**
   
   These instructions describe how to:
   • Install and build the SDK from source files
   • Provide credentials to use the SDK with your AWS account
   • Initialize and shutdown the SDK in your app or service
   • Create a CMake project to build your app or service

2. Create and run a sample app. For sample apps that use the AWS SDK for C++, see **AWS SDK for C++ + Code Examples**.

**Documentation for the AWS IoT Core services that the AWS SDK for C++ supports**

• [AWS::IoTClient](https://aws.amazon.com/documentation/iot-client/reference/) reference documentation
• [Aws::IoTDataPlane::IoTDataPlaneClient](https://aws.amazon.com/documentation/iot-data-plane/reference/) reference documentation
• [Aws::IoTJobsDataPlane::IoTJobsDataPlaneClient](https://aws.amazon.com/documentation/iot-jobs-data-plane/reference/) reference documentation
• [Aws::IoTSecureTunneling::IoTSecureTunnelingClient](https://aws.amazon.com/documentation/iot-secure-tunneling/reference/) reference documentation

Go

To install the **AWS SDK for Go** and use it to connect to AWS IoT:

1. Follow the instructions in **Getting Started with the AWS SDK for Go**

   These instructions describe how to:
   • Install the AWS SDK for Go
   • Get access keys for the SDK to access your AWS account
   • Import packages into the source code of our apps or services

2. Create and run a sample app. For sample apps that use the AWS SDK for Go, see **AWS SDK for Go Code Examples**.

**Documentation for the AWS IoT Core services that the AWS SDK for Go supports**

• [IoT](https://aws.amazon.com/documentation/iot/reference/) reference documentation
• [IoTDataPlane](https://aws.amazon.com/documentation/iot-data-plane/reference/) reference documentation
• [IoTJobsDataPlane](https://aws.amazon.com/documentation/iot-jobs-data-plane/reference/) reference documentation
• [IoTSecureTunneling](https://aws.amazon.com/documentation/iot-secure-tunneling/reference/) reference documentation

Java

To install the **AWS SDK for Java** and use it to connect to AWS IoT:

1. Follow the instructions in **Getting Started with AWS SDK for Java 2.x**

   These instructions describe how to:
   • Sign up for AWS and Create an IAM User
   • Download the SDK
   • Set up AWS Credentials and Region
A WS IoT Core Developer Guide
AWS SDKs

- Use the SDK with Apache Maven
- Use the SDK with Gradle

2. Create and run a sample app using one of the AWS SDK for Java 2.x Code Examples.

3. Review the SDK API reference documentation

Documentation for the AWS IoT Core services that the AWS SDK for Java supports

- IotClient reference documentation
- IotDataPlaneClient reference documentation
- IotJobsDataPlaneClient reference documentation
- IoTSecureTunnelingClient reference documentation

JavaScript

To install the AWS SDK for JavaScript and use it to connect to AWS IoT:

1. Follow the instructions in Setting Up the AWS SDK for JavaScript. These instructions apply to using the AWS SDK for JavaScript in the browser and with Node.JS. Make sure you follow the directions that apply to your installation.

   These instructions describe how to:
   - Check for the prerequisites
   - Install the SDK for JavaScript
   - Load the SDK for JavaScript

2. Create and run a sample app to get started with the SDK as the getting started option for your environment describes.
   - Get started with the AWS SDK for JavaScript in the Browser, or
   - Get started with the AWS SDK for JavaScript in Node.js

Documentation for the AWS IoT Core services that the AWS SDK for JavaScript supports

- AWS.Iot reference documentation
- AWS.IotData reference documentation
- AWS.IotJobsDataPlane reference documentation
- AWS.IotSecureTunneling reference documentation

.NET

To install the AWS SDK for .NET and use it to connect to AWS IoT:

1. Follow the instructions in Setting up your AWS SDK for .NET environment

2. Follow the instructions in Setting up your AWS SDK for .NET project

   These instructions describe how to:
   - Start a new project
   - Obtain and configure AWS credentials
   - Install AWS SDK packages

3. Create and run one of the sample programs in Working with AWS services in the AWS SDK for .NET

4. Review the SDK API reference documentation
Documentation for the AWS IoT Core services that the AWS SDK for .NET supports

- Amazon.IoT.Model reference documentation
- Amazon.iotData.Model reference documentation
- Amazon.IoTJobsDataPlane.Model reference documentation
- Amazon.IoTSecureTunneling.Model reference documentation

PHP

To install the AWS SDK for PHP and use it to connect to AWS IoT:

1. Follow the instructions in Getting Started with the AWS SDK for PHP Version 3

These instructions describe how to:

- Check for the prerequisites
- Install the SDK
- Apply the SDK to a PHP script

2. Create and run a sample app using one of the AWS SDK for PHP Version 3 Code Examples

Documentation for the AWS IoT Core services that the AWS SDK for PHP supports

- IoTClient reference documentation
- IoTDataPlaneClient reference documentation
- IoTJobsDataPlaneClient reference documentation
- IoTSecureTunnelingClient reference documentation

Python

To install the AWS SDK for Python (Boto3) and use it to connect to AWS IoT:

1. Follow the instructions in the AWS SDK for Python (Boto3) Quickstart

These instructions describe how to:

- Install the SDK
- Configure the SDK
- Use the SDK in your code

2. Create and run a sample program that uses the AWS SDK for Python (Boto3)

This program displays the account's currently configured logging options. After you install the SDK and configure it for your account, you should be able to run this program.

```python
import boto3
import json

# initialize client
iot = boto3.client('iot')

# get current logging levels, format them as JSON, and write them to stdout
response = iot.get_v2_logging_options()
print(json.dumps(response, indent=4))
```

For more information about the function used in this example, see the section called “Configure AWS IoT logging” (p. 439).
Documentation for the AWS IoT Core services that the AWS SDK for Python (Boto3) supports

- IoT reference documentation
- IoTDataPlane reference documentation
- IoTJobsDataPlane reference documentation
- IoTSecureTunneling reference documentation

Ruby

To install the AWS SDK for Ruby and use it to connect to AWS IoT:

- Follow the instructions in Getting Started with the AWS SDK for Ruby
  
  These instructions describe how to:
  - Install the SDK
  - Configure the SDK
  - Create and run the Hello World Tutorial

AWS Mobile SDKs

The AWS Mobile SDKs provide mobile app developers platform-specific support for the APIs of the AWS IoT Core services, IoT device communication using MQTT, and the APIs of other AWS services.

Android

AWS Mobile SDK for Android

The AWS Mobile SDK for Android contains a library, samples, and documentation for developers to build connected mobile applications using AWS. This SDK also includes support for MQTT device communications and calling the APIs of the AWS IoT Core services. For more information, see the following:

- AWS Mobile SDK for Android on GitHub
- AWS Mobile SDK for Android Readme
- AWS Mobile SDK for Android Samples
- AWS SDK for Android API reference
- AWSIoTClient Class reference documentation

iOS

AWS Mobile SDK for iOS

The AWS Mobile SDK for iOS is an open-source software development kit, distributed under an Apache Open Source license. The SDK for iOS provides a library, code samples, and documentation
to help developers build connected mobile applications using AWS. This SDK also includes support for MQTT device communications and calling the APIs of the AWS IoT Core services. For more information, see the following:

- AWS Mobile SDK for iOS on GitHub
- AWS SDK for iOS Readme
- AWS SDK for iOS Samples
- AWS IoT Class reference docs in the AWS SDK for iOS

**REST APIs of the AWS IoT Core services**

The REST APIs of the AWS IoT Core services can be called directly by using HTTP requests.

- **Endpoint URL**

  The service endpoints that expose the REST APIs of the AWS IoT Core services vary by Region and are listed in [AWS IoT Core Endpoints and Quotas](https://docs.aws.amazon.com/iot/core/latest/developerguide/endpoints.html). You must use the endpoint for the Region that has the AWS IoT resources that you want to access, because AWS IoT resources are Region specific.

- **Authentication**

  The REST APIs of the AWS IoT Core services use AWS IAM credentials for authentication. For more information, see [Signing AWS API requests](https://docs.aws.amazon.com/general/latest/gr腼ee.html) in the AWS General Reference.

- **API reference**

  For information about the specific functions provided by the REST APIs of the AWS IoT Core services, see:
  - API reference for IoT.
  - API reference for IoT data.
  - API reference for IoT jobs data.
  - API reference for IoT secure tunneling.

**Connecting devices to AWS IoT**

Devices connect to AWS IoT and other services through AWS IoT Core. Through AWS IoT Core, devices send and receive messages using device endpoints that are specific to your account. The [section called “AWS IoT Device SDKs”](https://docs.aws.amazon.com/iot/latest/developerguide/device-sdk-devices.html) support device communications using the MQTT and WSS protocols. For more information about the protocols that devices can use, see the [section called “Device communication protocols”](https://docs.aws.amazon.com/iot/latest/developerguide/device-sdk-protocols.html).

The message broker

AWS IoT manages device communication through a message broker. Devices and clients publish messages to the message broker and also subscribe to messages that the message broker publishes. Messages are identified by an application-defined [topic](https://docs.aws.amazon.com/iot/latest/developerguide/topic-topics.html). When the message broker receives a message published by a device or client, it republishes that message to the devices and clients that have subscribed to the message's topic. The message broker also forwards messages to the AWS IoT [rules](https://docs.aws.amazon.com/iot/latest/developerguide/rules.html) engine, which can act on the content of the message.

AWS IoT message security

Device connections to AWS IoT use the [section called “X.509 client certificates”](https://docs.aws.amazon.com/iot/latest/developerguide/x509-client-certificates.html) and [AWS signature V4](https://docs.aws.amazon.com/iot/latest/developerguide/sign-v4.html) for authentication. Device communications are secured by TLS version 1.2 and AWS IoT...
AWS IoT device data and service endpoints

**Important**
You can cache or store the endpoints in your device. This means you won't need to query the DescribeEndpoint API every time when a new device is connected. The endpoints won't change after AWS IoT Core creates them for your account.

Each account has several device endpoints that are unique to the account and support specific IoT functions. The AWS IoT device data endpoints support a publish/subscribe protocol that is designed for the communication needs of IoT devices; however, other clients, such as apps and services, can also use this interface if their application requires the specialized features that these endpoints provide. The AWS IoT device service endpoints support device-centric access to security and management services.

To learn your account's device data endpoint, you can find it in the Settings page of your AWS IoT Core console.

To learn your account's device endpoint for a specific purpose, including the device data endpoint, use the describe-endpoint CLI command shown here, or the DescribeEndpoint REST API, and provide the endpointType parameter value from the following table.

```
aws iot describe-endpoint --endpoint-type endpointType
```

This command returns an iot-endpoint in the following format: account-specific-prefix.iot.aws-region.amazonaws.com.

Every customer has an iot:Data-ATS and an iot:Data endpoint. Each endpoint uses an X.509 certificate to authenticate the client. We strongly recommend that customers use the newer iot:Data-ATS endpoint type to avoid issues related to the widespread distrust of Symantec certificate authorities. We provide the iot:Data endpoint for devices to retrieve data from old endpoints that use VeriSign certificates for backward compatibility. For more information, see Server Authentication.

**AWS IoT endpoints for devices**

<table>
<thead>
<tr>
<th>Endpoint purpose</th>
<th>endpointType value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWS IoT Core - data plane operations</td>
<td>iot:Data-ATS</td>
<td>Used to send and receive data to and from the message broker, Device Shadow, Device Shadow (p. 657), and Rules Engine (p. 494) components of AWS IoT. iot:Data-ATS returns an ATS signed data endpoint.</td>
</tr>
<tr>
<td>AWS IoT Core - data plane operations (legacy)</td>
<td>iot:Data</td>
<td>iot:Data returns a VeriSign signed data endpoint provided for backward compatibility. MQTT 5 is not supported on Symantec (iot:Data) endpoints.</td>
</tr>
<tr>
<td>AWS IoT Core credential access</td>
<td>iot:CredentialProvider</td>
<td>Used to exchange a device's built-in X.509 certificate for temporary credentials to connect directly with other AWS services.</td>
</tr>
</tbody>
</table>
You can also use your own fully-qualified domain name (FQDN), such as example.com, and the associated server certificate to connect devices to AWS IoT by using the section called “Configurable endpoints” (p. 123).

**AWS IoT Device SDKs**

The AWS IoT Device SDKs help you connect your IoT devices to AWS IoT Core and they support MQTT and MQTT over WSS protocols.

The AWS IoT Device SDKs differ from the AWS SDKs in that the AWS IoT Device SDKs support the specialized communications needs of IoT devices, but don't support all of the services supported by the AWS SDKs. The AWS IoT Device SDKs are compatible with the AWS SDKs that support all of the AWS services; however, they use different authentication methods and connect to different endpoints, which could make using the AWS SDKs impractical on an IoT device.

**Mobile devices**

The the section called “AWS Mobile SDKs” (p. 80) support both MQTT device communications, some of the AWS IoT service APIs, and the APIs of other AWS services. If you're developing on a supported mobile device, review its SDK to see if it's the best option for developing your IoT solution.

**C++**

**AWS IoT C++ Device SDK**

The AWS IoT C++ Device SDK allows developers to build connected applications using AWS and the APIs of the AWS IoT Core services. Specifically, this SDK was designed for devices that are not resource constrained and require advanced features such as message queuing, multi-threading support, and the latest language features. For more information, see the following:

- [AWS IoT Device SDK C++ v2 on GitHub](#)
- [AWS IoT Device SDK C++ v2 Readme](#)
- [AWS IoT Device SDK C++ v2 Samples](#)
- [AWS IoT Device SDK C++ v2 API documentation](#)
Python

**AWS IoT Device SDK for Python**

The AWS IoT Device SDK for Python makes it possible for developers to write Python scripts to use their devices to access the AWS IoT platform through MQTT or MQTT over the WebSocket Secure (WSS) protocol. By connecting their devices to the APIs of the AWS IoT Core services, users can securely work with the message broker, rules, and Device Shadow service that AWS IoT Core provides and with other AWS services like AWS Lambda, Amazon Kinesis, and Amazon S3, and more.

- [AWS IoT Device SDK for Python v2 on GitHub](#)
- [AWS IoT Device SDK for Python v2 Readme](#)
- [AWS IoT Device SDK for Python v2 Samples](#)
- [AWS IoT Device SDK for Python v2 API documentation](#)

JavaScript

**AWS IoT Device SDK for JavaScript**

The AWS IoT Device SDK for JavaScript makes it possible for developers to write JavaScript applications that access APIs of the AWS IoT Core using MQTT or MQTT over the WebSocket protocol. It can be used in Node.js environments and browser applications. For more information, see the following:

- [AWS IoT Device SDK for JavaScript v2 on GitHub](#)
- [AWS IoT Device SDK for JavaScript v2 Readme](#)
- [AWS IoT Device SDK for JavaScript v2 Samples](#)
- [AWS IoT Device SDK for JavaScript v2 API documentation](#)

Java

**AWS IoT Device SDK for Java**

The AWS IoT Device SDK for Java makes it possible for Java developers to access the APIs of the AWS IoT Core through MQTT or MQTT over the WebSocket protocol. The SDK supports the Device Shadow service. You can access shadows by using HTTP methods, including GET, UPDATE, and DELETE. The SDK also supports a simplified shadow access model, which allows developers to exchange data with shadows by using getter and setter methods, without having to serialize or deserialize any JSON documents. For more information, see the following:

- [AWS IoT Device SDK for Java v2 on GitHub](#)
- [AWS IoT Device SDK for Java v2 Readme](#)
- [AWS IoT Device SDK for Java v2 Samples](#)
- [AWS IoT Device SDK for Java v2 API documentation](#)

Embedded C

**AWS IoT Device SDK for Embedded C**

**Important**

This SDK is intended for use by experienced embedded-software developers.

The AWS IoT Device SDK for Embedded C (C-SDK) is a collection of C source files under the MIT open source license that can be used in embedded applications to securely connect IoT devices to
AWS IoT Core. It includes MQTT, JSON Parser, and AWS IoT Device Shadow libraries and others. It is distributed in source form and intended to be built into customer firmware along with application code, other libraries and, optionally, an RTOS (Real Time Operating System).

The AWS IoT Device SDK for Embedded C is generally targeted at resource constrained devices that require an optimized C language runtime. You can use the SDK on any operating system and host it on any processor type (for example, MCUs and MPUs). If your device has sufficient memory and processing resources available, we recommend that you use one of the other AWS IoT Device and Mobile SDKs, such as the AWS IoT Device SDK for C++, Java, JavaScript, or Python.

For more information, see the following:
- AWS IoT Device SDK for Embedded C on GitHub
- AWS IoT Device SDK for Embedded C Readme
- AWS IoT Device SDK for Embedded C Samples

Device communication protocols

AWS IoT Core supports devices and clients that use the MQTT and the MQTT over WebSocket Secure (WSS) protocols to publish and subscribe to messages, and devices and clients that use the HTTPS protocol to publish messages. All protocols support IPv4 and IPv6. This section describes the different connection options for devices and clients.

TLS 1.2 and TLS 1.3

AWS IoT Core uses TLS version 1.2 and TLS version 1.3 to encrypt all communication. When connecting devices to AWS IoT Core, clients can send the Server Name Indication (SNI) extension, which is not required but highly recommended. To use features such as multi-account registration, custom domains, and VPC endpoints, you must use the SNI extension. For more information, see Transport Security in AWS IoT.

The AWS IoT Device SDKs (p. 83) support MQTT and MQTT over WSS and support the security requirements of client connections. We recommend using the AWS IoT Device SDKs (p. 83) to connect clients to AWS IoT.

Protocols, port mappings, and authentication

How a device or client connects to the message broker by using a device endpoint depends on the protocol it uses. The following table lists the protocols that the AWS IoT device endpoints support and the authentication methods and ports they use.

### Protocols, authentication, and port mappings

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Operations supported</th>
<th>Authentication</th>
<th>Port</th>
<th>ALPN protocol name</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQTT over WebSocket</td>
<td>Publish, Subscribe</td>
<td>Signature Version 4</td>
<td>443</td>
<td>N/A</td>
</tr>
<tr>
<td>MQTT over WebSocket</td>
<td>Publish, Subscribe</td>
<td>Custom authentication</td>
<td>443</td>
<td>N/A</td>
</tr>
<tr>
<td>MQTT</td>
<td>Publish, Subscribe</td>
<td>X.509 client certificate</td>
<td>443(^\d)</td>
<td>x-amzn-mqtt-ca</td>
</tr>
<tr>
<td>MQTT</td>
<td>Publish, Subscribe</td>
<td>X.509 client certificate</td>
<td>8883</td>
<td>N/A</td>
</tr>
<tr>
<td>Protocol</td>
<td>Operations supported</td>
<td>Authentication</td>
<td>Port</td>
<td>ALPN protocol name</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------</td>
<td>---------------------------------</td>
<td>------</td>
<td>-------------------</td>
</tr>
<tr>
<td>MQTT</td>
<td>Publish, Subscribe</td>
<td>Custom authentication</td>
<td>443†</td>
<td>mqtt</td>
</tr>
<tr>
<td>HTTPS</td>
<td>Publish only</td>
<td>Signature Version 4</td>
<td>443</td>
<td>N/A</td>
</tr>
<tr>
<td>HTTPS</td>
<td>Publish only</td>
<td>X.509 client certificate</td>
<td>443†</td>
<td>x-amzn-http-ca</td>
</tr>
<tr>
<td>HTTPS</td>
<td>Publish only</td>
<td>X.509 client certificate</td>
<td>8443</td>
<td>N/A</td>
</tr>
<tr>
<td>HTTPS</td>
<td>Publish only</td>
<td>Custom authentication</td>
<td>443</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Application Layer Protocol Negotiation (ALPN)**

†Clients that connect on port 443 with X.509 client certificate authentication must implement the Application Layer Protocol Negotiation (ALPN) TLS extension and use the ALPN protocol name listed in the ALPN ProtocolNameList sent by the client as part of the ClientHello message.

On port 443, the IoT:Data-ATS (p. 82) endpoint supports ALPN x-amzn-http-ca HTTP, but the IoT:Jobs (p. 82) endpoint does not.

On port 8443 HTTPS and port 443 MQTT with ALPN x-amzn-mqtt-ca, custom authentication (p. 322) can't be used.

Clients connect to their AWS account's device endpoints. See the section called "AWS IoT device data and service endpoints" (p. 82) for information about how to find your account's device endpoints.

**Note**

AWS SDKs don't require the entire URL. They only require the endpoint hostname such as the pubsub.py sample for AWS IoT Device SDK for Python on GitHub. Passing the entire URL as provided in the following table can generate an error such as invalid hostname.

**Connecting to AWS IoT Core**

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Endpoint or URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQTT</td>
<td>iot-endpoint</td>
</tr>
<tr>
<td>MQTT over WSS</td>
<td>wss://iot-endpoint/mqtt</td>
</tr>
<tr>
<td>HTTPS</td>
<td><a href="https://iot-endpoint/topics">https://iot-endpoint/topics</a></td>
</tr>
</tbody>
</table>

**Choosing a protocol for your device communication**

For most IoT device communication through the device endpoints, you'll want to use the MQTT or MQTT over WSS protocols; however, the device endpoints also support HTTPS. The following table compares how AWS IoT Core uses the two protocols for device communication.

**AWS IoT device protocols side-by-side**

<table>
<thead>
<tr>
<th>Feature</th>
<th>MQTT (p. 88)</th>
<th>HTTPS (p. 106)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publish/Subscribe support</td>
<td>Publish and subscribe</td>
<td>Publish only</td>
</tr>
</tbody>
</table>
### Device communication protocols

#### Feature

<table>
<thead>
<tr>
<th>Feature</th>
<th>MQTT (p. 88)</th>
<th>HTTPS (p. 106)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDK support</td>
<td>AWS Device SDKs (p. 83) support MQTT and WSS protocols</td>
<td>No SDK support, but you can use language-specific methods to make HTTPS requests</td>
</tr>
<tr>
<td>Quality of Service support</td>
<td>MQTT QoS levels 0 and 1 (p. 89)</td>
<td>QoS is supported by passing a query string parameter ?qos=qos where the value can be 0 or 1. You can add this query string to publish a message with the QoS value you want.</td>
</tr>
<tr>
<td>Can receive messages be missed while device was offline</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>clientId field support</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Device disconnection detection</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Secure communications</td>
<td>Yes. See Protocols, port mappings, and authentication (p. 85)</td>
<td>Yes. See Protocols, port mappings, and authentication (p. 85)</td>
</tr>
<tr>
<td>Topic definitions</td>
<td>Application defined</td>
<td>Application defined</td>
</tr>
<tr>
<td>Message data format</td>
<td>Application defined</td>
<td>Application defined</td>
</tr>
<tr>
<td>Protocol overhead</td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Power consumption</td>
<td>Lower</td>
<td>Higher</td>
</tr>
</tbody>
</table>

#### Connection duration limits

HTTPS connections aren’t guaranteed to last any longer than the time it takes to receive and respond to requests.

MQTT connection duration depends on the authentication feature that you use. The following table lists the maximum connection duration under ideal conditions for each feature.

#### MQTT connection duration by authentication feature

<table>
<thead>
<tr>
<th>Feature</th>
<th>Maximum duration *</th>
</tr>
</thead>
<tbody>
<tr>
<td>X.509 client certificate</td>
<td>1–2 weeks</td>
</tr>
<tr>
<td>Custom authentication</td>
<td>1–2 weeks</td>
</tr>
<tr>
<td>Signature Version 4</td>
<td>Up to 24 hours</td>
</tr>
</tbody>
</table>

| * Not guaranteed |

With X.509 certificates and custom authentication, connection duration has no hard limit, but it can be as short as a few minutes. Connection interruptions can occur for various reasons. The following list contains some of the most common reasons.

- Wi-Fi availability interruptions
- Internet service provider (ISP) connection interruptions
Your devices must implement strategies for detecting disconnections and reconnecting. For information about disconnect events and guidance on how to handle them, see ?? (p. 1219) in ?? (p. 1219).

MQTT

MQTT (Message Queuing Telemetry Transport) is a lightweight and widely adopted messaging protocol that is designed for constrained devices. AWS IoT Core support for MQTT is based on the MQTT v3.1.1 specification and the MQTT v5.0 specification, with some differences, as documented in the section called “AWS IoT differences from MQTT specifications” (p. 105). As the latest version of the standard, MQTT 5 introduces several key features that make an MQTT-based system more robust, including new scalability enhancements, improved error reporting with reason code responses, message and session expiry timers, and custom user message headers. For more information about MQTT 5 features that AWS IoT Core supports, see MQTT 5 supported features (p. 98). AWS IoT Core also supports cross MQTT version (MQTT 3 and MQTT 5) communication. An MQTT 3 publisher can send an MQTT 3 message to an MQTT 5 subscriber that will be receiving an MQTT 5 publish message, and vice versa.

AWS IoT Core supports device connections that use the MQTT protocol and MQTT over WSS protocol and that are identified by a client ID. The AWS IoT Device SDKs (p. 83) support both protocols and are the recommended ways to connect devices to AWS IoT Core. The AWS IoT Device SDKs support the functions necessary for devices and clients to connect to and access AWS IoT services. The Device SDKs support the authentication protocols that the AWS IoT services require and the connection ID requirements that the MQTT protocol and MQTT over WSS protocols require. For information about how to connect to AWS IoT using the AWS Device SDKs and links to examples of AWS IoT in the supported languages, see the section called “Connecting with MQTT using the AWS IoT Device SDKs” (p. 89). For more information about authentication methods and the port mappings for MQTT messages, see Protocols, port mappings, and authentication (p. 85).

While we recommend using the AWS IoT Device SDKs to connect to AWS IoT, they are not required. If you do not use the AWS IoT Device SDKs, however, you must provide the necessary connection and communication security. Clients must send the Server Name Indication (SNI) TLS extension in the connection request. Connection attempts that don’t include the SNI are refused. For more information, see Transport Security in AWS IoT. Clients that use IAM users and AWS credentials to authenticate clients must provide the correct Signature Version 4 authentication.

In this topic:

- Connecting with MQTT using the AWS IoT Device SDKs (p. 89)
- MQTT Quality of Service (QoS) options (p. 89)
- MQTT persistent sessions (p. 90)
- MQTT retained messages (p. 92)
- MQTT Last Will and Testament (LWT) messages (p. 97)
- Using connectAttributes (p. 97)
- MQTT 5 supported features (p. 98)
- MQTT 5 properties (p. 101)
- MQTT reason codes (p. 103)
- AWS IoT differences from MQTT specifications (p. 105)
Connecting with MQTT using the AWS IoT Device SDKs

This section contains links to the AWS IoT Device SDKs and to the source code of sample programs that illustrate how to connect a device to AWS IoT. The sample apps linked here show how to connect to AWS IoT using the MQTT protocol and MQTT over WSS.

Note
The AWS IoT Device SDKs have released an MQTT 5 client in developer preview. During the preview period, we might make backward incompatible changes to the public APIs, and the service clients in the AWS IoT Device SDKs continue to use the MQTT 3.1.1 client.

C++

Using the AWS IoT C++ Device SDK to connect devices

- Source code of a sample app that shows an MQTT connection example in C++
- AWS IoT C++ Device SDK v2 on GitHub

Python

Using the AWS IoT Device SDK for Python to connect devices

- Source code of a sample app that shows an MQTT connection example in Python
- AWS IoT Device SDK for Python v2 on GitHub

JavaScript

Using the AWS IoT Device SDK for JavaScript to connect devices

- Source code of a sample app that shows an MQTT connection example in JavaScript
- AWS IoT Device SDK for JavaScript v2 on GitHub

Java

Using the AWS IoT Device SDK for Java to connect devices

- Source code of a sample app that shows an MQTT connection example in Java
- AWS IoT Device SDK for Java v2 on GitHub

Embedded C

Using the AWS IoT Device SDK for Embedded C to connect devices

Important
This SDK is intended for use by experienced embedded-software developers.

- Source code of a sample app that shows an MQTT connection example in Embedded C
- AWS IoT Device SDK for Embedded C on GitHub

MQTT Quality of Service (QoS) options

AWS IoT and the AWS IoT Device SDKs support the MQTT Quality of Service (QoS) levels 0 and 1. The MQTT protocol defines a third level of QoS, level 2, but AWS IoT does not support it. Only the MQTT protocol supports the QoS feature. HTTPS supports QoS by passing a query string parameter ?qos=qos where the value can be 0 or 1.
This table describes how each QoS level affects messages published to and by the message broker.

<table>
<thead>
<tr>
<th>With a QoS level of...</th>
<th>The message is...</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>QoS level 0</td>
<td>Sent zero or more times</td>
<td>This level should be used for messages that are sent over reliable communication links or that can be missed without a problem.</td>
</tr>
<tr>
<td>QoS level 1</td>
<td>Sent at least one time, and then repeatedly until a PUBACK response is received</td>
<td>The message is not considered complete until the sender receives a PUBACK response to indicate successful delivery.</td>
</tr>
</tbody>
</table>

**MQTT persistent sessions**

Persistent sessions store a client's subscriptions and messages, with a Quality of Service (QoS) of 1, that haven't been acknowledged by the client. When the device reconnects to a persistent session, the session resumes, subscriptions are reinstated, and unacknowledged subscribed messages received and stored prior to the reconnection are sent to the client.

The processing of the stored messages is recorded in CloudWatch and CloudWatch Logs. For information about the entries written to CloudWatch and CloudWatch Logs, see [Message broker metrics](#) and [Queued log entry](#).

**Creating a persistent session**

In MQTT 3, you create an MQTT persistent session by sending a CONNECT message and setting the cleanSession flag to 0. If no session exists for the client sending the CONNECT message, a new persistent session is created. If a session already exists for the client, the client resumes the existing session. To create a clean session, you send a CONNECT message and set the cleanSession flag to 1, and the broker will not store any session state when the client disconnects.

In MQTT 5, you handle persistent sessions by setting the Clean Start flag and Session Expiry Interval. Clean Start controls the beginning of the connecting session and the end of the previous session. When you set Clean Start = 1, a new session is created and a previous session is terminated if it exists. When you set Clean Start = 0, the connecting session resumes a previous session if it exists. Session Expiry Interval controls the end of the connecting session. Session Expiry Interval specifies the time, in seconds (4-byte integer), that a session will persist after disconnect. Setting Session Expiry interval = 0 causes the session to terminate immediately upon disconnect. If the Session Expiry Interval is not specified in the CONNECT message, the default is 0.

**MQTT 5 Clean Start and Session Expiry**

<table>
<thead>
<tr>
<th>Property value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Start=1</td>
<td>Creates a new session and terminates a previous session if one exists.</td>
</tr>
<tr>
<td>Clean Start=0</td>
<td>Resumes a session if a previous session exists.</td>
</tr>
<tr>
<td>Session Expiry Interval&gt;0</td>
<td>Persists a session.</td>
</tr>
<tr>
<td>Session Expiry interval=0</td>
<td>Does not persist a session.</td>
</tr>
</tbody>
</table>
In MQTT 5, if you set `Clean Start = 1` and `Session Expiry Interval = 0`, this is the equivalent of an MQTT 3 clean session. If you set `Clean Start = 0` and `Session Expiry Interval > 0`, this is the equivalent of an MQTT 5 persistent session.

**Note**

Cross MQTT version (MQTT 3 and MQTT 5) persistent sessions are not supported. An MQTT 3 persistent session can't be resumed as an MQTT 5 session, and vice versa.

**Operations during a persistent session**

Clients use the `sessionPresent` attribute in the connection acknowledged (CONNACK) message to determine if a persistent session is present. If `sessionPresent` is 1, a persistent session is present and any stored messages for the client are delivered to the client after the client receives the CONNACK, as described in *Message traffic after reconnection to a persistent session* (p. 91). If `sessionPresent` is 1, the client does not need to resubscribe. However, if `sessionPresent` is 0, no persistent session is present and the client must resubscribe to its topic filters.

After the client joins a persistent session, it can publish messages and subscribe to topic filters without any additional flags on each operation.

**Message traffic after reconnection to a persistent session**

A persistent session represents an ongoing connection between a client and an MQTT message broker. When a client connects to the message broker using a persistent session, the message broker saves all subscriptions that the client makes during the connection. When the client disconnects, the message broker stores unacknowledged QoS 1 messages and new QoS 1 messages published to topics to which the client is subscribed. Messages are stored according to account limit. Messages that exceed the limit will be dropped. For more information about persistent message limits, see *AWS IoT Core endpoints and quotas*. When the client reconnects to its persistent session, all subscriptions are reinstated and all stored messages are sent to the client at a maximum rate of 10 messages per second. In MQTT 5, if an outbound QoS1 with the Message Expiry Interval expires when a client is offline, after the connection resumes, the client won't receive the expired message.

After reconnection, the stored messages are sent to the client, at a rate that is limited to 10 stored messages per second, along with any current message traffic until the Publish requests per second per connection limit is reached. Because the delivery rate of the stored messages is limited, it will take several seconds to deliver all stored messages if a session has more than 10 stored messages to deliver after reconnection.

**Ending a persistent session**

Persistent sessions can end in the following ways:

- The persistent session expiration time elapses. The persistent session expiration timer starts when the message broker detects that a client has disconnected, either by the client disconnecting or the connection timing out.
- The client sends a CONNECT message that sets the `cleanSession` flag to 1.

In MQTT 3, the default value of persistent sessions expiration time is an hour, and this applies to all the sessions in the account.

In MQTT 5, you can set the Session Expiry Interval for each session on CONNECT and DISCONNECT packets.

**For Session Expiry Interval on DISCONNECT packet:**

- If the current session has a Session Expiry Interval of 0, you can't set Session Expiry Interval to greater than 0 on the DISCONNECT packet.
• If the current session has a Session Expiry Interval of greater than 0, and you set the Session Expiry Interval to 0 on the DISCONNECT packet, the session will be ended on DISCONNECT.
• Otherwise, the Session Expiry Interval on DISCONNECT packet will update the Session Expiry Interval of the current session.

**Note**
The stored messages waiting to be sent to the client when a session ends are discarded; however, they are still billed at the standard messaging rate, even though they could not be sent. For more information about message pricing, see [AWS IoT Core Pricing](#). You can configure the expiration time interval.

**Reconnection after a persistent session has expired**
If a client doesn't reconnect to its persistent session before it expires, the session ends and its stored messages are discarded. When a client reconnects after the session has expired with a `cleanSession` flag to 0, the service creates a new persistent session. Any subscriptions or messages from the previous session are not available to this session because they were discarded when the previous session expired.

**Persistent session message charges**
Messages are charged to your AWS account when the message broker sends a message to a client or an offline persistent session. When an offline device with a persistent session reconnects and resumes its session, the stored messages are delivered to the device and charged to your account again. For more information about message pricing, see [AWS IoT Core pricing - Messaging](#).

The default persistent session expiration time of one hour can be increased by using the standard limit increase process. Note that increasing the session expiration time might increase your message charges because the additional time could allow for more messages to be stored for the offline device and those additional messages would be charged to your account at the standard messaging rate. The session expiration time is approximate and a session could persist for up to 30 minutes longer than the account limit; however, a session will not be shorter than the account limit. For more information about session limits, see [AWS Service Quotas](#).

**MQTT retained messages**
AWS IoT Core supports the RETAIN flag described in the MQTT protocol. When a client sets the RETAIN flag on an MQTT message that it publishes, AWS IoT Core saves the message. It can then be sent to new subscribers, retrieved by calling the `GetRetainedMessage` operation, and viewed in the AWS IoT console.

**Examples of using MQTT retained messages**
• **As an initial configuration message**
  MQTT retained messages are sent to a client after the client subscribes to a topic. If you want all clients that subscribe to a topic to receive the MQTT retained message immediately after their subscription, you can publish a configuration message with the RETAIN flag set. Subscribing clients also receive updates to that configuration whenever a new configuration message is published.

• **As a last-known state message**
  Devices can set the RETAIN flag on current-state messages so that AWS IoT Core will save them. When applications connect or reconnect, they can subscribe to this topic and get the last reported state immediately after subscribing to the retained message topic. This way they can avoid having to wait until the next message from the device to see the current state.
Common tasks with MQTT retained messages in AWS IoT Core

AWS IoT Core saves MQTT messages with the RETAIN flag set. These retained messages are sent to all clients that have subscribed to the topic, as a normal MQTT message, and they are also stored to be sent to new subscribers to the topic.

MQTT retained messages require specific policy actions to authorize clients to access them. For examples of using retained message policies, see Retained message policy examples.

This section describes common operations that involve retained messages.

- Creating a retained message

  The client determines whether a message is retained when it publishes an MQTT message. Clients can set the RETAIN flag when they publish a message by using a Device SDK. Applications and services can set the RETAIN flag when they use the Publish action to publish an MQTT message.

  Only one message per topic name is retained. A new message with the RETAIN flag set published to a topic replaces any existing retained message that was sent to the topic earlier.

  **NOTE:** You can't publish to a reserved topic with the RETAIN flag set.

- Subscribing to a retained message topic

  Clients subscribe to retained message topics as they would any other MQTT message topic. Retained messages received by subscribing to a retained message topic have the RETAIN flag set.

  Retained messages are deleted from AWS IoT Core when a client publishes a retained message with a 0-byte message payload to the retained message topic. Clients that have subscribed to the retained message topic will also receive the 0-byte message.

  Subscribing to a wild card topic filter that includes a retained message topic lets the client receive subsequent messages published to the retained message's topic, but it doesn't deliver the retained message upon subscription.

  **NOTE:** To receive a retained message upon subscription, the topic filter in the subscription request must match the retained message topic exactly.

  Retained messages received upon subscribing to a retained message topic have the RETAIN flag set. Retained messages that are received by a subscribing client after subscription, don't.

- Retrieving a retained message

  Retained messages are delivered to clients automatically when they subscribe to the topic with the retained message. For a client to receive the retained message upon subscription, it must subscribe to the exact topic name of the retained message. Subscribing to a wild card topic filter that includes a retained message topic lets the client receive subsequent messages published to the retained message's topic, but it does not deliver the retained message upon subscription.

  Services and apps can list and retrieve retained messages by calling ListRetainedMessages and GetRetainedMessage.

  A client is not prevented from publishing messages to a retained message topic without setting the RETAIN flag. This could cause unexpected results, such as the retained message not matching the message received by subscribing to the topic.
With MQTT 5, if a retained message has the Message Expiry Interval set and the retained message expires, a new subscriber that subscribes to that topic will not receive the retained message upon successful subscription.

- **Listing retained message topics**

You can list retained messages by calling `ListRetainedMessages` and the retained messages can be viewed in the AWS IoT console.

- **Getting retained message details**

You can get retained message details by calling `GetRetainedMessage` and they can be viewed in the AWS IoT console.

- **Retaining a Will message**

MQTT Will messages that are created when a device connects can be retained by setting the Will Retain flag in the Connect Flag bits field.

- **Deleting a retained message**

Devices, applications, and services can delete a retained message by publishing a message with the RETAIN flag set and an empty (0-byte) message payload to the topic name of the retained message to delete. Such messages delete the retained message from AWS IoT Core, are sent to clients with a subscription to the topic, but they are not retained by AWS IoT Core.

Retained messages can also be deleted interactively by accessing the retained message in the AWS IoT console. Retained messages that are deleted by using the AWS IoT console also send a 0-byte message to clients that have subscribed to the retained message's topic.

Retained messages can't be restored after they are deleted. A client would need to publish a new retained message to take the place of the deleted message.

- **Debugging and troubleshooting retained messages**

The AWS IoT console provides several tools to help you troubleshoot retained messages:

  - **The Retained messages page**

    The Retained messages page in the AWS IoT console provides a paginated list of the retained messages that have been stored by your Account in the current Region. From this page, you can:
    - See the details of each retained message, such as the message payload, QoS, the time it was received.
    - Update the contents of a retained message.
    - Delete a retained message.

  - **The MQTT test client**

    The MQTT test client page in the AWS IoT console can subscribe and publish to MQTT topics. The publish option lets you set the RETAIN flag on the messages that you publish to simulate how your devices might behave.

Some unexpected results might be the result of these aspects of how retained messages are implemented in AWS IoT Core.

- **Retained message limits**

  When an account has stored the maximum number of retained messages, AWS IoT Core returns a throttled response to messages published with RETAIN set and payloads greater than 0 bytes until some retained messages are deleted and the retained message count falls below the limit.

- **Retained message delivery order**

  The sequence of retained message and subscribed message delivery is not guaranteed.
Billing and retained messages

Publishing messages with the RETAIN flag set from a client, by using AWS IoT console, or by calling `Publish` incurs additional messaging charges described in AWS IoT Core pricing - Messaging.

Retrieving retained messages by a client, by using AWS IoT console, or by calling `GetRetainedMessage` incurs messaging charges in addition to the normal API usage charges. The additional charges are described in AWS IoT Core pricing - Messaging.

MQTT Will messages that are published when a device disconnects unexpectedly incur messaging charges described in AWS IoT Core pricing - Messaging.

For more information about messaging costs, see AWS IoT Core pricing - Messaging.

Comparing MQTT retained messages and MQTT persistent sessions

Retained messages and persistent sessions are standard features of MQTT that make it possible for devices to receive messages that were published while they were offline. Retained messages can be published from persistent sessions. This section describes key aspects of these features and how they work together.

<table>
<thead>
<tr>
<th>Retained messages</th>
<th>Persistent sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key features</strong></td>
<td></td>
</tr>
<tr>
<td>Retained messages can be used to configure or notify large</td>
<td>Persistent sessions are useful for devices that have intermittent connectivity and</td>
</tr>
<tr>
<td>groups of devices after they connect.</td>
<td>could miss several important messages.</td>
</tr>
<tr>
<td>Retained messages can also be used where you want devices to</td>
<td>Devices can connect with a persistent session to receive messages sent while they</td>
</tr>
<tr>
<td>receive only the last message published to a topic after a</td>
<td>are offline.</td>
</tr>
<tr>
<td>reconnection.</td>
<td></td>
</tr>
<tr>
<td><strong>Examples</strong></td>
<td></td>
</tr>
<tr>
<td>Retained messages can give devices configuration information</td>
<td>Devices that connect over a cellular network with intermittent connectivity could</td>
</tr>
<tr>
<td>about their environment when they come online. The initial</td>
<td>use persistent sessions to avoid missing important messages that are sent while a</td>
</tr>
<tr>
<td>configuration could include a list of other message topics to</td>
<td>device is out of network coverage or needs to turn off its cellular radio.</td>
</tr>
<tr>
<td>which it should subscribe or information about how it should</td>
<td></td>
</tr>
<tr>
<td>configure its local time zone.</td>
<td></td>
</tr>
<tr>
<td><strong>Messages received on initial subscription to a topic</strong></td>
<td></td>
</tr>
<tr>
<td>After subscribing to a topic with a retained message, the</td>
<td>After subscribing to a topic without a retained message, no message is received</td>
</tr>
<tr>
<td>most recent retained message is received.</td>
<td>until one is published to the topic.</td>
</tr>
<tr>
<td><strong>Subscribed topics after reconnection</strong></td>
<td></td>
</tr>
<tr>
<td>Without a persistent session, the client must subscribe to</td>
<td>Subscribed topics are restored after reconnection.</td>
</tr>
<tr>
<td>topics after reconnection.</td>
<td></td>
</tr>
<tr>
<td><strong>Messages received after reconnection</strong></td>
<td></td>
</tr>
<tr>
<td>After subscribing to a topic with a retained message, the</td>
<td>All messages published with a QOS = 1 and subscribed to with a QOS = 1 while the</td>
</tr>
<tr>
<td>most recent retained message is received.</td>
<td>device was</td>
</tr>
</tbody>
</table>
Retained messages | Persistent sessions
--- | ---
Data/session expiration | In MQTT 3, retained messages do not expire. They are stored until they are replaced or deleted. In MQTT 5, retained messages expire after the message expiry interval you set. For more information, see Message Expiry (p. 98).
Persistent sessions expire if the client doesn't reconnect within the timeout period. After a persistent session expires, the client's subscriptions and saved messages that were published with a QoS = 1 and subscribed to with a QoS = 1 while the device was disconnected are deleted. Expired messages won't be delivered. For more information about session expirations with persistent sessions, see the section called ‘MQTT persistent sessions’ (p. 90).

For information about persistent sessions, see the section called “MQTT persistent sessions” (p. 90).

With Retained Messages, the publishing client determines whether a message should be retained and delivered to a device after it connects, whether it had a previous session or not. The choice to store a message is made by the publisher and the stored message is delivered to all current and future clients that subscribe with a QoS 0 or QoS 1 subscriptions. Retained messages keep only one message on a given topic at a time.

When an account has stored the maximum number of retained messages, AWS IoT Core returns a throttled response to messages published with RETAIN set and payloads greater than 0 bytes until some retained messages are deleted and the retained message count falls below the limit.

**MQTT retained messages and AWS IoT Device Shadows**

Retained messages and Device Shadows both retain data from a device, but they behave differently and serve different purposes. This section describes their similarities and differences.

<table>
<thead>
<tr>
<th>Retained messages</th>
<th>Device Shadows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message payload has a pre-defined structure or schema</td>
<td>As defined by the implementation. MQTT does not specify a structure or schema for its message payload.</td>
</tr>
<tr>
<td>Updating the message payload generates event messages</td>
<td>Publishing a retained message sends the message to subscribed clients, but doesn't generate additional update messages.</td>
</tr>
<tr>
<td>Message updates are numbered</td>
<td>Retained messages are not numbered automatically.</td>
</tr>
<tr>
<td>Message payload is attached to a thing resource</td>
<td>Retained messages are not attached to a thing resource.</td>
</tr>
</tbody>
</table>
### Retained messages

<table>
<thead>
<tr>
<th>Updating individual elements of the message payload</th>
<th>Individual elements of the message can't be changed without updating the entire message payload.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client receives message data upon subscription</td>
<td>Client automatically receives a retained message after it subscribes to a topic with a retained message.</td>
</tr>
<tr>
<td>Indexing and searchability</td>
<td>Retained messages are not indexed for search.</td>
</tr>
</tbody>
</table>

### Device Shadows

<table>
<thead>
<tr>
<th>Updating individual elements of the message payload</th>
<th>Individual elements of a Device Shadow document can be updated without the need to update the entire Device Shadow document.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client receives message data upon subscription</td>
<td>Clients can subscribe to Device Shadow updates, but they must request the current state deliberately.</td>
</tr>
<tr>
<td>Indexing and searchability</td>
<td>Fleet indexing indexes Device Shadow data for search and aggregation.</td>
</tr>
</tbody>
</table>

### MQTT Last Will and Testament (LWT) messages

Last Will and Testament (LWT) is a feature in MQTT. With LWT, clients can specify a message which the broker will publish to a client-defined topic and send to all clients that subscribed to the topic when an uninitiated disconnection occurs. The message that clients specify is called an LWT message or a Will Message, and the topic that clients define is referred to as a Will Topic. You can specify an LWT message when a device connects to the broker. These messages can be retained by setting the Will Retain flag in the Connect Flag bits field during the connection. For example, if the Will Retain flag is set to 1, a Will Message will be stored in the broker in the associated Will Topic. For more information, see [Will Messages](https://docs.aws.amazon.com/iot/latest/developerguide/iot-core-features.html#iot-core-features-lwt).

The broker will store the Will Messages until an uninitiated disconnection occurs. When that happens, the broker will publish the messages to all clients that subscribed to the Will Topic to notify the disconnection. If the client disconnects from the broker with a client-initiated disconnection using the MQTT DISCONNECT message, the broker won't publish the stored LWT messages. In all other cases, the LWT messages will be dispatched. For a complete list of the disconnect scenarios when the broker will send the LWT messages, see [Connect/Disconnect events](https://docs.aws.amazon.com/iot/latest/developerguide/iot-core-features.html#iot-core-features-lwt).

### Using connectAttributes

ConnectAttributes allow you to specify what attributes you want to use in your connect message in your IAM policies such as PersistentConnect and LastWill. With ConnectAttributes, you can build policies that don't give devices access to new features by default, which can be helpful if a device is compromised.

connectAttributes supports the following features:

- **PersistentConnect**
  
  Use the PersistentConnect feature to save all subscriptions the client makes during the connection when the connection between the client and broker is interrupted.

- **LastWill**
  
  Use the LastWill feature to publish a message to the LastWillTopic when a client unexpectedly disconnects.

By default, your policy has a non-persistent connection and there are no attributes passed for this connection. You must specify a persistent connection in your IAM policy if you want to have one.

For ConnectAttributes examples, see [Connect Policy Examples](https://docs.aws.amazon.com/iot/latest/developerguide/iot-core-features.html#iot-core-features-lwt).
MQTT 5 supported features

AWS IoT Core support for MQTT 5 is based on the MQTT v5.0 specification with some differences as documented in the section called "AWS IoT differences from MQTT specifications" (p. 105).

AWS IoT Core supports the following MQTT 5 features:

- Shared Subscriptions (p. 98)
- Clean Start and Session Expiry (p. 100)
- Reason Code on all ACKs (p. 100)
- Topic Aliases (p. 100)
- Message Expiry (p. 100)
- Other MQTT 5 features (p. 101)

Shared Subscriptions

AWS IoT Core supports Shared Subscriptions for both MQTT 3 and MQTT 5. Shared Subscriptions allow multiple clients to share a subscription to a topic and only one client will receive messages published to that topic using a random distribution. Shared Subscriptions can effectively load balance MQTT messages across a number of subscribers. For example, say you have 1,000 devices publishing to the same topic, and 10 backend applications processing those messages. In that case, the backend applications can subscribe to the same topic and each would randomly receive messages published by the devices to the shared topic. This is effectively "sharing" the load of those messages. Shared Subscriptions also allow for better resiliency. When any backend application disconnects, the broker distributes the load to remaining subscribers in the group.

To use Shared Subscriptions, clients subscribe to a Shared Subscription's topic filter as follows:

```
$share/{ShareName}/{TopicFilter}
```

- `$share` is a literal string to indicate a Shared Subscription's topic filter, which must start with `$share`
- `{ShareName}` is a character string to specify the shared name used by a group of subscribers. A Shared Subscription's topic filter must contain a ShareName and be followed by the `/` character. The `{ShareName}` must not include the following characters: `/`, `*`, or `#`. The maximum size for `{ShareName}` is 128 bytes.
- `{TopicFilter}` follows the same topic filter syntax as a Non-shared Subscription. The maximum size for `{TopicFilter}` is 256 bytes.
- The two required slashes (`/`) for `$share/{ShareName}/{TopicFilter}` are not included in the Maximum number of slashes in topic and topic filter limit.

Subscriptions that have the same `{ShareName}/{TopicFilter}` belong to the same Shared Subscription group. You can create multiple Shared Subscription groups and don't exceed the Shared Subscriptions per group limit. For more information, see AWS IoT Core endpoints and quotas from the AWS General Reference.

The following tables compare Non-shared Subscriptions and Shared Subscriptions:

<table>
<thead>
<tr>
<th>Subscription</th>
<th>Description</th>
<th>Topic filter examples</th>
</tr>
</thead>
</table>
| Non-shared Subscriptions | Each client creates a separate subscription to receive the published messages. When a message is published to a topic, all subscribers to that topic receive a copy of the message. | sports/tennis  
sports/# |
## Subscription

<table>
<thead>
<tr>
<th>Subscription</th>
<th>Description</th>
<th>Topic filter examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared Subscriptions</td>
<td>Multiple clients can share a subscription to a topic and only one client will receive messages published to that topic at a random distribution.</td>
<td>$share/consumer/sports/tennis $share/consumer/sports/#</td>
</tr>
</tbody>
</table>

### Important notes for using Shared Subscriptions

- When a publish attempt to a QoS0 subscriber fails, no retry attempt will happen, and the message will be dropped.
- When a publish attempt to a QoS1 subscriber with clean session fails, the message will be sent to another subscriber in the group for multiple retry attempts. Messages that fail to be delivered after all the retry attempts will be dropped.
- When a publish attempt to a QoS1 subscriber with persistent sessions (p. 90) fails because the subscriber is offline, the messages won't be queued and will be attempted to another subscriber in the group. Messages that fail to be delivered after all the retry attempts will be dropped.
- Shared Subscriptions don't receive retained messages.
- When Shared Subscriptions contain wildcard characters (# or +), there might be multiple matching Shared Subscriptions to a topic. If that happens, the message broker copies the publishing message and sends it to a random client in each matching Shared Subscription. The wildcard behavior of Shared Subscriptions can be explained in the following diagram.

In this example, there are three matching Shared Subscriptions to the publishing MQTT topic `sports/tennis`. The message broker copies the published message and sends the message to a random client in each matching group.

- Client 1 and client 2 share the subscription: `$share/consumer1/sports/tennis`
- Client 3 and client 4 share the subscription: `$share/consumer1/sports/#`
Client 5 and client 6 share the subscription: $share/consumer2/sports/tennis

For more information about Shared Subscriptions limits, see AWS IoT Core endpoints and quotas from the AWS General Reference. To test Shared Subscriptions using the AWS IoT MQTT client in the AWS IoT console, see ??? (p. 71). For more information about Shared Subscriptions, see Shared Subscriptions from the MQTTv5.0 specification.

**Clean Start and Session Expiry**

You can use Clean Start and Session Expiry to handle your persistent sessions with more flexibility. A Clean Start flag indicates whether the session should start without using an existing session. A Session Expiry interval indicates how long to retain the session after a disconnect. The session expiry interval can be modified at disconnect. For more information, see the section called “MQTT persistent sessions” (p. 90).

**Reason Code on all ACKs**

You can debug or process error messages more easily using the reason codes. Reason codes are returned by the message broker based on the type of interaction with the broker (Subscribe, Publish, Acknowledge). For more information, see MQTT reason codes (p. 103). For a complete list of MQTT reason codes, see MQTT v5 specification.

**Topic Aliases**

You can substitute a topic name with a topic alias, which is a two-byte integer. Using topic aliases can optimize the transmission of topic names to potentially reduce data costs on metered data services. AWS IoT Core has a default limit of 8 topic aliases. For more information, see AWS IoT Core endpoints and quotas from the AWS General Reference.

**Message Expiry**

You can add message expiry values to published messages. These values represent the message expiry interval in seconds. If the messages haven't been sent to the subscribers within that interval, the message will expire and be removed. If you don't set the message expiry value, the message will not expire.

On the outbound, the subscriber will receive a message with the remaining time left in the expiry interval. For example, if an inbound publish message has a message expire of 30 seconds, and it's routed to the subscriber after 20 seconds, the message expiry field will be updated to 10. It is possible for the message received by the subscriber to have an updated MEI of 0. This is because as soon as the time remaining is 999 ms or less, it will be updated to 0.

In AWS IoT Core, the minimum message expiry interval is 1. If the interval is set to 0 from the client side, it will be adjusted to 1. The maximum message expiry interval is 604800 (7 days). Any values higher than this will be adjusted to the maximum value.

In cross version communication, the behavior of message expiry is decided by MQTT version of the inbound publish message. For example, a message with message expiry sent by a session connected via MQTT5 can expire for devices subscribed with MQTT3 sessions. The table below lists how message expiry supports the following types of publish messages:

<table>
<thead>
<tr>
<th>Publish Message Type</th>
<th>Message Expiry Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular Publish</td>
<td>If a server fails to deliver the message within the specified time, the expired message will be removed and the subscriber won't receive it. This includes situations such as when a device is not pubacking their QoS 1 messages.</td>
</tr>
</tbody>
</table>
Device communication protocols

### Publish Message Type

<table>
<thead>
<tr>
<th>Message Type</th>
<th>Message Expiry Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retain</td>
<td>If a retained message expires and a new client subscribes to the topic, the client won't receive the message upon subscription.</td>
</tr>
<tr>
<td>Last Will</td>
<td>The interval for last will messages starts after the client disconnects and the server attempts to deliver the last will message to its subscribers.</td>
</tr>
<tr>
<td>Queued messages</td>
<td>If an outbound QoS1 with Message Expiry Interval expires when a client is offline, after the persistent session (p. 90) resumes, the client won't receive the expired message.</td>
</tr>
</tbody>
</table>

### Other MQTT 5 features

#### Server disconnect

When a disconnection happens, the server can proactively send the client a DISCONNECT to notify connection closure with a reason code for disconnection.

#### Request/Response

Publishers can request a response be sent by the receiver to a publisher-specified topic upon reception.

#### Maximum Packet Size

Client and Server can independently specify the maximum packet size that they support.

#### Payload format and content type

You can specify the payload format (binary, text) and content type when a message is published. These are forwarded to the receiver of the message.

#### MQTT 5 properties

MQTT 5 properties are important additions to the MQTT standard to support new MQTT 5 features such as Session Expiry and the Request/Response pattern. In AWS IoT Core, you can create rules that can forward the properties in outbound messages, or use HTTP Publish to publish MQTT messages with some of the new properties.

The following table lists all the MQTT 5 properties that AWS IoT Core supports.

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Input type</th>
<th>Packet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload Format Indicator</td>
<td>A boolean value that indicates whether the payload is formatted as UTF-8.</td>
<td>Byte</td>
<td>PUBLISH, CONNECT</td>
</tr>
<tr>
<td>Content Type</td>
<td>A UTF-8 string that describes the content of the payload.</td>
<td>UTF-8 string</td>
<td>PUBLISH, CONNECT</td>
</tr>
<tr>
<td>Response Topic</td>
<td>A UTF-8 string that describes the topic the receiver should publish to as part of the request-response flow. The topic must not have wildcard characters.</td>
<td>UTF-8 string</td>
<td>PUBLISH, CONNECT</td>
</tr>
<tr>
<td>Property</td>
<td>Description</td>
<td>Input type</td>
<td>Packet</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Correlation Data</td>
<td>Binary data used by the sender of the request message to identify which request the response message is for.</td>
<td>Binary</td>
<td>PUBLISH, CONNECT</td>
</tr>
<tr>
<td>User Property</td>
<td>A UTF-8 string pair. This property can appear multiple times in one packet. Receivers will receive the key-value pairs in the same order they are sent.</td>
<td>UTF-8 string pair</td>
<td>CONNECT, PUBLISH, Will Properties, SUBSCRIBE, DISCONNECT, UNSUBSCRIBE</td>
</tr>
<tr>
<td>Message Expiry Interval</td>
<td>A 4-byte integer that represents the message expiry interval in seconds. If absent, the message doesn't expire.</td>
<td>4-byte integer</td>
<td>PUBLISH, CONNECT</td>
</tr>
<tr>
<td>Session Expiry Interval</td>
<td>A 4-byte integer that represents the session expiry interval in seconds. AWS IoT Core supports a maximum of 7 days, with a default maximum of one hour. If the value you set exceeds the maximum of your account, AWS IoT Core will return the adjusted value in the CONNACK.</td>
<td>4-byte integer</td>
<td>CONNECT, CONNACK, DISCONNECT</td>
</tr>
<tr>
<td>Assigned Client Identifier</td>
<td>A random client ID generated by AWS IoT Core when a client ID isn't specified by devices. The random client ID must be a new client identifier that's not used by any other session currently managed by the broker.</td>
<td>UTF-8 string</td>
<td>CONNACK</td>
</tr>
<tr>
<td>Server Keep Alive</td>
<td>A 2-byte integer that represents the keep alive time assigned by the server. The server will disconnect the client if the client is inactive for more than the keep alive time.</td>
<td>2-byte integer</td>
<td>CONNACK</td>
</tr>
<tr>
<td>Request Problem Information</td>
<td>A boolean value that indicates whether the Reason String or User Properties are sent in the case of failures.</td>
<td>Byte</td>
<td>CONNECT</td>
</tr>
<tr>
<td>Receive Maximum</td>
<td>A 2-byte integer that represents the maximum number of PUBLISH QOS &gt; 0 packets which can be sent without receiving an PUBACK.</td>
<td>2-byte integer</td>
<td>CONNECT, CONNACK</td>
</tr>
<tr>
<td>Topic Alias Maximum</td>
<td>This value indicates the highest value that will be accepted as a Topic Alias. Default is 0.</td>
<td>2-byte integer</td>
<td>CONNECT, CONNACK</td>
</tr>
<tr>
<td>Maximum QoS</td>
<td>The maximum value of QoS that AWS IoT Core supports. Default is 1. AWS IoT Core doesn't support QoS2.</td>
<td>Byte</td>
<td>CONNACK</td>
</tr>
<tr>
<td>Retain Available</td>
<td>A boolean value that indicates whether AWS IoT Core message broker supports retained messages. The default is 1.</td>
<td>Byte</td>
<td>CONNACK</td>
</tr>
<tr>
<td>Maximum Packet Size</td>
<td>The maximum packet size that AWS IoT Core accepts and sends. Cannot exceed 128KB.</td>
<td>4-byte integer</td>
<td>CONNECT, CONNACK</td>
</tr>
</tbody>
</table>
### Device communication protocols

<table>
<thead>
<tr>
<th>Property</th>
<th>Description</th>
<th>Input type</th>
<th>Packet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildcard Subscription Available</td>
<td>A boolean value that indicates whether AWS IoT Core message broker supports Wildcard Subscription Available. The default is 1.</td>
<td>Byte</td>
<td>CONNACK</td>
</tr>
<tr>
<td>Subscription Identifier Available</td>
<td>A boolean value that indicates whether AWS IoT Core message broker supports Subscription Identifier Available. The default is 0.</td>
<td>Byte</td>
<td>CONNACK</td>
</tr>
</tbody>
</table>

### MQTT reason codes

MQTT 5 introduces improved error reporting with reason code responses. AWS IoT Core may return reason codes including but not limited to the following grouped by packets. For a complete list of reason codes supported by MQTT 5, see [MQTT 5 specifications](#).

#### CONNACK Reason Codes

<table>
<thead>
<tr>
<th>Value</th>
<th>Hex</th>
<th>Reason Code name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0x00</td>
<td>Success</td>
<td>The connection is accepted.</td>
</tr>
<tr>
<td>128</td>
<td>0x80</td>
<td>Unspecified error</td>
<td>The server does not wish to reveal the reason for the failure, or none of the other reason codes apply.</td>
</tr>
<tr>
<td>133</td>
<td>0x85</td>
<td>Client Identifier not valid</td>
<td>The client identifier is a valid string but is not allowed by the server.</td>
</tr>
<tr>
<td>134</td>
<td>0x86</td>
<td>Bad User Name or Password</td>
<td>The server does not accept the user name or password specified by the client.</td>
</tr>
<tr>
<td>135</td>
<td>0x87</td>
<td>Not authorized</td>
<td>The client is not authorized to connect.</td>
</tr>
<tr>
<td>144</td>
<td>0x90</td>
<td>Topic Name invalid</td>
<td>The Will Topic Name is correctly formed but is not accepted by the server.</td>
</tr>
<tr>
<td>151</td>
<td>0x97</td>
<td>Quota exceeded</td>
<td>An implementation or administrative imposed limit has been exceeded.</td>
</tr>
<tr>
<td>155</td>
<td>0x9B</td>
<td>QoS not supported</td>
<td>The server does not support the QoS set in Will QoS.</td>
</tr>
</tbody>
</table>

#### PUBACK Reason Codes

<table>
<thead>
<tr>
<th>Value</th>
<th>Hex</th>
<th>Reason Code name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0x00</td>
<td>Success</td>
<td>The message is accepted. Publication of the QoS 1 message proceeds.</td>
</tr>
<tr>
<td>128</td>
<td>0x80</td>
<td>Unspecified error</td>
<td>The receiver does not accept the publish, but either does not want to reveal the reason, or it does not match one of the other values.</td>
</tr>
<tr>
<td>135</td>
<td>0x87</td>
<td>Not authorized</td>
<td>The PUBLISH is not authorized.</td>
</tr>
<tr>
<td>Value</td>
<td>Hex</td>
<td>Reason Code name</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-----</td>
<td>------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>144</td>
<td>0x90</td>
<td>Topic Name invalid</td>
<td>The topic name is not malformed, but is not accepted by the client or server.</td>
</tr>
<tr>
<td>145</td>
<td>0x91</td>
<td>Packet identifier in use</td>
<td>The packet identifier is already in use. This might indicate a mismatch in the session state between the client and server.</td>
</tr>
<tr>
<td>151</td>
<td>0x97</td>
<td>Quota exceeded</td>
<td>An implementation or administrative imposed limit has been exceeded.</td>
</tr>
</tbody>
</table>

**DISCONNECT Reason Codes**

<table>
<thead>
<tr>
<th>Value</th>
<th>Hex</th>
<th>Reason Code name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>129</td>
<td>0x81</td>
<td>Malformed Packet</td>
<td>The received packet does not conform to this specification.</td>
</tr>
<tr>
<td>130</td>
<td>0x82</td>
<td>Protocol Error</td>
<td>An unexpected or out of order packet was received.</td>
</tr>
<tr>
<td>135</td>
<td>0x87</td>
<td>Not authorized</td>
<td>The request is not authorized.</td>
</tr>
<tr>
<td>139</td>
<td>0x88</td>
<td>Server shutting down</td>
<td>The server is shutting down.</td>
</tr>
<tr>
<td>141</td>
<td>0x8D</td>
<td>Keep Alive timeout</td>
<td>The connection is closed because no packet has been received for 1.5 times the Keep Alive time.</td>
</tr>
<tr>
<td>142</td>
<td>0x8E</td>
<td>Session taken over</td>
<td>Another connection using the same ClientID has connected, causing this connection to be closed.</td>
</tr>
<tr>
<td>143</td>
<td>0x8F</td>
<td>Topic Filter invalid</td>
<td>The topic filter is correctly formed but is not accepted by the server.</td>
</tr>
<tr>
<td>144</td>
<td>0x90</td>
<td>Topic Name invalid</td>
<td>The topic name is correctly formed but is not accepted by this client or server.</td>
</tr>
<tr>
<td>147</td>
<td>0x93</td>
<td>Receive Maximum exceeded</td>
<td>The client or server has received more than the Receive Maximum publication for which it has not sent PUBACK or PUBCOMP.</td>
</tr>
<tr>
<td>148</td>
<td>0x94</td>
<td>Topic Alias invalid</td>
<td>The client or server has received a PUBLISH packet containing a topic alias greater than the Maximum Topic Alias it sent in the CONNECT or CONNACK packet.</td>
</tr>
<tr>
<td>151</td>
<td>0x97</td>
<td>Quota exceeded</td>
<td>An implementation or administrative imposed limit has been exceeded.</td>
</tr>
<tr>
<td>152</td>
<td>0x98</td>
<td>Administrative action</td>
<td>The connection is closed due to an administrative action.</td>
</tr>
<tr>
<td>155</td>
<td>0x9B</td>
<td>QoS not supported</td>
<td>The client specified a QoS greater than the QoS specified in a Maximum QoS in the CONNACK.</td>
</tr>
<tr>
<td>161</td>
<td>0xA1</td>
<td>Subscription Identifiers not supported</td>
<td>The server does not support subscription identifiers; the subscription is not accepted.</td>
</tr>
</tbody>
</table>
### SUBACK Reason Codes

<table>
<thead>
<tr>
<th>Value</th>
<th>Hex</th>
<th>Reason Code name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0x00</td>
<td>Granted QoS 0</td>
<td>The subscription is accepted and the maximum QoS sent will be QoS 0. This might be a lower QoS than was requested.</td>
</tr>
<tr>
<td>1</td>
<td>0x01</td>
<td>Granted QoS 1</td>
<td>The subscription is accepted and the maximum QoS sent will be QoS 1. This might be a lower QoS than was requested.</td>
</tr>
<tr>
<td>128</td>
<td>0x80</td>
<td>Unspecified error</td>
<td>The subscription is not accepted and the Server either does not wish to reveal the reason or none of the other Reason Codes apply.</td>
</tr>
<tr>
<td>135</td>
<td>0x87</td>
<td>Not authorized</td>
<td>The Client is not authorized to make this subscription.</td>
</tr>
<tr>
<td>143</td>
<td>0x8F</td>
<td>Topic Filter invalid</td>
<td>The Topic Filter is correctly formed but is not allowed for this Client.</td>
</tr>
<tr>
<td>145</td>
<td>0x91</td>
<td>Packet Identifier in use</td>
<td>The specified Packet Identifier is already in use.</td>
</tr>
<tr>
<td>151</td>
<td>0x97</td>
<td>Quota exceeded</td>
<td>An implementation or administrative imposed limit has been exceeded.</td>
</tr>
</tbody>
</table>

### UNSUBACK Reason Codes

<table>
<thead>
<tr>
<th>Value</th>
<th>Hex</th>
<th>Reason Code name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0x00</td>
<td>Success</td>
<td>The subscription is deleted.</td>
</tr>
<tr>
<td>128</td>
<td>0x80</td>
<td>Unspecified error</td>
<td>The unsubscribe could not be completed and the Server either does not wish to reveal the reason or none of the other Reason Codes apply.</td>
</tr>
<tr>
<td>143</td>
<td>0x8F</td>
<td>Topic Filter invalid</td>
<td>The Topic Filter is correctly formed but is not allowed for this Client.</td>
</tr>
<tr>
<td>145</td>
<td>0x91</td>
<td>Packet Identifier in use</td>
<td>The specified Packet Identifier is already in use.</td>
</tr>
</tbody>
</table>

### AWS IoT differences from MQTT specifications

The message broker implementation is based on the [MQTT v3.1.1 specification](https://www.eclipse.org/mqtt/spec-3.1.1.html) and the [MQTT v5.0 specification](https://www.eclipse.org/mqtt/spec-5.0.html), but it differs from the specifications in these ways:

- AWS IoT doesn't support the following packets for MQTT 3: PUBREC, PUBREL, and PUBCOMP.
- AWS IoT doesn't support the following packets for MQTT 5: PUBREC, PUBREL, PUBCOMP, and AUTH.
- AWS IoT doesn't support MQTT 5 server redirection.
- AWS IoT supports MQTT quality of service (QoS) levels 0 and 1 only. AWS IoT doesn't support publishing or subscribing with QoS level 2. When QoS level 2 is requested, the message broker doesn't send a PUBACK or SUBACK.
- In AWS IoT, subscribing to a topic with QoS level 0 means that a message is delivered zero or more times. A message might be delivered more than once. Messages delivered more than once might be sent with a different packet ID. In these cases, the DUP flag is not set.
• When responding to a connection request, the message broker sends a CONNACK message. This message contains a flag to indicate if the connection is resuming a previous session.

• Before sending additional control packets or a disconnect request, the client must wait for the CONNACK message to be received on their device from the AWS IoT message broker.

• When a client subscribes to a topic, there might be a delay between the time the message broker sends a SUBACK and the time the client starts receiving new matching messages.

• When a client uses the wildcard character # in the topic filter to subscribe to a topic, all strings at and below its level in the topic hierarchy are matched. However, the parent topic is not matched. For example, a subscription to the topic sensor/# receives messages published to the topics sensor/, sensor/temperature, sensor/temperature/room1, but not messages published to sensor.

• The message broker uses the client ID to identify each client. The client ID is passed in from the client to the message broker as part of the MQTT payload. Two clients with the same client ID can't be connected concurrently to the message broker. When a client connects to the message broker using a client ID that another client is using, the new client connection is accepted and the previously connected client is disconnected.

• On rare occasions, the message broker might resend the same logical PUBLISH message with a different packet ID.

• Subscription to topic filters that contain a wildcard character can't receive retained messages. To receive a retained message, the subscribe request must contain a topic filter that matches the retained message topic exactly.

• The message broker doesn't guarantee the order in which messages and ACK are received.

• AWS IoT may have limits that are different from the specifications. For more information, see AWS IoT Core message broker and protocol limits and quotas from the AWS IoT Reference Guide.

HTTPS

Clients can publish messages by making requests to the REST API using the HTTP 1.0 or 1.1 protocols. For the authentication and port mappings used by HTTP requests, see Protocols, port mappings, and authentication (p. 85).

**Note**

HTTPS doesn't support a `clientId` value like MQTT does. `clientId` is available when using MQTT, but it's not available when using HTTPS.

HTTPS message URL

Devices and clients publish their messages by making POST requests to a client-specific endpoint and a topic-specific URL:

```
https://IoT_data_endpoint/topics/url_encoded_topic_name?qos=1
```

• `IoT_data_endpoint` is the AWS IoT device data endpoint (p. 82). You can find the endpoint in the AWS IoT console on the thing’s details page or on the client by using the AWS CLI command:

```
aws iot describe-endpoint --endpoint-type iot:Data-ATS
```

The endpoint should look something like this: a3qjEXAAMPLEffp-ats.iot.us-west-2.amazonaws.com

• `url_encoded_topic_name` is the full topic name (p. 109) of the message being sent.
HTTPS message code examples

These are some examples of how to send an HTTPS message to AWS IoT.

Python (port 8443)

```python
import requests
import argparse

# define command-line parameters
parser = argparse.ArgumentParser(description="Send messages through an HTTPS connection.")
parser.add_argument('--endpoint', required=True, help="Your AWS IoT data custom endpoint, not including a port. " + "Ex: ""abcdEXAMPLExyz-ats.iot.us-east-1.amazonaws.com""")
parser.add_argument('--cert', required=True, help="File path to your client certificate, in PEM format.")
parser.add_argument('--key', required=True, help="File path to your private key, in PEM format.")
parser.add_argument('--topic', default="test/topic", help="Topic to publish messages to.")
parser.add_argument('--message', default="Hello World!", help="Message to publish. " + "Specify empty string to publish nothing."")

# parse and load command-line parameter values
args = parser.parse_args()

# create and format values for HTTPS request
publish_url = 'https://' + args.endpoint + ':8443/topics/' + args.topic + '?qos=1
publish_msg = args.message.encode('utf-8')

# make request
publish = requests.request('POST', publish_url, data=publish_msg, cert=[args.cert, args.key])

# print results
print("Response status: ", str(publish.status_code))
if publish.status_code == 200:
    print("Response body:" , publish.text)
```

Python (port 443)

```python
import requests
import http.client
import json
import ssl

ssl_context = ssl.SSLContext(protocol=ssl.PROTOCOL_TLS_CLIENT)
ssl_context.minimum_version = ssl.TLSVersion.TLSv1_2

# note the use of ALPN
ssl_context.set_alpn_protocols(["x-amzn-http-ca"])  
ssl_context.load_verify_locations(cfile="./<root_certificate>"")

# update the certificate and the AWS endpoint
ssl_context.load_cert_chain("./<certificate_in_PEM_Format>", "<private_key_in_PEM_format>")
connection = http.client.HTTPSConnection("<the ats IoT endpoint>", 443, context=ssl_context)
```
message = {'data': 'Hello, I'm using TLS Client authentication!'}
json_data = json.dumps(message)
connection.request('POST', '/topics/device%2Fmessage?qos=1', json_data)

# make request
response = connection.getresponse()

# print results
print(response.read().decode())

**CURL**

You can use `curl` from a client or device to send a message to AWS IoT.

**To use curl to send a message from an AWS IoT client device**

1. Check the `curl` version.
   a. On your client, run this command at a command prompt.
      
      ```
      curl --help
      ```
      
      In the help text, look for the TLS options. You should see the `--tlsv1.2` option.
   b. If you see the `--tlsv1.2` option, continue.
   c. If you don’t see the `--tlsv1.2` option or you get a `command not found` error, you might need to update or install curl on your client or install `openssl` before you continue.

2. Install the certificates on your client.

   Copy the certificate files that you created when you registered your client (thing) in the AWS IoT console. Make sure you have these three certificate files on your client before you continue.

   - The CA certificate file (`Amazon-root-CA-1.pem` in this example).
   - The client’s certificate file (`device.pem.crt` in this example).
   - The client’s private key file (`private.pem.key` in this example).

3. Create the `curl` command line, replacing the replaceable values for those of your account and system.

   ```
   curl --tlsv1.2 \ 
   --cacert Amazon-root-CA-1.pem \ 
   --cert device.pem.crt \ 
   --key private.pem.key \ 
   --request POST \ 
   --data "\"message\": \"Hello, world\" \" \ 
   "https://IoT_data_endpoint:8443/topics/topic?qos=1"
   ```

   **--tlsv1.2**

   Use TLS 1.2 (SSL).

   **--cacert** `Amazon-root-CA-1.pem`  
   The file name and path, if necessary, of the CA certificate to verify the peer.

   **--cert** `device.pem.crt`  
   The client’s certificate file name and path, if necessary.

   **--key** `private.pem.key`  
   The client’s private key file name and path, if necessary.
--request POST

The type of HTTP request (in this case, POST).

--data "\"message\": \"Hello, world\" \"

The HTTP POST data you want to publish. In this case, it's a JSON string, with the internal quotation marks escaped with the backslash character (\).

"https://IoT_data_endpoint:8443/topics/topic?qos=1"

The URL of your client's AWS IoT device data endpoint, followed by the HTTPS port, :8443, which is then followed by the keyword, /topics/ and the topic name, topic, in this case. Specify the Quality of Service as the query parameter, ?qos=1.

4. Open the MQTT test client in the AWS IoT console.

Follow the instructions in View MQTT messages with the AWS IoT MQTT client (p. 67) and configure the console to subscribe to messages with the topic name of topic used in your curl command, or use the wildcard topic filter of #.

5. Test the command.

While monitoring the topic in the test client of the AWS IoT console, go to your client and issue the curl command line that you created in step 3. You should see your client's messages in the console.

MQTT topics

MQTT topics identify AWS IoT messages. AWS IoT clients identify the messages they publish by giving the messages topic names. Clients identify the messages to which they want to subscribe (receive) by registering a topic filter with AWS IoT Core. The message broker uses topic names and topic filters to route messages from publishing clients to subscribing clients.

The message broker uses topics to identify messages sent using MQTT and sent using HTTP to the HTTPS message URL (p. 106).

While AWS IoT supports some reserved system topics (p. 111), most MQTT topics are created and managed by you, the system designer. AWS IoT uses topics to identify messages received from publishing clients and select messages to send to subscribing clients, as described in the following sections. Before you create a topic namespace for your system, review the characteristics of MQTT topics to create the hierarchy of topic names that works best for your IoT system.

**Topic names**

Topic names and topic filters are UTF-8 encoded strings. They can represent a hierarchy of information by using the forward slash (/) character to separate the levels of the hierarchy. For example, this topic name could refer to a temperature sensor in room 1:

- sensor/temperature/room1

In this example, there might also be other types of sensors in other rooms with topic names such as:

- sensor/temperature/room2
- sensor/humidity/room1
- sensor/humidity/room2
Note
As you consider topic names for the messages in your system, keep in mind:

- Topic names and topic filters are case sensitive.
- Topic names must not contain personally identifiable information.
- Topic names that begin with a $ are reserved topics (p. 111) to be used only by AWS IoT Core.
- AWS IoT Core can't send or receive messages between AWS accounts or Regions.

For more information on designing your topic names and namespace, see our whitepaper, Designing MQTT Topics for AWS IoT Core.

For examples of how apps can publish and subscribe to messages, start with Getting started with AWS IoT Core (p. 17) and AWS IoT Device SDKs, Mobile SDKs, and AWS IoT Device Client (p. 1428).

Important
The topic namespace is limited to an AWS account and Region. For example, the sensor/temp/room1 topic used by an AWS account in one Region is distinct from the sensor/temp/room1 topic used by the same AWS account in another Region or used by any other AWS account in any Region.

Topic ARN
All topic ARNs (Amazon Resource Names) have the following form:

```
```

For example, arn:aws:iot:us-west-2:123EXAMPLE456:topic/application/topic/device/sensor is an ARN for the topic application/topic/device/sensor.

Topic filters
Subscribing clients register topic filters with the message broker to specify the message topics that the message broker should send to them. A topic filter can be a single topic name to subscribe to a single topic name or it can include wildcard characters to subscribe to multiple topic names at the same time.

Publishing clients can't use wildcard characters in the topic names they publish.

The following table lists the wildcard characters that can be used in a topic filter.

### Topic wildcards

<table>
<thead>
<tr>
<th>Wildcard character</th>
<th>Matches</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>All strings at and below its level in the topic hierarchy.</td>
<td>Must be the last character in the topic filter. Must be the only character in its level of the topic hierarchy. Can be used in a topic filter that also contains the + wildcard character.</td>
</tr>
<tr>
<td>+</td>
<td>Any string in the level that contains the character.</td>
<td>Must be the only character in its level of the topic hierarchy.</td>
</tr>
</tbody>
</table>
AWS IoT Core Developer Guide
MQTT topics

<table>
<thead>
<tr>
<th>Wildcard character</th>
<th>Matches</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>Matches</td>
<td>Can be used in multiple levels of a topic filter.</td>
</tr>
</tbody>
</table>

Using wildcards with the previous sensor topic name examples:

- A subscription to sensor/# receives messages published to sensor/, sensor/temperature, sensor/temperature/room1, but not messages published to sensor.
- A subscription to sensor/+/room1 receives messages published to sensor/temperature/room1 and sensor/humidity/room1, but not messages sent to sensor/temperature/room2 or sensor/humidity/room2.

**Topic filter ARN**

All topic filter ARNs (Amazon Resource Names) have the following form:

```
```

For example, arn:aws:iot:us-west-2:123EXAMPLE456:topicfilter/application/topic/+/sensor is an ARN for the topic filter application/topic/+/sensor.

**MQTT message payload**

The message payload that is sent in your MQTT messages isn't specified by AWS IoT, unless it's for one of the section called "Reserved topics" (p. 111). To accommodate your application's needs, we recommend you define the message payload for your topics within the constraints of the AWS IoT Core Service Quotas for Protocols.

Using a JSON format for your message payload enables the AWS IoT rules engine to parse your messages and apply SQL queries to it. If your application doesn't require the rules engine to apply SQL queries to your message payloads, you can use any data format that your application requires. For information about limitations and reserved characters in a JSON document used in SQL queries, see JSON extensions (p. 646).

For more information about designing your MQTT topics and their corresponding message payloads, see Designing MQTT Topics for AWS IoT Core.

If a message size limit exceeds the service quotas, it will result in a CLIENT_ERROR with reason PAYLOAD_LIMIT_EXCEEDED and "Message payload exceeds size limit for message type." For more information about message size limit, see AWS IoT Core message broker limits and quotas.

**Reserved topics**

Topics that begin with a dollar sign ($) are reserved for use by AWS IoT. You can subscribe and publish to these reserved topics as they allow; however, you can't create new topics that begin with a dollar sign. Unsupported publish or subscribe operations to reserved topics can result in a terminated connection.

**Asset model topics**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/sitewise/asset-models/assetModelId/</td>
<td>Subscribe</td>
<td>AWS IoT SiteWise publishes asset property notifications</td>
</tr>
</tbody>
</table>
AWS IoT Core Developer Guide
MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>assets/&lt;assetId&gt;/properties/&lt;propertyId&gt;</td>
<td></td>
<td>to this topic. For more information, see Interacting with other AWS services in the AWS IoT SiteWise User Guide.</td>
</tr>
</tbody>
</table>

AWS IoT Device Defender topics

These messages support response buffers in Concise Binary Object Representation (CBOR) format and JavaScript Object Notation (JSON), depending on the `payload-format` of the topic. AWS IoT Device Defender topics only support MQTT publish.

<table>
<thead>
<tr>
<th>payload-format</th>
<th>Response format data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>cbor</td>
<td>Concise Binary Object Representation (CBOR)</td>
</tr>
<tr>
<td>json</td>
<td>JavaScript Object Notation (JSON)</td>
</tr>
</tbody>
</table>

For more information, see Sending metrics from devices (p. 1064).

AWS IoT Core Device Location topics

AWS IoT Core Device Location can resolve the measurement data from your device and provide an estimated location of your IoT devices. The measurement data from the device can include GNSS, Wi-Fi, cellular, and IP address. AWS IoT Core Device Location then chooses the measurement type that provides the best accuracy and solves the device location information. For more information, see AWS IoT Core Device Location (p. 1187) and Resolving device location using AWS IoT Core Device Location MQTT topics (p. 1194).
### MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Allowed operations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/device_location/customer_device_id/get_position_estimate</td>
<td>Publish</td>
<td>A device publishes to this topic to get the scanned raw measurement data to be resolved by AWS IoT Core Device Location.</td>
</tr>
<tr>
<td>$aws/device_location/customer_device_id/get_position_estimate/accepted</td>
<td>Subscribe</td>
<td>AWS IoT Core Device Location publishes to this topic after it has resolved the device location successfully.</td>
</tr>
<tr>
<td>$aws/device_location/customer_device_id/get_position_estimate/rejected</td>
<td>Subscribe</td>
<td>AWS IoT Core Device Location publishes to this topic when it is unable to resolve the device location successfully due to 4xx errors.</td>
</tr>
</tbody>
</table>

### Event topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/events/certificates/registered/caCertificateId</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when AWS IoT automatically registers a certificate and when a client presents a certificate with the PENDING_ACTIVATION status. For more information, see the section called “Configure the first connection by a client for automatic registration” (p. 314).</td>
</tr>
<tr>
<td>$aws/events/job/jobID/canceled</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job is canceled. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/job/jobID/cancellation_in_progress</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job cancellation is in progress. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/job/jobID/completed</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job has completed. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/job/jobID/deleted</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job is deleted. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/job/jobID/deletion_in_progress</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job deletion is in progress. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobID/canceled</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job execution is canceled. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>Topic</td>
<td>Client operations allowed</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobID/deleted</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job execution is deleted. For more information, see <a href="#">Jobs events</a>.</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobID/failed</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job execution has failed. For more information, see <a href="#">Jobs events</a>.</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobID/rejected</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job execution was rejected. For more information, see <a href="#">Jobs events</a>.</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobID/removed</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job execution was removed. For more information, see <a href="#">Jobs events</a>.</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobID/succeeded</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job execution succeeded. For more information, see <a href="#">Jobs events</a>.</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobID/timed_out</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message when a job execution timed out. For more information, see <a href="#">Jobs events</a>.</td>
</tr>
<tr>
<td>$aws/events/presence/connected/clientId</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when an MQTT client with the specified client ID connects to AWS IoT. For more information, see <a href="#">Connect/Disconnect events</a>.</td>
</tr>
<tr>
<td>$aws/events/presence/disconnected/clientId</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when an MQTT client with the specified client ID disconnects to AWS IoT. For more information, see <a href="#">Connect/Disconnect events</a>.</td>
</tr>
<tr>
<td>$aws/events/subscriptions/subscribed/clientId</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when an MQTT client with the specified client ID subscribes to an MQTT topic. For more information, see <a href="#">Subscribe/Unsubscribe events</a>.</td>
</tr>
<tr>
<td>$aws/events/subscriptions/unsubscribed/clientId</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when an MQTT client with the specified client ID unsubscribes to an MQTT topic. For more information, see <a href="#">Subscribe/Unsubscribe events</a>.</td>
</tr>
<tr>
<td>$aws/events/thing/thingName/created</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when the <code>thingName</code> thing is created. For more information, see the section called &quot;Registry events&quot; (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thing/thingName/updated</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when the <code>thingName</code> thing is updated. For more information, see the section called &quot;Registry events&quot; (p. 1208).</td>
</tr>
<tr>
<td>Topic</td>
<td>Client operations allowed</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>---------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>$aws/events/thing/thingName/deleted</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when the <strong>thingName</strong> thing is deleted. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingGroup/thingGroupName/created</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing group <strong>thingGroupName</strong> is created. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingGroup/thingGroupName/updated</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing group <strong>thingGroupName</strong> is updated. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingGroup/thingGroupName/deleted</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing group <strong>thingGroupName</strong> is deleted. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingType/thingTypeName/created</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when the <strong>thingTypeName</strong> thing type is created. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingType/thingTypeName/updated</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when the <strong>thingTypeName</strong> thing type is updated. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingType/thingTypeName/deleted</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when the <strong>thingTypeName</strong> thing type is deleted. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingTypeAssociation/thing/thingName/thingTypeName</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing <strong>thingName</strong> is associated with or disassociated from thing type <strong>thingTypeName</strong>. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingGroupMembership/thingGroup/thingGroupName/thing/thingName/added</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing <strong>thingName</strong> is added to thing group <strong>thingGroupName</strong>. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingGroupMembership/thingGroup/thingGroupName/thing/thingName/removed</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing <strong>thingName</strong> is removed from thing group <strong>thingGroupName</strong>. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
</tbody>
</table>
### MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/events/thingGroupHierarchy/thingGroup/parentThingGroupName/childThingGroup/childThingGroupName/added</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing group <code>childThingGroupName</code> is added to thing group <code>parentThingGroupName</code>. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
<tr>
<td>$aws/events/thingGroupHierarchy/thingGroup/parentThingGroupName/childThingGroup/childThingGroupName/removed</td>
<td>Subscribe</td>
<td>AWS IoT publishes to this topic when thing group <code>childThingGroupName</code> is removed from thing group <code>parentThingGroupName</code>. For more information, see the section called “Registry events” (p. 1208).</td>
</tr>
</tbody>
</table>

### Fleet provisioning topics

**Note**

The client operations noted as **Receive** in this table indicate topics that AWS IoT publishes directly to the client that requested it, whether the client has subscribed to the topic or not. Clients should expect to receive these response messages even if they haven't subscribed to them. These response messages don't pass through the message broker and they can't be subscribed to by other clients or rules.

These messages support response buffers in Concise Binary Object Representation (CBOR) format and JavaScript Object Notation (JSON), depending on the `payload-format` of the topic.

<table>
<thead>
<tr>
<th><code>payload-format</code></th>
<th>Response format data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>cbor</td>
<td>Concise Binary Object Representation (CBOR)</td>
</tr>
<tr>
<td>json</td>
<td>JavaScript Object Notation (JSON)</td>
</tr>
</tbody>
</table>

For more information, see [Device provisioning MQTT API (p. 879)](#).

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/certificates/create/payload-format</td>
<td>Publish</td>
<td>Publish to this topic to create a certificate from a certificate signing request (CSR).</td>
</tr>
<tr>
<td>$aws/certificates/create/payload-format/accepted</td>
<td>Subscribe, Receive</td>
<td>AWS IoT publishes to this topic after a successful call to <code>$aws/certificates/create/payload-format</code>.</td>
</tr>
<tr>
<td>$aws/certificates/create/payload-format/rejected</td>
<td>Subscribe, Receive</td>
<td>AWS IoT publishes to this topic after an unsuccessful call to <code>$aws/certificates/create/payload-format</code>.</td>
</tr>
<tr>
<td>$aws/certificates/create-from-csr/payload-format</td>
<td>Publish</td>
<td>Publishes to this topic to create a certificate from a CSR.</td>
</tr>
</tbody>
</table>
### MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>$aws/certificates/create-from-csr/payload-format</code>/accepted</td>
<td>Subscribe, Receive</td>
<td>AWS IoT publishes to this topic a successful call to <code>$aws/certificates/create-from-csr/payload-format</code>.</td>
</tr>
<tr>
<td><code>$aws/certificates/create-from-csr/payload-format</code>/rejected</td>
<td>Subscribe, Receive</td>
<td>AWS IoT publishes to this topic an unsuccessful call to <code>$aws/certificates/create-from-csr/payload-format</code>.</td>
</tr>
<tr>
<td><code>$aws/provisioning-templates/templateName/provision/payload-format</code></td>
<td>Publish</td>
<td>Publish to this topic to register a thing.</td>
</tr>
<tr>
<td><code>$aws/provisioning-templates/templateName/provision/payload-format</code>/accepted</td>
<td>Subscribe, Receive</td>
<td>AWS IoT publishes to this topic after a successful call to <code>$aws/provisioning-templates/templateName/provision/payload-format</code>.</td>
</tr>
<tr>
<td><code>$aws/provisioning-templates/templateName/provision/payload-format</code>/rejected</td>
<td>Subscribe, Receive</td>
<td>AWS IoT publishes to this topic after an unsuccessful call to <code>$aws/provisioning-templates/templateName/provision/payload-format</code>.</td>
</tr>
</tbody>
</table>

### Job topics

**Note**
The client operations noted as **Receive** in this table indicate topics that AWS IoT publishes directly to the client that requested it, whether the client has subscribed to the topic or not. Clients should expect to receive these response messages even if they haven't subscribed to them.

These response messages don't pass through the message broker and they can't be subscribed to by other clients or rules. To subscribe to job activity related messages, use the notify and notify-next topics.

When subscribing to the job and jobExecution event topics for your fleet-monitoring solution, you must first enable job and job execution events (p. 1205) to receive any events on the cloud side.

For more information, see [Jobs device MQTT API operations](p. 785).

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>$aws/things/thingName/jobs/get</code></td>
<td>Publish</td>
<td>Devices publish a message to this topic to make a GetPendingJobExecutions request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td><code>$aws/things/thingName/jobs/get/accepted</code></td>
<td>Subscribe, Receive</td>
<td>Devices subscribe to this topic to receive successful responses from a GetPendingJobExecutions request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td><code>$aws/things/thingName/jobs/get/rejected</code></td>
<td>Subscribe, Receive</td>
<td>Devices subscribe to this topic to receive a response when a GetPendingJobExecutions request is...</td>
</tr>
</tbody>
</table>
### Topic

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/things/thingName/jobs/start-next</td>
<td>Publish</td>
<td>Devices publish a message to this topic to make a StartNextPendingJobExecution request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td>$aws/things/thingName/jobs/start-next/accepted</td>
<td>Subscribe, Receive</td>
<td>Devices subscribe to this topic to receive successful responses to a StartNextPendingJobExecution request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td>$aws/things/thingName/jobs/start-next/rejected</td>
<td>Subscribe, Receive</td>
<td>Devices subscribe to this topic to receive a response when a StartNextPendingJobExecution request is rejected. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td>$aws/things/thingName/jobs/jobId/get</td>
<td>Publish</td>
<td>Devices publish a message to this topic to make a DescribeJobExecution request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td>$aws/things/thingName/jobs/jobId/get/accepted</td>
<td>Subscribe, Receive</td>
<td>Devices subscribe to this topic to receive successful responses to a DescribeJobExecution request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td>$aws/things/thingName/jobs/jobId/get/rejected</td>
<td>Subscribe, Receive</td>
<td>Devices subscribe to this topic to receive a response when a DescribeJobExecution request is rejected. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td>$aws/things/thingName/jobs/jobId/update</td>
<td>Publish</td>
<td>Devices publish a message to this topic to make an UpdateJobExecution request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
<tr>
<td>$aws/things/thingName/jobs/jobId/update/accepted</td>
<td>Subscribe, Receive</td>
<td>Devices subscribe to this topic to receive successful responses to an UpdateJobExecution request. For more information, see [Jobs device MQTT API operations](p. 785).</td>
</tr>
</tbody>
</table>

**Note**

Only the device that publishes to $aws/things/thingName/jobs/jobId/update receives messages on this topic.
### MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
</table>
| `$aws/things/thingName/jobs/jobId/update/rejected` | Subscribe, Receive | Devices subscribe to this topic to receive a response when an `UpdateJobExecution` request is rejected. For more information, see [Jobs device MQTT API operations (p. 785)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-mqtt-api.html).  
**Note** Only the device that publishes to `$aws/things/thingName/jobs/jobId/update` receives messages on this topic. |
| `$aws/things/thingName/jobs/notify` | Subscribe | Devices subscribe to this topic to receive notifications when a job execution is added or removed to the list of pending executions for a thing. For more information, see [Jobs device MQTT API operations (p. 785)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-mqtt-api.html). |
| `$aws/things/thingName/jobs/notify-next` | Subscribe | Devices subscribe to this topic to receive notifications when the next pending job execution for the thing is changed. For more information, see [Jobs device MQTT API operations (p. 785)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-mqtt-api.html). |
| `$aws/events/job/jobId/completed` | Subscribe | The Jobs service publishes an event on this topic when a job completes. For more information, see [Jobs events (p. 1216)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-events.html). |
| `$aws/events/job/jobId/canceled` | Subscribe | The Jobs service publishes an event on this topic when a job is canceled. For more information, see [Jobs events (p. 1216)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-events.html). |
| `$aws/events/job/jobId/deleted` | Subscribe | The Jobs service publishes an event on this topic when a job is deleted. For more information, see [Jobs events (p. 1216)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-events.html). |
| `$aws/events/job/jobId/cancellation_in_progress` | Subscribe | The Jobs service publishes an event on this topic when a job cancellation begins. For more information, see [Jobs events (p. 1216)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-events.html). |
| `$aws/events/job/jobId/deletion_in_progress` | Subscribe | The Jobs service publishes an event on this topic when a job deletion begins. For more information, see [Jobs events (p. 1216)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-events.html). |
| `$aws/events/jobExecution/jobId/succeeded` | Subscribe | The Jobs service publishes an event on this topic when job execution succeeds. For more information, see [Jobs events (p. 1216)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-events.html). |
| `$aws/events/jobExecution/jobId/failed` | Subscribe | The Jobs service publishes an event on this topic when a job execution fails. For more information, see [Jobs events (p. 1216)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs-events.html). |
## MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/events/jobExecution/jobId/rejected</td>
<td>Subscribe</td>
<td>The Jobs service publishes an event on this topic when a job execution is rejected. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobId/canceled</td>
<td>Subscribe</td>
<td>The Jobs service publishes an event on this topic when a job execution is canceled. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobId/timed_out</td>
<td>Subscribe</td>
<td>The Jobs service publishes an event on this topic when a job execution times out. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobId/removed</td>
<td>Subscribe</td>
<td>The Jobs service publishes an event on this topic when a job execution is removed. For more information, see Jobs events (p. 1216).</td>
</tr>
<tr>
<td>$aws/events/jobExecution/jobId/deleted</td>
<td>Subscribe</td>
<td>The Jobs service publishes an event on this topic when a job execution is deleted. For more information, see Jobs events (p. 1216).</td>
</tr>
</tbody>
</table>

### Rule topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/rules/ruleName</td>
<td>Publish</td>
<td>A device or an application publishes to this topic to trigger rules directly. For more information, see Reducing messaging costs with Basic Ingest (p. 585).</td>
</tr>
</tbody>
</table>

### Secure tunneling topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/things/thing-name/tunnels/notify</td>
<td>Subscribe</td>
<td>AWS IoT publishes this message for an IoT agent to start a local proxy on the remote device. For more information, see the section called “IoT agent snippet” (p. 841).</td>
</tr>
</tbody>
</table>

### Shadow topics

The topics in this section are used by named and unnamed shadows. The topics used by each differ only in the topic prefix. This table shows the topic prefix used by each shadow type.
AWS IoT Core Developer Guide

MQTT topics

<table>
<thead>
<tr>
<th>ShadowTopicPrefix value</th>
<th>Shadow type</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/things/thingName/shadow</td>
<td>Unnamed (classic) shadow</td>
</tr>
<tr>
<td>$aws/things/thingName/shadow/thingName/shadowName</td>
<td>Named shadow</td>
</tr>
</tbody>
</table>

To create a complete topic, select the ShadowTopicPrefix for the type of shadow to which you want to refer, replace thingName and if applicable, shadowName, with their corresponding values, and then append that with the topic stub as shown in the following table. Remember that topics are case sensitive.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ShadowTopicPrefix/delete</td>
<td>Publish/Subscribe</td>
<td>A device or an application publishes to this topic to delete a shadow. For more information, see /delete (p. 692).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/delete/accepted</td>
<td>Subscribe</td>
<td>The Device Shadow service sends messages to this topic when a shadow is deleted. For more information, see /delete/accepted (p. 693).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/delete/rejected</td>
<td>Subscribe</td>
<td>The Device Shadow service sends messages to this topic when a request to delete a shadow is rejected. For more information, see /delete/rejected (p. 693).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/get</td>
<td>Publish/Subscribe</td>
<td>An application or a thing publishes an empty message to this topic to get a shadow. For more information, see Device Shadow MQTT topics (p. 686).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/get/accepted</td>
<td>Subscribe</td>
<td>The Device Shadow service sends messages to this topic when a request for a shadow is made successfully. For more information, see /get/accepted (p. 687).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/get/rejected</td>
<td>Subscribe</td>
<td>The Device Shadow service sends messages to this topic when a request for a shadow is rejected. For more information, see /get/rejected (p. 688).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/update</td>
<td>Publish/Subscribe</td>
<td>A thing or application publishes to this topic to update a shadow. For more information, see /update (p. 689).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/update/accepted</td>
<td>Subscribe</td>
<td>The Device Shadow service sends messages to this topic when an update is successfully made to a shadow. For more information, see /update/accepted (p. 690).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/update/rejected</td>
<td>Subscribe</td>
<td>The Device Shadow service sends messages to this topic when an update to a shadow is rejected. For more information, see /update/rejected (p. 692).</td>
</tr>
</tbody>
</table>
### MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ShadowTopicPrefix/update/delta</td>
<td>Subscribe</td>
<td>The Device Shadow service sends messages to this topic when a difference is detected between the reported and desired sections of a shadow. For more information, see [update/delta](p. 690).</td>
</tr>
<tr>
<td>ShadowTopicPrefix/update/documents</td>
<td>Subscribe</td>
<td>AWS IoT publishes a state document to this topic whenever an update to the shadow is successfully performed. For more information, see [update/documents](p. 691).</td>
</tr>
</tbody>
</table>

### MQTT-based file delivery topics

These messages support response buffers in Concise Binary Object Representation (CBOR) format and JavaScript Object Notation (JSON), depending on the `payload-format` of the topic.

<table>
<thead>
<tr>
<th><code>payload-format</code></th>
<th>Response format data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>cbor</td>
<td>Concise Binary Object Representation (CBOR)</td>
</tr>
<tr>
<td>json</td>
<td>JavaScript Object Notation (JSON)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Topic</th>
<th>Client operations allowed</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/things/ThingName/streams/StreamId/data/payload-format</td>
<td>Subscribe</td>
<td>AWS MQTT-based file delivery publishes to this topic if the &quot;GetStream&quot; request from a device is accepted. The payload contains the stream data. For more information, see [Using AWS IoT MQTT-based file delivery in devices](p. 922).</td>
</tr>
<tr>
<td>$aws/things/ThingName/streams/StreamId/get/payload-format</td>
<td>Publish</td>
<td>A device publishes to this topic to perform a &quot;GetStream&quot; request. For more information, see [Using AWS IoT MQTT-based file delivery in devices](p. 922).</td>
</tr>
<tr>
<td>$aws/things/ThingName/streams/StreamId/description/payload-format</td>
<td>Subscribe</td>
<td>AWS MQTT-based file delivery publishes to this topic if the &quot;DescribeStream&quot; request from a device is accepted. The payload contains the stream description. For more information, see [Using AWS IoT MQTT-based file delivery in devices](p. 922).</td>
</tr>
<tr>
<td>$aws/things/ThingName/streams/StreamId/describe/payload-format</td>
<td>Publish</td>
<td>A device publishes to this topic to perform a &quot;DescribeStream&quot; request. For more information, see [Using AWS IoT MQTT-based file delivery in devices](p. 922).</td>
</tr>
</tbody>
</table>
Configurable endpoints

With AWS IoT Core, you can configure and manage the behaviors of your data endpoints by using domain configurations. With domain configurations, you can generate multiple AWS IoT Core data endpoints, customize data endpoints with your own fully qualified domain names (FQDN) and associated server certificates, and also associate a custom authorizer. For more information, see Custom authentication and authorization (p. 322).

Note
This feature is not available in GovCloud AWS Regions.

You can use domain configurations to simplify tasks such as the following.

- Migrate devices to AWS IoT Core.
- Support heterogeneous device fleets by maintaining separate domain configurations for separate device types.
- Maintain brand identity (for example, through domain name) while migrating application infrastructure to AWS IoT Core.

AWS IoT Core uses the server name indication (SNI) TLS extension to apply domain configurations. Devices must use this extension when they connect. They also must pass a server name that is identical to the domain name that you specify in the domain configuration. To test this service, use the v2 version of the AWS IoT Device SDKs in GitHub.

If you create multiple data endpoints in your AWS account, they will share AWS IoT Core resources such as MQTT topics, device shadows, and rules.

When you provide the server certificates for AWS IoT Core custom domain configuration, the certificates have a maximum of four domain names. For more information, see AWS IoT Core endpoints and quotas.

Topics
- Creating and configuring AWS-managed domains (p. 124)
- Creating and configuring custom domains (p. 124)
- Managing domain configurations (p. 127)
- Configuring TLS settings in domain configurations (p. 128)
Creating and configuring AWS-managed domains

You create a configurable endpoint on an AWS-managed domain by using the `CreateDomainConfiguration` API. A domain configuration for an AWS-managed domain consists of the following:

- **domainConfigurationName**
  
  A user-defined name that identifies the domain configuration and the value must be unique to your AWS Region. You can't use domain configuration names that start with `IoT:` because they are reserved for default endpoints.

- **defaultAuthorizerName** (optional)
  
  The name of the custom authorizer to use on the endpoint.

- **allowAuthorizerOverride**
  
  A Boolean value that specifies whether devices can override the default authorizer by specifying a different authorizer in the HTTP header of the request. This value is required if a value for `defaultAuthorizerName` is specified.

- **serviceType**
  
  The service type that the endpoint delivers. AWS IoT Core only supports the DATA service type. When you specify `DATA`, AWS IoT Core returns an endpoint with an endpoint type of `iot:Data-ATS`. You can't create a configurable `iot:Data` endpoint.

- **TlsConfig** (optional)
  
  An object that specifies the TLS configuration for a domain. For more information, see ??? (p. 128).

The following example AWS CLI command creates a domain configuration for a Data endpoint.

```
aws iot create-domain-configuration --domain-configuration-name "myDomainConfigurationName" --service-type "DATA"
```

Creating and configuring custom domains

Domain configurations let you specify a custom fully qualified domain name (FQDN) to connect to AWS IoT Core. With custom domains, you can manage your own server certificates so that you can manage details, such as the root certificate authority (CA) used to sign the certificate, the signature algorithm, the certificate chain depth, and the lifecycle of the certificate.

The workflow to set up a domain configuration with a custom domain consists of the following three stages.

1. Registering Server Certificates in AWS Certificate Manager (p. 124)
2. Creating a Domain Configuration (p. 126)
3. Creating DNS Records (p. 127)

Registering server certificates in AWS certificate manager

Before you create a domain configuration with a custom domain, you must register your server certificate chain in **AWS Certificate Manager (ACM)**. You can use the following three types of server certificates.

- ACM Generated Public Certificates (p. 125)
Note
AWS IoT Core considers a certificate to be signed by a public CA if it's included in Mozilla's trusted ca-bundle.

Certificate requirements

See Prerequisites for Importing Certificates for the requirements for importing certificates into ACM. In addition to these requirements, AWS IoT Core adds the following requirements.

- The leaf certificate must include contain the Extended Key Usage x509 v3 extension with a value of serverAuth (TLS Web Server Authentication). If you request the certificate from ACM, this extension is automatically added.
- The maximum certificate chain depth is 5 certificates.
- The maximum certificate chain size is 16KB.
- The certificate key size is 2048.

Using one certificate for multiple domains

If you plan to use one certificate to cover multiple subdomains, use a wildcard domain in the common name (CN) or Subject Alternative Names (SAN) field. For example, use *iot.example.com to cover dev.iot.example.com, qa.iot.example.com, and prod.iot.example.com. Each FQDN requires its own domain configuration, but more than one domain configuration can use the same wildcard value. Either the CN or the SAN must cover the FQDN that you want to use as a custom domain. If SANs are present, the CN is ignored and a SAN must cover the FQDN that you want to use as a custom domain. This coverage can be an exact match or a wildcard match. After a wildcard certificate has been validated and registered to an account, other accounts in the region are blocked from creating custom domains that overlap with the certificate.

The following sections describe how to get each type of certificate. Every certificate resource requires an Amazon Resource Name (ARN) registered with ACM that you use when you create your domain configuration.

ACM-generated public certificates

You can generate a public certificate for your custom domain by using the RequestCertificate API. When you generate a certificate in this way, ACM validates your ownership of the custom domain. For more information, see Request a Public Certificate in the AWS Certificate Manager User Guide.

External certificates signed by a public CA

If you already have a server certificate that is signed by a public CA (a CA that is included in Mozilla's trusted ca-bundle), you can import the certificate chain directly into ACM by using the ImportCertificate API. To learn more about this task and the prerequisites and certificate format requirements, see Importing Certificates.

External certificates signed by a private CA

If you already have a server certificate that is signed by a private CA or self-signed, you can use the certificate to create your domain configuration, but you also must create an extra public certificate in ACM to validate ownership of your domain. To do this, register your server certificate chain in ACM using the ImportCertificate API. To learn more about this task and the prerequisites and certificate format requirements, see Importing Certificates.
Creating a validation certificate

After you import your certificate to ACM, generate a public certificate for your custom domain by using the `RequestCertificate` API. When you generate a certificate in this way, ACM validates your ownership of the custom domain. For more information, see Request a Public Certificate. When you create your domain configuration, use this public certificate as your validation certificate.

Creating a domain configuration

You create a configurable endpoint on a custom domain by using the `CreateDomainConfiguration` API. A domain configuration for a custom domain consists of the following:

- **domainConfigurationName**
  A user-defined name that identifies the domain configuration. Domain configuration names starting with `IoT:` are reserved for default endpoints and can't be used. Also, this value must be unique to your AWS Region.

- **domainName**
  The FQDN that your devices use to connect to AWS IoT Core. AWS IoT Core leverages the server name indication (SNI) TLS extension to apply domain configurations. Devices must use this extension when connecting and pass a server name that is identical to the domain name that is specified in the domain configuration.

- **serverCertificateArns**
  The ARN of the server certificate chain that you registered with ACM. AWS IoT Core currently supports only one server certificate.

- **validationCertificateArn**
  The ARN of the public certificate that you generated in ACM to validate ownership of your custom domain. This argument isn't required if you use a publicly signed or ACM-generated server certificate.

- **defaultAuthorizerName (optional)**
  The name of the custom authorizer to use on the endpoint.

- **allowAuthorizerOverride**
  A Boolean value that specifies whether devices can override the default authorizer by specifying a different authorizer in the HTTP header of the request. This value is required if a value for `defaultAuthorizerName` is specified.

- **serviceType**
  AWS IoT Core currently supports only the DATA service type. When you specify DATA, AWS IoT returns an endpoint with an endpoint type of `iot:Data-ATS`.

- **TlsConfig (optional)**
  An object that specifies the TLS configuration for a domain. For more information, see ??? (p. 128).

The following AWS CLI command creates a domain configuration for `iot.example.com`.

```
aws iot create-domain-configuration --domain-configuration-name "myDomainConfigurationName" --service-type "DATA" --domain-name "iot.example.com" --server-certificate-arns serverCertARN --validation-certificate-arn validationCertArn
```

**Note**

After you create your domain configuration, it might take up to 60 minutes until AWS IoT Core serves your custom server certificates.
Creating DNS records

After you register your server certificate chain and create your domain configuration, create a DNS record so that your custom domain points to an AWS IoT domain. This record must point to an AWS IoT endpoint of type iot:Data-ATS. You can get your endpoint by using the DescribeEndpoint API.

The following AWS CLI command shows how to get your endpoint.

```
aws iot describe-endpoint --endpoint-type iot:Data-ATS
```

After you get your iot:Data-ATS endpoint, create a CNAME record from your custom domain to this AWS IoT endpoint. If you create multiple custom domains in the same AWS account, alias them to this same iot:Data-ATS endpoint.

Troubleshooting

If you have trouble connecting devices to a custom domain, make sure that AWS IoT Core has accepted and applied your server certificate. You can verify that AWS IoT Core has accepted your certificate by using either the AWS IoT Core console or the AWS CLI.

To use the AWS IoT Core console, navigate to the Settings page and select the domain configuration name. In the Server certificate details section, check the status and status details. If the certificate is invalid, replace it in ACM with a certificate that meets the certificate requirements (p. 125) listed in the previous section. If the certificate has the same ARN, AWS IoT Core will be pick it up and apply it automatically.

To check the certificate status by using the AWS CLI, call the DescribeDomainConfiguration API and specify your domain configuration name.

**Note**

If your certificate is invalid, AWS IoT Core will continue to serve the last valid certificate.

You can check which certificate is being served on your endpoint by using the following openssl command.

```
openssl s_client -connect custom-domain-name:8883 -showcerts -servername custom-domain-name
```

Managing domain configurations

You can manage the lifecycles of existing configurations by using the following APIs.

- ListDomainConfigurations
- DescribeDomainConfiguration
- UpdateDomainConfiguration
- DeleteDomainConfiguration

Viewing domain configurations

To return a paginated list of all domain configurations in your AWS account, use the ListDomainConfigurations API. You can see the details of a particular domain configuration using the DescribeDomainConfiguration API. This API takes a single domainConfigurationName parameter and returns the details of the specified configuration.

**Example**
Updating domain configurations

To update the status or the custom authorizer of your domain configuration, use the `UpdateDomainConfiguration` API. You can set the status to ENABLED or DISABLED. If you disable the domain configuration, devices connected to that domain receive an authentication error. Currently you can’t update the server certificate in your domain configuration. To change the certificate of a domain configuration, you must delete and recreate it.

Example

Deleting domain configurations

Before you delete a domain configuration, use the `UpdateDomainConfiguration` API to set the status to DISABLED. This helps you avoid accidentally deleting the endpoint. After you disable the domain configuration, delete it by using the `DeleteDomainConfiguration` API. You must place AWS-managed domains in DISABLED status for 7 days before you can delete them. You can place custom domains in DISABLED status and then immediately delete them.

Example

After you delete a domain configuration, AWS IoT Core no longer serves the server certificate associated with that custom domain.

Rotating certificates in custom domains

You may need to periodically replace your server certificate with an updated certificate. The rate at which you do this depends on the validity period of your certificate. If you generated your server certificate by using AWS Certificate Manager (ACM), you can set the certificate to renew automatically. When ACM renews your certificate, AWS IoT Core automatically picks up the new certificate. You don’t have to perform any additional action. If you imported your server certificate from a different source, you can rotate it by reimporting it to ACM. For information about reimporting certificates, see Reimport a certificate.

Note

AWS IoT Core only picks up certificate updates under the following conditions.

- The new certificate has the same ARN as the old one.
- The new certificate has the same signing algorithm, common name, or subject alternative name as the old one.

Configuring TLS settings in domain configurations

AWS IoT Core provides predefined security policies (p. 386) for you to customize your Transport Layer Security (TLS) settings for TLS 1.2 and TLS 1.3 in domain configurations. A security policy is a combination of TLS protocols and their ciphers that determine the supported protocols and ciphers during TLS negotiations between a client and a server. With the supported security policies, you can manage your devices’ TLS settings with more flexibility, apply the most up-to-date security measures when connecting new devices, and maintain consistent TLS configurations for existing devices.

The following table describes the security policies, their TLS versions, and supported regions:

<table>
<thead>
<tr>
<th>Security policy name</th>
<th>Supported AWS Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>IoTSecurityPolicy_TLS13_1</td>
<td>All 2023 Regions</td>
</tr>
<tr>
<td>IoTSecurityPolicy_TLS13_2</td>
<td>All 2023 Regions</td>
</tr>
<tr>
<td>IoTSecurityPolicy_TLS12_1</td>
<td>All 2023 Regions</td>
</tr>
</tbody>
</table>
The names of the security policies in AWS IoT Core include version information based on the year and month that they were released. If you create a new domain configuration, the security policy will default to IoTSecurityPolicy_TLS13_1_2_2022_10. For a complete table of security policies with details of protocols, TCP ports, and ciphers, see Security policies (p. 386). AWS IoT Core doesn’t support custom security policies. For more information, see ?? (p. 386).

To configure TLS settings in domain configurations, you can use the AWS IoT console or the AWS CLI.

Contents
- Configure TLS settings in domain configurations (console) (p. 129)
- Configure TLS settings in domain configurations (CLI) (p. 129)

Configure TLS settings in domain configurations (console)

To configure TLS settings using the AWS IoT console

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. To configure TLS settings when you create a new domain configuration, follow these steps.
   1. In the left navigation pane, choose Settings, and then, from the Domain configurations section, choose Create domain configuration.
   2. In the Create domain configuration page, in the Custom domain settings - optional section, choose a security policy from Select security policy.
   3. Follow the widget and complete the rest of the steps. Choose Create domain configuration.
3. To update TLS settings in an existing domain configuration, follow these steps.
   1. In the left navigation pane, choose Settings, and then, under Domain configurations, choose a domain configuration.
   2. In the Domain configuration details page, choose Edit. Then, in the Custom domain settings - optional section, under Select security policy, choose a security policy.
   3. Choose Update domain configuration.

For more information, see Create a domain configuration and Manage domain configurations (p. 127).

Configure TLS settings in domain configurations (CLI)

You can use the create-domain-configuration and update-domain-configuration CLI commands to configure your TLS settings in domain configurations.

1. To specify TLS settings using the create-domain-configuration CLI command:

```
aws iot create-domain-configuration \
  --domain-configuration-name domainConfigurationName \n  --tls-config securityPolicy=IoTSecurityPolicy_TLS13_1_2_2022_10
```
The output of this command can look like the following:

```
{
    "domainConfigurationName": "test",
    "domainConfigurationArn": "arn:aws:iot:us-west-2:123456789012:domainconfiguration/test/34ga9"
}
```

If you create a new domain configuration without specifying the security policy, the value will default to: `IoTSecurityPolicy_TLS13_1_2_2022_10`.

2. To describe TLS settings using the `describe-domain-configuration` CLI command:

```
aws iot describe-domain-configuration \
    --domain-configuration-name domainConfigurationName
```

This command can return the domain configuration details that include the TLS settings like the following:

```
{
    "tlsConfig": {
        "securityPolicy": "IoTSecurityPolicy_TLS13_1_2_2022_10"
    },
    "domainConfigurationStatus": "ENABLED",
    "serviceType": "DATA",
    "domainType": "AWS_MANAGED",
    "domainName": "d1234567890abcdefgij-ats.iot.us-west-2.amazonaws.com",
    "serverCertificates": [],
    "lastStatusChangeDate": 1678750928.997,
    "domainConfigurationName": "test",
    "domainConfigurationArn": "arn:aws:iot:us-west-2:123456789012:domainconfiguration/test/34ga9"
}
```

3. To update TLS settings using the `update-domain-configuration` CLI command:

```
aws iot update-domain-configuration \
    --domain-configuration-name domainConfigurationName \
    --tls-config securityPolicy=IoTSecurityPolicy_TLS13_1_2_2022_10
```

The output of this command can look like the following:

```
{
    "domainConfigurationName": "test",
    "domainConfigurationArn": "arn:aws:iot:us-west-2:123456789012:domainconfiguration/test/34ga9"
}
```

4. To update the TLS settings for your ATS endpoint, run the `update-domain-configuration` CLI command. The domain configuration name for your ATS endpoint is `iot:Data-ATS`.

```
aws iot update-domain-configuration \
    --domain-configuration-name "iot:Data-ATS" \
    --tls-config securityPolicy=IoTSecurityPolicy_TLS13_1_2_2022_10
```

The output of the command can look like the following:

```
{
```

130
Connecting to AWS IoT FIPS endpoints

AWS IoT provides endpoints that support the Federal Information Processing Standard (FIPS) 140-2. FIPS compliant endpoints are different from standard AWS endpoints. To interact with AWS IoT in a FIPS-compliant manner, you must use the endpoints described below with your FIPS compliant client. The AWS IoT console is not FIPS compliant.

The following sections describe how to access the FIPS compliant AWS IoT endpoints by using the REST API, an SDK, or the AWS CLI.

Topics
- AWS IoT Core - control plane endpoints (p. 131)
- AWS IoT Core - data plane endpoints (p. 131)
- AWS IoT Device Management - jobs data endpoints (p. 132)
- AWS IoT Device Management - Fleet Hub endpoints (p. 132)
- AWS IoT Device Management - secure tunneling endpoints (p. 132)

AWS IoT Core - control plane endpoints

The FIPS compliant AWS IoT Core - control plane endpoints that support the AWS IoT operations and their related CLI commands are listed in FIPS Endpoints by Service. In FIPS Endpoints by Service, find the AWS IoT Core - control plane service, and look up the endpoint for your AWS Region.

To use the FIPS compliant endpoint when you access the AWS IoT operations, use the AWS SDK or the REST API with the endpoint that is appropriate for your AWS Region.

To use the FIPS compliant endpoint when you run aws iot CLI commands, add the --endpoint parameter with the appropriate endpoint for your AWS Region to the command.

AWS IoT Core - data plane endpoints

The FIPS compliant AWS IoT Core - data plane endpoints are listed in FIPS Endpoints by Service. In FIPS Endpoints by Service, find the AWS IoT Core - data plane service, and look up the endpoint for your AWS Region.

You can use the FIPS compliant endpoint for your AWS Region with a FIPS compliant client by using the AWS IoT Device SDK and providing the endpoint to the SDK's connection function in place of your account's default AWS IoT Core - data plane endpoint. The connection function is specific to the AWS IoT Device SDK. For an example of a connection function, see the Connection function in the AWS IoT Device SDK for Python.

Note
AWS IoT doesn't support AWS account-specific AWS IoT Core - data plane endpoints that are FIPS-compliant. Service features that require an AWS account-specific endpoint in the Server Name Indication (SNI) (p. 386) can't be used. FIPS-compliant AWS IoT Core - data plane
endpoints can't support Multi-Account Registration Certificates (p. 302), Custom Domains (p. 124), Custom Authorizers (p. 322), and Configurable Endpoints (p. 123) (including supported TLS policies (p. 386)).

AWS IoT Device Management - jobs data endpoints

The FIPS compliant AWS IoT Device Management - jobs data endpoints are listed in FIPS Endpoints by Service. In FIPS Endpoints by Service, find the AWS IoT Device Management - jobs data service, and look up the endpoint for your AWS Region.

To use the FIPS compliant AWS IoT Device Management - jobs data endpoint when you run aws iot-jobs-data CLI commands, add the --endpoint parameter with the appropriate endpoint for your AWS Region to the command. You can also use the REST API with this endpoint.

You can use the FIPS compliant endpoint for your AWS Region with a FIPS compliant client by using the AWS IoT Device SDK and providing the endpoint to the SDK's connection function in place of your account's default AWS IoT Device Management - jobs data endpoint. The connection function is specific to the AWS IoT Device SDK. For an example of a connection function, see the Connection function in the AWS IoT Device SDK for Python.

AWS IoT Device Management - Fleet Hub endpoints

The FIPS compliant AWS IoT Device Management - Fleet Hub endpoints to use with Fleet Hub for AWS IoT Device Management CLI commands are listed in FIPS Endpoints by Service. In FIPS Endpoints by Service, find the AWS IoT Device Management - Fleet Hub service, and look up the endpoint for your AWS Region.

To use the FIPS compliant AWS IoT Device Management - Fleet Hub endpoint when you run aws iotfleethub CLI commands, add the --endpoint parameter with the appropriate endpoint for your AWS Region to the command. You can also use the REST API with this endpoint.

AWS IoT Device Management - secure tunneling endpoints

The FIPS compliant AWS IoT Device Management - secure tunneling endpoints for the AWS IoT secure tunneling API and the corresponding CLI commands are listed in FIPS Endpoints by Service. In FIPS Endpoints by Service, find the AWS IoT Device Management - secure tunneling service, and look up the endpoint for your AWS Region.

To use the FIPS compliant AWS IoT Device Management - secure tunneling endpoint when you run aws iotsecuretunneling CLI commands, add the --endpoint parameter with the appropriate endpoint for your AWS Region to the command. You can also use the REST API with this endpoint.
AWS IoT tutorials

The AWS IoT tutorials are divided into two learning paths to support two different goals. Choose the best learning path for your goal.

- You want to build a proof-of-concept to test or demonstrate an AWS IoT solution idea
  
  To demonstrate common IoT tasks and applications using the AWS IoT Device Client on your devices, follow the section called “Building demos with the AWS IoT Device Client” (p. 133) learning path. The AWS IoT Device Client provides device software with which you can apply your own cloud resources to demonstrate an end-to-end solution with minimum development.
  
  For information about the AWS IoT Device Client, see the AWS IoT Device Client.
  
- You want to learn how to build production software to deploy your solution
  
  To create your own solution software that meets your specific requirements using an AWS IoT Device SDK, follow the section called “Building solutions with the AWS IoT Device SDKs” (p. 183) learning path.
  
  For information about the available AWS IoT Device SDKs, see ??? (p. 1428). For information about the AWS SDKs, see Tools to Build on AWS.

AWS IoT tutorial learning path options
- Building demos with the AWS IoT Device Client (p. 133)
- Building solutions with the AWS IoT Device SDKs (p. 183)

Building demos with the AWS IoT Device Client

The tutorials in this learning path walk you through the steps to develop demonstration software by using the AWS IoT Device Client. The AWS IoT Device Client provides software that runs on your IoT device to test and demonstrate aspects of an IoT solution that’s built on AWS IoT.

The goal of these tutorials is to facilitate exploration and experimentation so you can feel confident that AWS IoT supports your solution before you develop your device software.

What you’ll learn in these tutorials:
- How to prepare a Raspberry Pi for use as an IoT device with AWS IoT
- How to demonstrate AWS IoT features by using the AWS IoT Device Client on your device

In this learning path, you’ll install the AWS IoT Device Client on your own Raspberry Pi and create the AWS IoT resources in the cloud to demonstrate IoT solution ideas. While the tutorials in this learning path demonstrate features by using a Raspberry Pi, they explain the goals and procedures to help you adapt them to other devices.

Prerequisites to building demos with the AWS IoT Device Client

This section describes what you’ll need to have before you start the tutorials in this learning path.
To complete the tutorials in this learning path, you’ll need:

- **An AWS account**
  
  You can use your existing AWS account, if you have one, but you might need to add additional roles or permissions to use the AWS IoT features these tutorials use.

  If you need to create a new AWS account, see the section called “Set up your AWS account” (p. 18).

- **A Raspberry Pi or compatible IoT device**
  
  The tutorials use a Raspberry Pi because it comes in different form factors, it's ubiquitous, and it's a relatively inexpensive demonstration device. The tutorials have been tested on the Raspberry Pi 3 Model B+, the Raspberry Pi 4 Model B, and on an Amazon EC2 instance running Ubuntu Server 20.04 LTS (HVM). To use the AWS CLI and run the commands, We recommend that you use the the latest version of the Raspberry Pi OS (Raspberry Pi OS (64-bit) or the OS Lite). Earlier versions of the OS might work, but we haven't tested it.

  **Note**
  
  The tutorials explain the goals of each step to help you adapt them to IoT hardware that we haven’t tried them on; however, they do not specifically describe how to adapt them to other devices.

- **Familiarity with the IoT device's operating system**
  
  The steps in these tutorials assume that you are familiar with using basic Linux commands and operations from the command line interface supported by a Raspberry Pi. If you're not familiar with these operations, you might want to give yourself more time to complete the tutorials.

  To complete these tutorials, you should already understand how to:
  
  - Safely perform basic device operations such as assembling and connecting components, connecting the device to required power sources, and installing and removing memory cards.
  - Upload and download system software and files to the device. If your device doesn't use a removable storage device, such as a microSD card, you'll need to know how to connect to your device and upload and download system software and files to the device.
  - Connect your device to the networks that you plan to use it on.
  - Connect to your device from another computer using an SSH terminal or similar program.
  - Use a command line interface to create, copy, move, rename, and set the permissions of files and directories on the device.
  - Install new programs on the device.
  - Transfer files to and from your device using tools such as FTP or SCP.

- **A development and testing environment for your IoT solution**
  
  The tutorials describe the software and hardware required; however, the tutorials assume that you'll be able to perform operations that might not be described explicitly. Examples of such hardware and operations include:
  
  - **A local host computer to download and store files on**
    
    For the Raspberry Pi, this is usually a personal computer or laptop that can read and write to microSD memory cards. The local host computer must:
    
    - Be connected to the Internet.
    - Have the AWS CLI installed and configured.
    - Have a web browser that supports the AWS console.
    - A way to connect your local host computer to your device to communicate with it, to enter commands, and to transfer files
    
      On the Raspberry Pi, this is often done using SSH and SCP from the local host computer.
• **A monitor and keyboard to connect to your IoT device**
  
  These can be helpful, but are not required to complete the tutorials.

• **A way for your local host computer and your IoT devices to connect to the internet**

  This could be a cabled or a wireless network connection to a router or gateway that's connected to the internet. The local host must also be able to connect to the Raspberry Pi. This might require them to be on the same local area network. The tutorials can't show you how to set this up for your particular device or device configuration, but they show how you can test this connectivity.

• **Access to your local area network’s router to view the connected devices**

  To complete the tutorials in this learning path, you’ll need to be able to find the IP address of your IoT device.

  On a local area network, this can be done by accessing the admin interface of the network router your devices connect to. If you can assign a fixed IP address for your device in the router, you can simplify reconnection after each time the device restarts.

  If you have a keyboard and a monitor attached to the device, `ifconfig` can display the device's IP address.

  If none of these are an option, you'll need to find a way to identify the device's IP address after each time it restarts.

After you have all your materials, continue to the section called “Preparing your devices for the AWS IoT Device Client” (p. 135).

**Tutorials in this learning path**

- [Tutorial: Preparing your devices for the AWS IoT Device Client](#)
- [Tutorial: Installing and configuring the AWS IoT Device Client](#)
- [Tutorial: Demonstrate MQTT message communication with the AWS IoT Device Client](#)
- [Tutorial: Demonstrate remote actions (jobs) with the AWS IoT Device Client](#)
- [Tutorial: Cleaning up after running the AWS IoT Device Client tutorials](#)

**Tutorial: Preparing your devices for the AWS IoT Device Client**

This tutorial walks you through the initialization of your Raspberry Pi to prepare it for the subsequent tutorials in this learning path.

The goal of this tutorial is to install the current version of the device’s operating system and make sure that you can communicate with your device in the context of your development environment.

**To start this tutorial:**

- Have the items listed in the section called “Prerequisites to building demos with the AWS IoT Device Client” (p. 133) available and ready to use.

This tutorial takes about 90 minutes to complete.

**When you finish this tutorial:**

- Your IoT device will have an up-to-date operating system.
After you complete this tutorial, the next tutorial prepares your device for the demos that use the AWS IoT Device Client.

Procedures in this tutorial
- Step 1: Install and update the device's operating system (p. 136)
- Step 2: Install and verify required software on your device (p. 138)
- Step 3: Test your device and save the Amazon CA cert (p. 141)

Step 1: Install and update the device's operating system

The procedures in this section describe how to initialize the microSD card that the Raspberry Pi uses for its system drive. The Raspberry Pi's microSD card contains its operating system (OS) software as well as space for its application file storage. If you're not using a Raspberry Pi, follow the device's instructions to install and update the device's operating system software.

After you complete this section, you should be able to start your IoT device and connect to it from the terminal program on your local host computer.

Required equipment:
- Your local development and testing environment
- A Raspberry Pi that or your IoT device, that can connect to the internet
- A microSD memory card with at least 8 GB capacity or sufficient storage for the OS and required software.

**Note**
When selecting a microSD card for these exercises, choose one that is as large as necessary but, as small as possible. A small SD card will be faster to back up and update. On the Raspberry Pi, you won't need more than an 8-GB microSD card for these tutorials. If you need more space for your specific application, the smaller image files you save in these tutorials can resize the file system on a larger card to use all the supported space of the card you choose.

Optional equipment:
- A USB keyboard connected to the Raspberry Pi
- An HDMI monitor and cable to connect the monitor to the Raspberry Pi

Procedures in this section:
- Load the device's operating system onto microSD card (p. 136)
- Start your IoT device with the new operating system (p. 137)
- Connect your local host computer to your device (p. 138)

Load the device's operating system onto microSD card

This procedure uses the local host computer to load the device's operating system onto a microSD card.
Note
If your device doesn't use a removable storage medium for its operating system, install the operating system using the procedure for that device and continue to the section called “Start your IoT device with the new operating system” (p. 137).

To install the operating system on your Raspberry Pi

1. On your local host computer, download and unzip the Raspberry Pi operating system image that you want to use. The latest versions are available from https://www.raspberrypi.com/software/operating-systems/

Choosing a version of Raspberry Pi OS

This tutorial uses the Raspberry Pi OS Lite version because it's the smallest version that supports these the tutorials in this learning path. This version of the Raspberry Pi OS has only a command line interface and doesn't have a graphical user interface. A version of the latest Raspberry Pi OS with a graphical user interface will also work with these tutorials; however, the procedures described in this learning path use only the command line interface to perform operations on the Raspberry Pi.

2. Insert your microSD card into the local host computer.
3. Using an SD card imaging tool, write the unzipped OS image file to the microSD card.
4. After writing the Raspberry Pi OS image to the microSD card:
   a. Open the BOOT partition on the microSD card in a command line window or file explorer window.
   b. In the BOOT partition of the microSD card, in the root directory, create an empty file named ssh with no file extension and no content. This tells the Raspberry Pi to enable SSH communications the first time it starts.
5. Eject the microSD card and safely remove it from the local host computer.

Your microSD card is ready to the section called “Start your IoT device with the new operating system” (p. 137).

Start your IoT device with the new operating system

This procedure installs the microSD card and starts your Raspberry Pi for the first time using the downloaded operating system.

To start your IoT device with the new operation system

1. With the power disconnected from the device, insert the microSD card from the previous step, the section called “Load the device's operating system onto microSD card” (p. 136), into the Raspberry Pi.
2. Connect the device to a wired network.
3. These tutorials will interact with your Raspberry Pi from your local host computer using an SSH terminal.

   If you also want to interact with the device directly, you can:
   a. Connect an HDMI monitor to it to watch the Raspberry Pi's console messages before you can connect the terminal window on your local host computer to your Raspberry Pi.
   b. Connect a USB keyboard to it if you want to interact directly with the Raspberry Pi.
4. Connect the power to the Raspberry Pi and wait about a minute for it to initialize.

   If you have a monitor connected to your Raspberry Pi, you can watch the start-up process on it.
5. Find out your device's IP address:
• If you connected an HDMI monitor to the Raspberry Pi, the IP address appears in the messages displayed on the monitor.
• If you have access to the router your Raspberry Pi is connects to, you can see its address in the router's admin interface.

After you have your Raspberry Pi’s IP address, you’re ready to the section called “Connect your local host computer to your device” (p. 138).

Connect your local host computer to your device

This procedure uses the terminal program on your local host computer to connect to your Raspberry Pi and change its default password.

To connect your local host computer to your device

1. On your local host computer, open the SSH terminal program:
   • Windows: PuTTY
   • Linux/macOS: Terminal

   **Note**
   PuTTY isn't installed automatically on Windows. If it's not on your computer, you might need to download and install it.

2. Connect the terminal program to your Raspberry Pi’s IP address and log in using its default credentials.

   | username: pi | password: raspberry |

3. After you log in to your Raspberry Pi, change the password for the pi user.

   ```
   passwd
   ```

   Follow the prompts to change the password.

   ```
   Changing password for pi.
   Current password: raspberry
   New password: YourNewPassword
   Retype new password: YourNewPassword
   passwd: password updated successfully
   ```

After you have the Raspberry Pi’s command line prompt in the terminal window and changed the password, you’re ready to continue to the section called “Step 2: Install and verify required software on your device” (p. 138).

Step 2: Install and verify required software on your device

The procedures in this section continue from the previous section (p. 136) to bring your Raspberry Pi’s operating system up to date and install the software on the Raspberry Pi that will be used in the next section to build and install the AWS IoT Device Client.

After you complete this section, your Raspberry Pi will have an up-to-date operating system, the software required by the tutorials in this learning path, and it will be configured for your location.
Required equipment:

- Your local development and testing environment from the previous section (p. 136)
- The Raspberry Pi that you used in the previous section (p. 136)
- The microSD memory card from the previous section (p. 136)

Note

The Raspberry Pi Model 3+ and Raspberry Pi Model 4 can perform all the commands described in this learning path. If your IoT device can't compile software or run the AWS Command Line Interface, you might need to install the required compilers on your local host computer to build the software and then transfer it to your IoT device. For more information about how to install and build software for your device, see the documentation for your device's software.

Procedures in this section:

- Update the operating system software (p. 139)
- Install the required applications and libraries (p. 140)
- (Optional) Save the microSD card image (p. 141)

Update the operating system software

This procedure updates the operating system software.

To update the operating system software on the Raspberry Pi

Perform these steps in the terminal window of your local host computer.

1. Enter these commands to update the system software on your Raspberry Pi.

```
sudo apt-get -y update
sudo apt-get -y upgrade
sudo apt-get -y autoremove
```

2. Update the Raspberry Pi's locale and time zone settings (optional).

Enter this command to update the device's locale and time zone settings.

```
sudo raspi-config
```

a. To set the device's locale:

i. In the Raspberry Pi Software Configuration Tool (raspi-config) screen, choose option 5.

```
5 Localisation Options Configure language and regional settings
```

Use the Tab key to move to <Select>, and then press the space bar.

ii. In the localization options menu, choose option L1.

```
L1 Locale Configure language and regional settings
```

Use the Tab key to move to <Select>, and then press the space bar.

iii. In the list of locale options, choose the locales that you want to install on your Raspberry Pi by using the arrow keys to scroll and the space bar to mark those that you want.

In the United States, en_US.UTF-8 is a good one to choose.
iv. After selecting the locales for your device, use the **Tab** key to choose **<OK>**, and then press the **space bar** to display the **Configuring locales** confirmation page.

b. To set the device’s time zone:

i. In the **raspi-config** screen, choose option 5.

**5 Localisation Options Configure language and regional settings**

Use the **Tab** key to move to **<Select>**, and then press the **space bar**.

ii. In the localization options menu, use the arrow key to choose option **L2**:

**L2 time zone Configure time zone**

Use the **Tab** key to move to **<Select>**, and then press the **space bar**.

iii. In the **Configuring tzdata** menu, choose your geographical area from the list.

Use the **Tab** key to move to **<OK>**, and then press the **space bar**.

iv. In the list of cities, use the arrow keys to choose a city in your time zone.

To set the time zone, use the **Tab** key to move to **<OK>**, and then press the **space bar**.

c. When you’ve finished updating the settings, use the **Tab** key to move to **<Finish>**, and then press the **space bar** to close the **raspi-config** app.

3. Enter this command to restart your Raspberry Pi.

```
sudo shutdown -r 0
```

4. Wait for your Raspberry Pi to restart.

5. After your Raspberry Pi has restarted, reconnect the terminal window on your local host computer to your Raspberry Pi.

Your Raspberry Pi system software is now configured and you’re ready to continue to the section called "Install the required applications and libraries" (p. 140).

**Install the required applications and libraries**

This procedure installs the application software and libraries that the subsequent tutorials use.

If you are using a Raspberry Pi, or if you can compile the required software on your IoT device, perform these steps in the terminal window on your local host computer. If you must compile software for your IoT device on your local host computer, review the software documentation for your IoT device for information about how to do these steps on your device.

**To install the application software and libraries on your Raspberry Pi**

1. Enter this command to install the application software and libraries.

```
sudo apt-get -y install build-essential libssl-dev cmake unzip git python3-pip
```

2. Enter these commands to confirm that the correct version of the software was installed.

```
gcc --version
cmake --version
openssl version
git --version
```

3. Confirm that these versions of the application software are installed:
If your Raspberry Pi has acceptable versions of the required application software, you're ready to continue to the section called “(Optional) Save the microSD card image” (p. 141).

(Optional) Save the microSD card image

Throughout the tutorials in this learning path, you'll encounter these procedures to save a copy of the Raspberry Pi's microSD card image to a file on your local host computer. While encouraged, they are not required tasks. By saving the microSD card image where suggested, you can skip the procedures that precede the save point in this learning path, which can save time if you find the need to retry something. The consequence of not saving the microSD card image periodically is that you might have to restart the tutorials in the learning path from the beginning if your microSD card is damaged or if you accidentally configure an app or its settings incorrectly.

At this point, your Raspberry Pi's microSD card has an updated OS and the basic application software loaded. You can save the time it took you to complete the preceding steps by saving the contents of the microSD card to a file now. Having the current image of your device's microSD card image lets you start from this point to continue or retry a tutorial or procedure without the need to install and update the software from scratch.

To save the microSD card image to a file

1. Enter this command to shut down the Raspberry Pi.
   
   ```
   sudo shutdown -h 0
   ```

2. After the Raspberry Pi shuts down completely, remove its power.
3. Remove the microSD card from the Raspberry Pi.
4. On your local host computer:
   a. Insert the microSD card.
   b. Using your SD card imaging tool, save the microSD card's image to a file.
   c. After the microSD card's image has been saved, eject the card from the local host computer.
5. With the power disconnected from the Raspberry Pi, insert the microSD card into the Raspberry Pi.
6. Apply power to the Raspberry Pi.
7. After waiting about a minute, on the local host computer, reconnect the terminal window on your local host computer that was connected to your Raspberry Pi., and then log in to the Raspberry Pi.

Step 3: Test your device and save the Amazon CA cert

The procedures in this section continue from the previous section (p. 138) to install the AWS Command Line Interface and the Certificate Authority certificate used to authenticate your connections with AWS IoT Core.

After you complete this section, you'll know that your Raspberry Pi has the necessary system software to install the AWS IoT Device Client and that it has a working connection to the internet.

Required equipment:

- Your local development and testing environment from the previous section (p. 138)
• The Raspberry Pi that you used in the previous section (p. 138)
• The microSD memory card from the previous section (p. 138)

Procedures in this section:
• Install the AWS Command Line Interface (p. 142)
• Configure your AWS account credentials (p. 142)
• Download the Amazon Root CA certificate (p. 143)
• (Optional) Save the microSD card image (p. 144)

Install the AWS Command Line Interface

This procedure installs the AWS CLI onto your Raspberry Pi.

If you are using a Raspberry Pi or if you can compile software on your IoT device, perform these steps in the terminal window on your local host computer. If you must compile software for your IoT device on your local host computer, review the software documentation for your IoT device for information about the libraries it requires.

To install the AWS CLI on your Raspberry Pi

1. Run these commands to download and install the AWS CLI.

   ```
   export PATH=$PATH:~/.local/bin # configures the path to include the directory with the AWS CLI
   git clone https://github.com/aws/aws-cli.git # download the AWS CLI code from GitHub
   cd aws-cli && git checkout v2 # go to the directory with the repo and checkout version 2
   pip3 install -r requirements.txt # install the prerequisite software
   ```

2. Run this command to install the AWS CLI. This command can take up to 15 minutes to complete.

   ```
   pip3 install . # install the AWS CLI
   ```

3. Run this command to confirm that the correct version of the AWS CLI was installed.

   ```
   aws --version
   ```

   The version of the AWS CLI should be 2.2 or later.

   If the AWS CLI displayed its current version, you're ready to continue to the section called “Configure your AWS account credentials” (p. 142).

Configure your AWS account credentials

In this procedure, you'll obtain AWS account credentials and add them for use on your Raspberry Pi.

To add your AWS account credentials to your device

1. Obtain an Access Key ID and Secret Access Key from your AWS account to authenticate the AWS CLI on your device.

   If you're new to AWS IAM, https://aws.amazon.com/premiumsupport/knowledge-center/create-access-key/ describes the process to run in the AWS console to create AWS IAM credentials to use on your device.
2. In the terminal window on your local host computer that's connected to your Raspberry Pi, and with the Access Key ID and Secret Access Key credentials for your device:
   
a. Run the AWS configure app with this command:

```
aws configure
```

b. Enter your credentials and configuration information when prompted:

```
AWS Access Key ID: your Access Key ID
AWS Secret Access Key: your Secret Access Key
Default region name: your AWS Region code
Default output format: json
```

3. Run this command to test your device's access to your AWS account and AWS IoT Core endpoint.

```
aws iot describe-endpoint --endpoint-type iot:Data-ATS
```

It should return your AWS account-specific AWS IoT data endpoint, such as this example:

```
{
   "endpointAddress": "a3EXAMPLEffp-ats.iot.us-west-2.amazonaws.com"
}
```

If you see your AWS account-specific AWS IoT data endpoint, your Raspberry Pi has the connectivity and permissions to continue to the section called “Download the Amazon Root CA certificate” (p. 143).

**Important**

Your AWS account credentials are now stored on the microSD card in your Raspberry Pi. While this makes future interactions with AWS easy for you and the software you’ll create in these tutorials, they will also be saved and duplicated in any microSD card images you make after this step by default.

To protect the security of your AWS account credentials, before you save any more microSD card images, consider erasing the credentials by running `aws configure` again and entering random characters for the Access Key ID and Secret Access Key to prevent your AWS account credentials from compromised.

If you find that you have saved your AWS account credentials inadvertently, you can deactivate them in the AWS IAM console.

**Download the Amazon Root CA certificate**

This procedure downloads and saves a copy of a certificate of the Amazon Root Certificate Authority (CA). Downloading this certificate saves it for use in the subsequent tutorials and it also tests your device's connectivity with AWS services.

**To download and save the Amazon Root CA certificate**

1. Run this command to create a directory for the certificate.

```
mkdir ~/certs
```

2. Run this command to download the Amazon Root CA certificate.

```
curl -o ~/certs/AmazonRootCA1.pem https://www.amazontrust.com/repository/AmazonRootCA1.pem
```

3. Run these commands to set the access to the certificate directory and its file.
Run this command to see the CA certificate file in the new directory.

```bash
ls -l ~/certs
```

You should see an entry like this. The date and time will be different; however, the file size and all other info should be the same as shown here.

```
-rw-r--r-- 1 pi pi 1188 Oct 28 13:02 AmazonRootCA1.pem
```

If the file size is not 1188, check the `curl` command parameters. You might have downloaded an incorrect file.

(Optional) Save the microSD card image

At this point, your Raspberry Pi's microSD card has an updated OS and the basic application software loaded.

To save the microSD card image to a file

1. In the terminal window on your local host computer, clear your AWS credentials.

   a. Run the AWS configure app with this command:

   ```bash
   aws configure
   ```

   b. Replace your credentials when prompted. You can leave Default region name and Default output format as they are by pressing Enter.

   ```
   AWS Access Key ID [***************YT2H]: XYXYXYXYX
   AWS Secret Access Key [***************9plH]: XYXYXYXYX
   Default region name [us-west-2]:
   Default output format [json]:
   ```

2. Enter this command to shut down the Raspberry Pi.

   ```bash
   sudo shutdown -h 0
   ```

3. After the Raspberry Pi shuts down completely, remove its power connector.

4. Remove the microSD card from your device.

5. On your local host computer:

   a. Insert the microSD card.

   b. Using your SD card imaging tool, save the microSD card's image to a file.

   c. After the microSD card's image has been saved, eject the card from the local host computer.

6. With the power disconnected from the Raspberry Pi, insert the microSD card into the Raspberry Pi.

7. Apply power to the device.

8. After about a minute, on the local host computer, restart the terminal window session and log in to the device.

   **Don't reenter your AWS account credentials yet.**
After you have restarted and logged in to your Raspberry Pi, you're ready to continue to the section called "Installing and configuring the AWS IoT Device Client" (p. 145).

Tutorial: Installing and configuring the AWS IoT Device Client

This tutorial walks you through the installation and configuration of the AWS IoT Device Client and the creation of AWS IoT resources that you'll use in this and other demos.

To start this tutorial:

- Have your local host computer and Raspberry Pi from the previous tutorial (p. 135) ready.

This tutorial can take up to 90 minutes to complete.

When you're finished with this topic:

- Your IoT device will be ready to use in other AWS IoT Device Client demos.
- You'll have provisioned your IoT device in AWS IoT Core.
- You'll have downloaded and installed the AWS IoT Device Client on your device.
- You'll have saved an image of your device's microSD card that can be used in subsequent tutorials.

Required equipment:

- Your local development and testing environment from the previous section (p. 141)
- The Raspberry Pi that you used in the previous section (p. 141)
- The microSD memory card from the Raspberry Pi that you used in the previous section (p. 141)

Procedures in this tutorial

Step 1: Download and save the AWS IoT Device Client (p. 145)

(Optional) Save the microSD card image (p. 146)

Step 2: Provision your Raspberry Pi in AWS IoT (p. 147)

Step 3: Configure the AWS IoT Device Client to test connectivity (p. 151)

Step 1: Download and save the AWS IoT Device Client

The procedures in this section download the AWS IoT Device Client, compile it, and install it on your Raspberry Pi. After you test the installation, you can save the image of the Raspberry Pi's microSD card to use later when you want to try the tutorials again.

Procedures in this section:

- Download and build the AWS IoT Device Client (p. 145)
- Create the directories used by the tutorials (p. 146)

Download and build the AWS IoT Device Client

This procedure installs the AWS IoT Device Client on your Raspberry Pi.

Perform these commands in the terminal window on your local host computer that is connected to your Raspberry Pi.
To install the AWS IoT Device Client on your Raspberry Pi

1. Enter these commands to download and build the AWS IoT Device Client on your Raspberry Pi.

```bash
cd ~
mkdir ~/aws-iot-device-client/build && cd ~/aws-iot-device-client/build
cmake ../
```

2. Run this command to build the AWS IoT Device Client. This command can take up to 15 minutes to complete.

```bash
cmake --build . --target aws-iot-device-client
```

The warning messages displayed as the AWS IoT Device Client compiles can be ignored.

These tutorials have been tested with the AWS IoT Device Client built on gcc, version (Raspbian 10.2.1-6+rpi1) 10.2.1 20210110 on the Oct 30th 2021 version of Raspberry Pi OS (bullseye) on gcc, version (Raspbian 8.3.0-6+rpi1) 8.3.0 on the May 7th 2021 version of the Raspberry Pi OS (buster).

3. After the AWS IoT Device Client finishes building, test it by running this command.

```bash
/aws-iot-device-client --help
```

If you see the command line help for the AWS IoT Device Client, the AWS IoT Device Client has been built successfully and is ready for you to use.

Create the directories used by the tutorials

This procedure creates the directories on the Raspberry Pi that will be used to store the files used by the tutorials in this learning path.

To create the directories used by the tutorials in this learning path:

1. Run these commands to create the required directories.

```bash
mkdir ~/dc-configs
mkdir ~/policies
mkdir ~/messages
mkdir ~/certs/testconn
mkdir ~/certs/pubsub
mkdir ~/certs/jobs
```

2. Run these commands to set the permissions on the new directories.

```bash
chmod 745 ~
chmod 700 ~/certs/testconn
chmod 700 ~/certs/pubsub
chmod 700 ~/certs/jobs
```

After you create these directories and set their permission, continue to the section called “(Optional) Save the microSD card image” (p. 146).

(Optional) Save the microSD card image

At this point, your Raspberry Pi’s microSD card has an updated OS, the basic application software, and the AWS IoT Device Client.
If you want to come back to try these exercises and tutorials again, you can skip the preceding procedures by writing the microSD card image that you save with this procedure to a new microSD card and continue the tutorials from the section called “Step 2: Provision your Raspberry Pi in AWS IoT” (p. 147).

To save the microSD card image to a file:

In the terminal window on your local host computer that's connected to your Raspberry Pi:

1. Confirm that your AWS account credentials have not been stored.
   a. Run the AWS configure app with this command:

   ```
   aws configure
   ```
   b. If your credentials have been stored (if they are displayed in the prompt), then enter the `XYXYXYXYX` string when prompted as shown here. Leave Default region name and Default output format blank.

   ```
   AWS Access Key ID [****************YXYX]: XYXYXYXYX
   AWS Secret Access Key [****************YXYX]: XYXYXYXYX
   Default region name: 
   Default output format: 
   ```

2. Enter this command to shutdown the Raspberry Pi.

   ```
   sudo shutdown -h 0
   ```

3. After the Raspberry Pi shuts down completely, remove its power connector.

4. Remove the microSD card from your device.

5. On your local host computer:
   a. Insert the microSD card.
   b. Using your SD card imaging tool, save the microSD card's image to a file.
   c. After the microSD card's image has been saved, eject the card from the local host computer.

You can continue with this microSD card in the section called “Step 2: Provision your Raspberry Pi in AWS IoT” (p. 147).

Step 2: Provision your Raspberry Pi in AWS IoT

The procedures in this section start with the saved microSD image that has the AWS CLI and AWS IoT Device Client installed and create the AWS IoT resources and device certificates that provision your Raspberry Pi in AWS IoT.

Install the microSD card in your Raspberry Pi

This procedure installs the microSD card with the necessary software loaded and configured into the Raspberry Pi and configures your AWS account so that you can continue with the tutorials in this learning path.

Use a microSD card from the section called ”(Optional) Save the microSD card image” (p. 146) that has the necessary software for the exercises and tutorials in this learning path.

To install the microSD card in your Raspberry Pi

1. With the power disconnected from the Raspberry Pi, insert the microSD card into the Raspberry Pi.
2. Apply power to the Raspberry Pi.
3. After about a minute, on the local host computer, restart the terminal window session and log in to the Raspberry Pi.
4. On your local host computer, in the terminal window, and with the Access Key ID and Secret Access Key credentials for your Raspberry Pi:
   a. Run the AWS configure app with this command:
      ```bash
      aws configure
      ```
   b. Enter your AWS account credentials and configuration information when prompted:
      ```
      AWS Access Key ID [****************YXYX]: your Access Key ID
      AWS Secret Access Key [****************YXYX]: your Secret Access Key
      Default region name [us-west-2]: your AWS Region code
      Default output format [json]: json
      ```

      After you have restored your AWS account credentials, you're ready to continue to the section called "Provision your device in AWS IoT Core" (p. 148).

Provision your device in AWS IoT Core

The procedures in this section create the AWS IoT resources that provision your Raspberry Pi in AWS IoT. As you create these resources, you'll be asked to record various pieces of information. This information is used by the AWS IoT Device Client configuration in the next procedure.

For your Raspberry Pi to work with AWS IoT, it must be provisioned. Provisioning is the process of creating and configuring the AWS IoT resources that are necessary to support your Raspberry Pi as an IoT device.

With your Raspberry Pi powered up and restarted, connect the terminal window on your local host computer to the Raspberry Pi and complete these procedures.

Procedures in this section:
- Create and download device certificate files (p. 148)
- Create AWS IoT resources (p. 149)

Create and download device certificate files

This procedure creates the device certificate files for this demo.

To create and download the device certificate files for your Raspberry Pi

1. In the terminal window on your local host computer, enter these commands to create the device certificate files for your device.
   ```bash
   mkdir ~/certs/testconn
   aws iot create-keys-and-certificate
     --set-as-active
     --certificate-pem-outfile "~/certs/testconn/device.pem.crt"
     --public-key-outfile "~/certs/testconn/public.pem.key"
     --private-key-outfile "~/certs/testconn/private.pem.key"
   ```

   The command returns a response like the following. Record the certificateArn value for later use.
2. Enter the following commands to set the permissions on the certificate directory and its files.

```bash
chmod 745 ~
chmod 700 ~/certs/testconn
chmod 644 ~/certs/testconn/*
chmod 600 ~/certs/testconn/private.pem.key
```

3. Run this command to review the permissions on your certificate directories and files.

```bash
ls -l ~/certs/testconn
```

The output of the command should be the same as what you see here, except the file dates and times will be different.

```
-rw-r--r-- 1 pi pi 1220 Oct 28 13:02 device.pem.crt
-rw------- 1 pi pi 1675 Oct 28 13:02 private.pem.key
-rw-r--r-- 1 pi pi  451 Oct 28 13:02 public.pem.key
```

At this point, you have the device certificate files installed on your Raspberry Pi and you can continue to the section called "Create AWS IoT resources" (p. 149).

Create AWS IoT resources

This procedure provisions your device in AWS IoT by creating the resources that your device needs to access AWS IoT features and services.

To provision your device in AWS IoT

1. In the terminal window on your local host computer, enter the following command to get the address of the device data endpoint for your AWS account.

```bash
aws iot describe-endpoint --endpoint-type IoT:Data-ATS
```

The command from the previous steps returns a response like the following. Record the `endpointAddress` value for later use.

```
{
  "endpointAddress": "a3qjEXAMPLEEffp-ats.iot.us-west-2.amazonaws.com"
}
```

2. Enter this command to create an AWS IoT thing resource for your Raspberry Pi.
aws iot create-thing --thing-name "DevCliTestThing"

If your AWS IoT thing resource was created, the command returns a response like this.

```
{
    "thingName": "DevCliTestThing",
    "thingId": "8ea78707-32c3-4f8a-9252-14bEXAMPLEfd"
}
```

3. In the terminal window:
   a. Open a text editor, such as nano.
   b. Copy this JSON policy document and paste it into your open text editor.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish",
                "iot:Subscribe",
                "iot:Receive",
                "iot:Connect"
            ],
            "Resource": ["*"]
        }
    ]
}
```

**Note**

This policy document generously grants every resource permission to connect, receive, publish, and subscribe. Normally policies grant only permission to specific resources to perform specific actions. However, for the initial device connectivity test, this overly general and permissive policy is used to minimize the chance of an access problem during this test. In the subsequent tutorials, more narrowly scoped policy documents will be used to demonstrate better practices in policy design.

c. Save the file in your text editor as `~/policies/dev_cli_test_thing_policy.json`.

4. Run this command to use the policy document from the previous steps to create an AWS IoT policy.

```
aws iot create-policy
   --policy-name "DevCliTestThingPolicy"
   --policy-document "file://~/policies/dev_cli_test_thing_policy.json"
```

If the policy is created, the command returns a response like this.

```
{
    "policyName": "DevCliTestThingPolicy",
    "policyDocument": "\n        "Version": "2012-10-17",
        "Statement": [
            {"Effect": "Allow",
             "Action": ["iot:Publish",
                         "iot:Subscribe",
                         "iot:Receive",
                         "iot:Connect"],
             "Resource": ["*"]}
        ]\n    }
```

150
5. Run this command to attach the policy to the device certificate. Replace `certificateArn` with the `certificateArn` value you saved earlier.

```bash
aws iot attach-policy \
--policy-name "DevCliTestThingPolicy" \
--target "certificateArn"
```

If successful, this command returns nothing.

6. Run this command to attach the device certificate to the AWS IoT thing resource. Replace `certificateArn` with the `certificateArn` value you saved earlier.

```bash
aws iot attach-thing-principal \
--thing-name "DevCliTestThing" \
--principal "certificateArn"
```

If successful, this command returns nothing.

After you successfully provisioned your device in AWS IoT, you're ready to continue to the section called "Step 3: Configure the AWS IoT Device Client to test connectivity" (p. 151).

**Step 3: Configure the AWS IoT Device Client to test connectivity**

The procedures in this section configure the AWS IoT Device Client to publish an MQTT message from your Raspberry Pi.

**Procedures in this section:**
- Create the config file (p. 151)
- Open MQTT test client (p. 152)
- Run AWS IoT Device Client (p. 153)

**Create the config file**

This procedure creates the config file to test the AWS IoT Device Client.

**To create the config file to test the AWS IoT Device Client**

- In the terminal window on your local host computer that's connected to your Raspberry Pi:
  a. Enter these commands to create a directory for the config files and set the permission on the directory:

    ```bash
    mkdir ~/dc-configs
    chmod 745 ~/dc-configs
    ```

  b. Open a text editor, such as nano.
  c. Copy this JSON document and paste it into your open text editor.

    ```json
    {
      "endpoint": "a3qEXAMPLEaffp-ats.iot.us-west-2.amazonaws.com",
      "cert": "~/certs/testconn/device.pem.crt",
      "key": "~/certs/testconn/private.pem.key",
      "root-ca": "~/certs/AmazonRootCA1.pem",
    }
    ```
d. Replace the endpoint value with device data endpoint for your AWS account that you found in the section called “Provision your device in AWS IoT Core” (p. 148).

e. Save the file in your text editor as ~/dc-configs/dc-testconn-config.json.

f. Run this command to set the permissions on the new config file.

`chmod 644 ~/dc-configs/dc-testconn-config.json`

After you save the file, you're ready to continue to the section called “Open MQTT test client” (p. 152).

Open MQTT test client

This procedure prepares the MQTT test client in the AWS IoT console to subscribe to the MQTT message that the AWS IoT Device Client publishes when it runs.

To prepare the MQTT test client to subscribe to all MQTT messages

1. On your local host computer, in the AWS IoT console, choose MQTT test client.
2. In the **Subscribe to a topic** tab, in **Topic filter**, enter # (a single pound sign), and choose **Subscribe** to subscribe to every MQTT topic.
3. Below the **Subscriptions** label, confirm that you see # (a single pound sign).

Leave the window with the **MQTT test client** open as you continue to the section called “Run AWS IoT Device Client” (p. 153).

**Run AWS IoT Device Client**

This procedure runs the AWS IoT Device Client so that it publishes a single MQTT message that the **MQTT test client** receives and displays.

**To send an MQTT message from the AWS IoT Device Client**

1. Make sure that both the terminal window that's connected to your Raspberry Pi and the window with the **MQTT test client** are visible while you perform this procedure.
2. In the terminal window, enter these commands to run the AWS IoT Device Client using the config file created in the section called “Create the config file” (p. 151).

```bash
$ cd ~/aws-iot-device-client/build
$ ./aws-iot-device-client --config-file ~/dc-configs/dc-testconn-config.json
```

In the terminal window, the AWS IoT Device Client displays information messages and any errors that occur when it runs.

If no errors are displayed in the terminal window, review the **MQTT test client**.

3. In the **MQTT test client**, in the Subscriptions window, see the *Hello World!* message sent to the test/dc/pubtopic message topic.
4. If the AWS IoT Device Client displays no errors and you see *Hello World!* sent to the test/dc/pubtopic message in the **MQTT test client**, you've demonstrated a successful connection.
5. In the terminal window, enter ^C (Ctrl-C) to stop the AWS IoT Device Client.

After you've demonstrated that the AWS IoT Device Client is running correctly on your Raspberry Pi and can communicate with AWS IoT, you can continue to the section called “Demonstrate MQTT message communication with the AWS IoT Device Client” (p. 153).

**Tutorial: Demonstrate MQTT message communication with the AWS IoT Device Client**

This tutorial demonstrates how the AWS IoT Device Client can subscribe to and publish MQTT messages, which are commonly used in IoT solutions.

**To start this tutorial:**

- Have your local host computer and Raspberry Pi configured as used in the previous section (p. 145).

  If you saved the microSD card image after installing the AWS IoT Device Client, you can use a microSD card with that image with your Raspberry Pi.

- If you have run this demo before, review ??? (p. 178) to delete all AWS IoT resources that you created in earlier runs to avoid duplicate resource errors.

This tutorial takes about 45 minutes to complete.
When you're finished with this topic:

- You'll have demonstrated different ways that your IoT device can subscribe to MQTT messages from AWS IoT and publish MQTT messages to AWS IoT.

Required equipment:

- Your local development and testing environment from the previous section (p. 145)
- The Raspberry Pi that you used in the previous section (p. 145)
- The microSD memory card from the Raspberry Pi that you used in the previous section (p. 145)

Procedures in this tutorial

- Step 1: Prepare the Raspberry Pi to demonstrate MQTT message communication (p. 154)
- Step 2: Demonstrate publishing messages with the AWS IoT Device Client (p. 159)
- Step 3: Demonstrate subscribing to messages with the AWS IoT Device Client (p. 162)

Step 1: Prepare the Raspberry Pi to demonstrate MQTT message communication

This procedure creates the resources in AWS IoT and in the Raspberry Pi to demonstrate MQTT message communication using the AWS IoT Device Client.

Procedures in this section:

- Create the certificate files to demonstrate MQTT communication (p. 154)
- Provision your device to demonstrate MQTT communication (p. 155)
- Configure the AWS IoT Device Client config file and MQTT test client to demonstrate MQTT communication (p. 157)

Create the certificate files to demonstrate MQTT communication

This procedure creates the device certificate files for this demo.

To create and download the device certificate files for your Raspberry Pi

1. In the terminal window on your local host computer, enter the following command to create the device certificate files for your device.

```bash
mkdir ~/certs/pubsub
aws iot create-keys-and-certificate
--set-as-active
--certificate-pem-outfile ~/certs/pubsub/device.pem.crt
--public-key-outfile ~/certs/pubsub/public.pem.key
--private-key-outfile ~/certs/pubsub/private.pem.key
```

The command returns a response like the following. Save the `certificateArn` value for later use.

```json
{
"certificateArn": "arn:aws:iot:us-west-2:57EXAMPLE833:cert/76e7e4eb3e52f52334be2f387a06145b2aa4c7fcdb810f3ae2d92abc227d269",
"certificateId": "76e7e4eb3e52f52334be2f387a06145b2aa4c7fcdb810f3ae2d92abc227d269",
"certificatePem": "------BEGIN CERTIFICATE-----
\nMIIDWTCCAkGgAwIBAgI_SHORTENED_FOR_EXAMPLE_Lgn4jfgt5\n--END CERTIFICATE-----
```

154
Demonstrate MQTT message communication with the AWS IoT Device Client

"keyPair": {
   "PublicKey": "-----BEGIN PUBLIC KEY-----
   MIIBIjANBgkqhkiG9w0BA_SHORTENED_FOR_EXAMPLE_ImwIDAQAB
   -----END PUBLIC KEY-----
   "PrivateKey": "-----BEGIN RSA PRIVATE KEY-----
   MIIEowIBAAKCAQE_SHORTENED_FOR_EXAMPLE_T9RoDiukY
   -----END RSA PRIVATE KEY-----
   }

2. Enter the following commands to set the permissions on the certificate directory and its files.

```bash
chmod 700 ~/certs/pubsub
chmod 644 ~/certs/pubsub/*
chmod 600 ~/certs/pubsub/private.pem.key
```

3. Run this command to review the permissions on your certificate directories and files.

```bash
ls -l ~/certs/pubsub
```

The output of the command should be the same as what you see here, except the file dates and times will be different.

```
-rw-r--r-- 1 pi pi 1220 Oct 28 13:02 device.pem.crt
-rw------- 1 pi pi 1675 Oct 28 13:02 private.pem.key
-rw-r--r-- 1 pi pi  451 Oct 28 13:02 public.pem.key
```

4. Enter these commands to create the directories for the log files.

```bash
mkdir ~/.aws-iot-device-client
mkdir ~/.aws-iot-device-client/log
chmod 745 ~/.aws-iot-device-client/log
echo " " > ~/.aws-iot-device-client/log/aws-iot-device-client.log
echo " " > ~/.aws-iot-device-client/log/pubsub_rx_msgs.log
chmod 600 ~/.aws-iot-device-client/log/*
```

Provision your device to demonstrate MQTT communication

This section creates the AWS IoT resources that provision your Raspberry Pi in AWS IoT.

To provision your device in AWS IoT:

1. In the terminal window on your local host computer, enter the following command to get the address of the device data endpoint for your AWS account.

```bash
aws iot describe-endpoint --endpoint-type IoT:Data-ATS
```

The endpoint value hasn't changed since the time you ran this command for the previous tutorial. Running the command again here is done to make it easy to find and paste the data endpoint value into the config file used in this tutorial.

The command from the previous steps returns a response like the following. Record the **endpointAddress** value for later use.

```
{
   "endpointAddress": "a3qjEXAMPLEffp-ats.iot.us-west-2.amazonaws.com"
}
```

2. Enter this command to create a new AWS IoT thing resource for your Raspberry Pi.
aws iot create-thing --thing-name "PubSubTestThing"

Because an AWS IoT thing resource is a virtual representation of your device in the cloud, we can create multiple thing resources in AWS IoT to use for different purposes. They can all be used by the same physical IoT device to represent different aspects of the device.

These tutorials will only use one thing resource at a time to represent the Raspberry Pi. This way, in these tutorials, they represent the different demos so that after you create the AWS IoT resources for a demo, you can go back and repeat the demo using the resources you created specifically for each.

If your AWS IoT thing resource was created, the command returns a response like this.

```
{
    "thingName": "PubSubTestThing",
    "thingArn": "arn:aws:iot:us-west-2:57EXAMPLE833:thing/PubSubTestThing",
    "thingId": "8ea78707-32c3-4f8a-9232-14bEXAMPLEfd"
}
```

3. In the terminal window:
   a. Open a text editor, such as nano.
   b. Copy this JSON document and paste it into your open text editor.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [ "iot:Connect" ],
        },
        {
            "Effect": "Allow",
            "Action": [ "iot:Publish" ],
        },
        {
            "Effect": "Allow",
            "Action": [ "iot:Subscribe" ],
        },
        {
            "Effect": "Allow",
            "Action": [ "iot:Receive" ],
        }
    ]
}
```
In the editor, in each Resource section of the policy document, replace `us-west-2:57EXAMPLE833` with your AWS Region, a colon character (:) , and your 12-digit AWS account number.

d. Save the file in your text editor as `~/policies/pubsub_test_thing_policy.json`.

4. Run this command to use the policy document from the previous steps to create an AWS IoT policy.

```
aws iot create-policy
  --policy-name "PubSubTestThingPolicy"
  --policy-document "file://~/policies/pubsub_test_thing_policy.json"
```

If the policy is created, the command returns a response like this.

```
{
  "policyName": "PubSubTestThingPolicy",
  "policyDocument": {
    "Version": "2012-10-17",
    "Statement": [
      {
        "Effect": "Allow",
        "Action": ["iot:Connect"],
      },
      {
        "Effect": "Allow",
        "Action": ["iot:Publish"],
      },
      {
        "Effect": "Allow",
        "Action": ["iot:Subscribe"],
      },
      {
        "Effect": "Allow",
        "Action": ["iot:Receive"],
      }
    ]
  },
  "policyVersionId": "1"
}
```

5. Run this command to attach the policy to the device certificate. Replace `certificateArn` with the `certificateArn` value you saved earlier in this section.

```
aws iot attach-policy
  --policy-name "PubSubTestThingPolicy"
  --target "certificateArn"
```

If successful, this command returns nothing.

6. Run this command to attach the device certificate to the AWS IoT thing resource. Replace `certificateArn` with the `certificateArn` value you saved earlier in this section.

```
aws iot attach-thing-principal
  --thing-name "PubSubTestThing"
  --principal "certificateArn"
```

If successful, this command returns nothing.

After you successfully provision your device in AWS IoT, you’re ready to continue to the section called “Configure the AWS IoT Device Client config file and MQTT test client to demonstrate MQTT communication” (p. 157).

Configure the AWS IoT Device Client config file and MQTT test client to demonstrate MQTT communication

This procedure creates a config file to test the AWS IoT Device Client.
To create the config file to test the AWS IoT Device Client

1. In the terminal window on your local host computer that's connected to your Raspberry Pi:
   a. Open a text editor, such as nano.
   b. Copy this JSON document and paste it into your open text editor.

   ```json
   {
     "endpoint": "a3qEXAMPLEaffp-ats.iot.us-west-2.amazonaws.com",
     "cert": "~/certs/pubsub/device.pem.crt",
     "key": "~/certs/pubsub/private.pem.key",
     "root-ca": "~/certs/AmazonRootCA1.pem",
     "thing-name": "PubSubTestThing",
     "logging": {
       "enable-sdk-logging": true,
       "level": "DEBUG",
       "type": "STDOUT",
       "file": ""
     },
     "jobs": {
       "enabled": false,
       "handler-directory": ""
     },
     "tunneling": {
       "enabled": false
     },
     "device-defender": {
       "enabled": false,
       "interval": 300
     },
     "fleet-provisioning": {
       "enabled": false,
       "template-name": "",
       "template-parameters": "",
       "csr-file": "",
       "device-key": ""
     },
     "samples": {
       "pub-sub": {
         "enabled": true,
         "publish-topic": "test/dc/pubtopic",
         "publish-file": "",
         "subscribe-topic": "test/dc/subtopic",
         "subscribe-file": "~/aws-iot-device-client/log/pubsub_rxmsgs.log"
       }
     },
     "config-shadow": {
       "enabled": false
     },
     "sample-shadow": {
       "enabled": false,
       "shadow-name": "",
       "shadow-input-file": "",
       "shadow-output-file": ""
     }
   }
   ```
   c. Replace the **endpoint** value with device data endpoint for your AWS account that you found in the section called “Provision your device in AWS IoT Core” (p. 148).
   d. Save the file in your text editor as `~/dc-configs/dc-pubsub-config.json`.
   e. Run this command to set the permissions on the new config file.

158
AWS IoT Core Developer Guide
Demonstrate MQTT message communication with the AWS IoT Device Client

chmod 644 ~/dc-configs/dc-pubsub-config.json

2. To prepare the **MQTT test client** to subscribe to all MQTT messages:
   a. On your local host computer, in the [AWS IoT console](https://console.aws.amazon.com/iot), choose **MQTT test client**.
   b. In the **Subscribe to a topic** tab, in **Topic filter**, enter # (a single pound sign), and choose **Subscribe**.
   c. Below the **Subscriptions** label, confirm that you see # (a single pound sign).

Leave the window with the **MQTT test client** open while you continue this tutorial.

After you save the file and configure the **MQTT test client**, you’re ready to continue to the section called "Step 2: Demonstrate publishing messages with the AWS IoT Device Client" (p. 159).

**Step 2: Demonstrate publishing messages with the AWS IoT Device Client**

The procedures in this section demonstrate how the AWS IoT Device Client can send default and custom MQTT messages.

These policy statements in the policy that you created in the previous step for these exercises give the Raspberry Pi permission to perform these actions:

- **iot:Connect**

  Gives the client named PubSubTestThing, your Raspberry Pi running the AWS IoT Device Client, to connect.

  ```json
  {
    "Effect": "Allow",
    "Action": [
      "iot:Connect"
    ],
    "Resource": [
      "arn:aws:iot:us-west-2:57EXAMPLE833:client/PubSubTestThing"
    ]
  }
  ```

- **iot:Publish**

  Gives the Raspberry Pi permission to publish messages with an MQTT topic of test/dc/pubtopic.

  ```json
  {
    "Effect": "Allow",
    "Action": [
      "iot:Publish"
    ],
    "Resource": [
    ]
  }
  ```

The **iot:Publish** action gives permission to publish to the MQTT topics listed in the Resource array. The **content** of those messages is not controlled by the policy statement.
Publish the default message using the AWS IoT Device Client

This procedure runs the AWS IoT Device Client so that it publishes a single default MQTT message that the MQTT test client receives and displays.

To send the default MQTT message from the AWS IoT Device Client

1. Make sure that both the terminal window on your local host computer that's connected to your Raspberry Pi and the window with the MQTT test client are visible while you perform this procedure.
2. In the terminal window, enter these commands to run the AWS IoT Device Client using the config file created in the section called “Create the config file” (p. 151).

```
cd ~/aws-iot-device-client/build
./aws-iot-device-client --config-file ~/dc-configs/dc-pubsub-config.json
```

In the terminal window, the AWS IoT Device Client displays information messages and any errors that occur when it runs.

If no errors are displayed in the terminal window, review the MQTT test client.

3. In the MQTT test client, in the Subscriptions window, see the Hello World! message sent to the test/dc/pubtopic message topic.
4. If the AWS IoT Device Client displays no errors and you see Hello World! sent to the test/dc/pubtopic message in the MQTT test client, you've demonstrated a successful connection.
5. In the terminal window, enter ^C (Ctrl-C) to stop the AWS IoT Device Client.

After you've demonstrated that the AWS IoT Device Client published the default MQTT message, you can continue to the the section called “Publish a custom message using the AWS IoT Device Client.” (p. 160).

Publish a custom message using the AWS IoT Device Client.

The procedures in this section create a custom MQTT message and then runs the AWS IoT Device Client so that it publishes the custom MQTT message one time for the MQTT test client to receive and display.

Create a custom MQTT message for the AWS IoT Device Client

Perform these steps in the terminal window on the local host computer that's connected to your Raspberry Pi.

To create a custom message for the AWS IoT Device Client to publish

1. In the terminal window, open a text editor, such as nano.
2. Into the text editor, copy and paste the following JSON document. This will be the MQTT message payload that the AWS IoT Device Client publishes.

```json
{
  "temperature": 28,
  "humidity": 80,
  "barometer": 1013,
  "wind": {
    "velocity": 22,
    "bearing": 255
  }
}
```
3. Save the contents of the text editor as `~/messages/sample-ws-message.json`.
4. Enter the following command to set the permissions of the message file that you just created.

   ```bash
   chmod 600 ~/messages/*
   ```

**To create a config file for the AWS IoT Device Client to use to send the custom message**

1. In the terminal window, in a text editor such as `nano`, open the existing AWS IoT Device Client config file: `~/dc-configs/dc-pubsub-config.json`.
2. Edit the `samples` object to look like this. No other part of this file needs to be changed.

   ```json
   "samples": {
     "pub-sub": {
       "enabled": true,
       "publish-topic": "test/dc/pubtopic",
       "publish-file": "~/messages/sample-ws-message.json",
       "subscribe-topic": "test/dc/subtopic",
       "subscribe-file": "~/.aws-iot-device-client/log/pubsub_rx_msgs.log"
     }
   }
   ```
4. Run this command to set the permissions on the new config file.

   ```bash
   chmod 644 ~/dc-configs/dc-pubsub-custom-config.json
   ```

**Publish the custom MQTT message by using the AWS IoT Device Client**

This change affects only the contents of the MQTT message payload, so the current policy will continue to work. However, if the MQTT topic (as defined by the `publish-topic` value in `~/dc-configs/dc-pubsub-custom-config.json`) was changed, the `iot::Publish` policy statement would also need to be modified to allow the Raspberry Pi to publish to the new MQTT topic.

**To send the MQTT message from the AWS IoT Device Client**

1. Make sure that both the terminal window and the window with the MQTT test client are visible while you perform this procedure. Also, make sure that your MQTT test client is still subscribed to the # topic filter. If it isn’t, subscribe to the # topic filter again.
2. In the terminal window, enter these commands to run the AWS IoT Device Client using the config file created in the section called “Create the config file” (p. 151).

   ```bash
   cd ~/aws-iot-device-client/build
   ./aws-iot-device-client --config-file ~/dc-configs/dc-pubsub-custom-config.json
   ```

   In the terminal window, the AWS IoT Device Client displays information messages and any errors that occur when it runs.

   If no errors are displayed in the terminal window, review the MQTT test client.

   3. In the MQTT test client, in the Subscriptions window, see the custom message payload sent to the test/dc/pubtopic message topic.
   4. If the AWS IoT Device Client displays no errors and you see the custom message payload that you published to the test/dc/pubtopic message in the MQTT test client, you’ve published a custom message successfully.
   5. In the terminal window, enter `^C` (Ctrl-C) to stop the AWS IoT Device Client.
After you've demonstrated that the AWS IoT Device Client published a custom message payload, you can continue to the section called “Step 3: Demonstrate subscribing to messages with the AWS IoT Device Client” (p. 162).

**Step 3: Demonstrate subscribing to messages with the AWS IoT Device Client**

In this section, you'll demonstrate two types of message subscriptions:

- Single topic subscription
- Wild-card topic subscription

These policy statements in the policy created for these exercises give the Raspberry Pi permission to perform these actions:

**iot:Receive**

Gives the AWS IoT Device Client permission to receive MQTT topics that match those named in the Resource object.

```
{
   "Effect": "Allow",
   "Action": [
      "iot:Receive"
   ],
   "Resource": [
   ]
}
```

**iot:Subscribe**

Gives the AWS IoT Device Client permission to subscribe to MQTT topic filters that match those named in the Resource object.

```
{
   "Effect": "Allow",
   "Action": [
      "iot:Subscribe"
   ],
   "Resource": [
   ]
}
```

**Subscribe to a single MQTT message topic**

This procedure demonstrates how the AWS IoT Device Client can subscribe to and log MQTT messages.

In the terminal window on your local host computer that's connected to your Raspberry Pi, list the contents of `~/dc-configs/dc-pubsub-custom-config.json` or open the file in a text editor to review its contents. Locate the samples object, which should look like this.

```
"samples": {
   "pub-sub": {
      "enabled": true,
```
Demonstrate MQTT message communication with the AWS IoT Device Client

```
"publish-topic": "test/dc/pubtopic",
"publish-file": "~/messages/sample-ws-message.json",
"subscribe-topic": "test/dc/subtopic",
"subscribe-file": "~/aws-iot-device-client/log/pubsub_rx_msgs.log"
```

Notice the subscribe-topic value is the MQTT topic to which the AWS IoT Device Client will subscribe when it runs. The AWS IoT Device Client writes the message payloads that it receives from this subscription to the file named in the subscribe-file value.

**To subscribe to a MQTT message topic from the AWS IoT Device Client**

1. Make sure that both the terminal window and the window with the MQTT test client are visible while you perform this procedure. Also, make sure that your MQTT test client is still subscribed to the # topic filter. If it isn't, subscribe to the # topic filter again.
2. In the terminal window, enter these commands to run the AWS IoT Device Client using the config file created in the section called "Create the config file" (p. 151).

   ```
   cd ~/aws-iot-device-client/build
   ./aws-iot-device-client --config-file ~/dc-configs/dc-pubsub-custom-config.json
   ```

   In the terminal window, the AWS IoT Device Client displays information messages and any errors that occur when it runs.

   If no errors are displayed in the terminal window, continue in the AWS IoT console.

3. In the AWS IoT console, in the MQTT test client, choose the Publish to a topic tab.
4. In Topic name, enter test/dc/subtopic
5. In Message payload, review the message contents.
6. Choose Publish to publish the MQTT message.
7. In the terminal window, watch for the message received entry from the AWS IoT Device Client that looks like this.

   ```
   2021-11-10T16:02:20.890Z [DEBUG] {samples/PubSubFeature.cpp}: Message received on
   subscribe topic, size: 45 bytes
   ```

8. After you see the message received entry that shows the message was received, enter ^C (Ctrl-C) to stop the AWS IoT Device Client.
9. Enter this command to view the end of the message log file and see the message you published from the MQTT test client.

   ```
   tail ~/.aws-iot-device-client/log/pubsub_rx_msgs.log
   ```

By viewing the message in the log file, you've demonstrated that the AWS IoT Device Client received the message that you published from the MQTT test client.

**Subscribe to multiple/MQTT message topic using wildcard characters**

These procedures demonstrate how the AWS IoT Device Client can subscribe to and log MQTT messages using wildcard characters. To do this, you'll:

1. Update the topic filter that the AWS IoT Device Client uses to subscribe to MQTT topics.
2. Update the policy used by the device to allow the new subscriptions.
3. Run the AWS IoT Device Client and publish messages from the MQTT test console.
To create a config file to subscribe to multiple MQTT message topics by using a wildcard MQTT topic filter

1. In the terminal window on your local host computer that's connected to your Raspberry Pi, open `~/dc-configs/dc-pubsub-custom-config.json` for editing and locate the `samples` object.
2. In the text editor, locate the `samples` object and update the `subscribe-topic` value to look like this.

   ```json
   "samples": {
       "pub-sub": {
           "enabled": true,
           "publish-topic": "test/dc/pubtopic",
           "publish-file": "~/messages/sample-ws-message.json",
           "subscribe-topic": "test/dc/#",
           "subscribe-file": "~/aws-iot-device-client/log/pubsub_rx_msgs.log"
       }
   }
   ``

   The new `subscribe-topic` value is an MQTT topic filter (p. 110) with an MQTT wild card character at the end. This describes a subscription to all MQTT topics that start with `test/dc/`. The AWS IoT Device Client writes the message payloads that it receives from this subscription to the file named in `subscribe-file`.

3. Save the modified config file as `~/dc-configs/dc-pubsub-wild-config.json`, and exit the editor.

To modify the policy used by your Raspberry Pi to allow subscribing to and receiving multiple MQTT message topics

1. In the terminal window on your local host computer that's connected to your Raspberry Pi, in your favorite text editor, open `~/policies/pubsub_test_thing_policy.json` for editing, and then locate the `iot::Subscribe` and `iot::Receive` policy statements in the file.

2. In the `iot::Subscribe` policy statement, update the string in the Resource object to replace `subtopic` with *, so that it looks like this.

   ```json
   {   
       "Effect": "Allow",
       "Action": [
           "iot:Subscribe"
       ],
       "Resource": [
       ]
   }
   ```

   Note
   The MQTT topic filter wild card characters (p. 110) are the + (plus sign) and the # (pound sign). A subscription request with a # at the end subscribes to all topics that start with the string that precedes the # character (for example, `test/dc/` in this case). The resource value in the policy statement that authorizes this subscription, however, must use a * (an asterisk) in place of the # (a pound sign) in the topic filter ARN. This is because the policy processor uses a different wild card character than MQTT uses. For more information about using wild card characters for topics and topic filters in policies, see Using wildcard characters in MQTT and AWS IoT Core policies (p. 354).

3. In the `iot::Receive` policy statement, update the string in the Resource object to replace `subtopic` with *, so that it looks like this.

   ```json
   {   
       "Effect": "Allow",
   }
   ```
4. Save the updated policy document as 
   `/~policies/pubsub_wild_test_thing_policy.json`, and exit the editor.

5. Enter this command to update the policy for this tutorial to use the new resource definitions.

   ```bash
   aws iot create-policy-version 
   --set-as-default 
   --policy-name "PubSubTestThingPolicy" 
   --policy-document "file://~/policies/pubsub_wild_test_thing_policy.json"
   ```

   If the command succeeds, it returns a response like this. Notice that policyVersionId is now 2, indicating this is the second version of this policy.

   ```json
   {
   ```

   If you get an error that there are too many policy versions to save a new one, enter this command to list the current versions of the policy. Review the list that this command returns to find a policy version that you can delete.

   ```bash
   aws iot list-policy-versions --policy-name "PubSubTestThingPolicy"
   ```

   Enter this command to delete a version that you no longer need. Note that you can’t delete the default policy version. The default policy version is the one with a isDefaultVersion value of true.

   ```bash
   aws iot delete-policy-version 
   --policy-name "PubSubTestThingPolicy" 
   --policy-version-id policyId
   ```

   After deleting a policy version, retry this step.

   With the updated config file and policy, you're ready to demonstrate wild card subscriptions with the AWS IoT Device Client.
To demonstrate how the AWS IoT Device Client subscribes to and receives multiple MQTT message topics

1. In the MQTT test client, check the subscriptions. If the MQTT test client is subscribed to the to the in the # topic filter, continue to the next step. If not, in the MQTT test client, in Subscribe to a topic tab, in Topic filter, enter # (a pound sign character), and then choose Subscribe to subscribe to it.

2. In the terminal window on your local host computer that's connected to your Raspberry Pi, enter these commands to start the AWS IoT Device Client.

   ```
   cd ~/aws-iot-device-client/build
   ./aws-iot-device-client --config-file ~/dc-configs/dc-pubsub-wild-config.json
   ```

3. While watching the AWS IoT Device Client output in the terminal window on the local host computer, return to the MQTT test client. In the Publish to a topic tab, in Topic name, enter test/dc/subtopic, and then choose Publish.

4. In the terminal window, confirm that the message was received by looking for a message such as:

   ```
   2021-11-10T16:34:20.101Z [DEBUG] {samples/PubSubFeature.cpp}: Message received on subscribe topic, size: 76 bytes
   ```

5. While watching the AWS IoT Device Client output in the terminal window of the local host computer, return to the MQTT test client. In the Publish to a topic tab, in Topic name, enter test/dc/subtopic2, and then choose Publish.

6. In the terminal window, confirm that the message was received by looking for a message such as:

   ```
   2021-11-10T16:34:32.078Z [DEBUG] {samples/PubSubFeature.cpp}: Message received on subscribe topic, size: 77 bytes
   ```

7. After you see the messages that confirm both messages were received, enter ^C (Ctrl-C) to stop the AWS IoT Device Client.

8. Enter this command to view the end of the message log file and see the message you published from the MQTT test client.

   ```
   tail -n 20 ~/.aws-iot-device-client/log/pubsub_rx_msgs.log
   ```

   **Note**
   The log file contains only message payloads. The message topics are not recorded in the received message log file.
   You might also see the message published by the AWS IoT Device Client in the received log. This is because the wild card topic filter includes that message topic and, sometimes, the subscription request can be processed by message broker before the published message is sent to subscribers.

The entries in the log file demonstrate that the messages were received. You can repeat this procedure using other topic names. All messages that have a topic name that begins with test/dc/ should be received and logged. Messages with topic names that begin with any other text are ignored.

After demonstrating how the AWS IoT Device Client can publish and subscribe to MQTT messages, continue to Tutorial: Demonstrate remote actions (jobs) with the AWS IoT Device Client (p. 167).
Tutorial: Demonstrate remote actions (jobs) with the AWS IoT Device Client

In these tutorials, you'll configure and deploy jobs to your Raspberry Pi to demonstrate how you can send remote operations to your IoT devices.

To start this tutorial:

• Have your local host computer an Raspberry Pi configured as used in the previous section (p. 153).
• If you haven't completed the tutorial in the previous section, you can try this tutorial by using the Raspberry Pi with a microSD card that has the image you saved after you installed the AWS IoT Device Client in (Optional) Save the microSD card image (p. 146).
• If you have run this demo before, review (p. 178) to delete all AWS IoT resources that you created in earlier runs to avoid duplicate resource errors.

This tutorial takes about 45 minutes to complete.

When you're finished with this topic:

• You'll have demonstrated different ways that your IoT device can use the AWS IoT Core to run remote operations that are managed by AWS IoT.

Required equipment:

• Your local development and testing environment that you tested in a previous section (p. 145)
• The Raspberry Pi that you tested in a previous section (p. 145)
• The microSD memory card from the Raspberry Pi that you tested in a previous section (p. 145)

Procedures in this tutorial

• Step 1: Prepare the Raspberry Pi to run jobs (p. 167)
• Step 2: Create and run the job in AWS IoT (p. 173)

Step 1: Prepare the Raspberry Pi to run jobs

The procedures in this section describe how to prepare your Raspberry Pi to run jobs by using the AWS IoT Device Client.

Note

These procedures are device specific. If you want to perform the procedures in this section with more than one device at the same time, each device will need its own policy and unique, device-specific certificate and thing name. To give each device its unique resources, perform this procedure one time for each device while changing the device-specific elements as described in the procedures.

Procedures in this tutorial

• Provision your Raspberry Pi to demonstrate jobs (p. 168)
• Configure the AWS IoT Device Client to run the jobs agent (p. 172)
Provision your Raspberry Pi to demonstrate jobs

The procedures in this section provision your Raspberry Pi in AWS IoT by creating AWS IoT resources and device certificates for it.

Create and download device certificate files to demonstrate AWS IoT jobs

This procedure creates the device certificate files for this demo.

If you are preparing more than one device, this procedure must be performed on each device.

To create and download the device certificate files for your Raspberry Pi:

In the terminal window on your local host computer that's connected to your Raspberry Pi, enter these commands.

1. Enter the following command to create the device certificate files for your device.

```bash
aws iot create-keys-and-certificate \
--set-as-active \
--certificate-pem-outfile "~/certs/jobs/device.pem.crt" \
--public-key-outfile "~/certs/jobs/public.pem.key" \
--private-key-outfile "~/certs/jobs/private.pem.key"
```

The command returns a response like the following. Save the `certificateArn` value for later use.

```
{
"certificateArn": "arn:aws:iot:us-west-2:57EXAMPLE833:cert/76e7e4edbe52f52334be2f3a87a06145b2aa4c7fcd810f3aa2d92abc227d269",
"certificateId": "76e7e4edbe52f52334be2f3a87a06145b2aa4c7fcd810f3aa2d92abc227d269",
"certificatePem": "-----BEGIN CERTIFICATE-----
MIIDWTCCAkGgAwIBAgI_SHORTENED_FOR_EXAMPLE_Lgn4jfgtS\n-----END CERTIFICATE-----
",
"keyPair": {
"PublicKey": "-----BEGIN PUBLIC KEY-----
MIIBIjANBgkqhkiG9w0BA_SHORTENED_FOR_EXAMPLE_ImwIDAQAB
-----END PUBLIC KEY-----
",
"PrivateKey": "-----BEGIN RSA PRIVATE KEY-----
MIIEowIBAAKCAQI_SHORTENED_FOR_EXAMPLE_T9RoDiukY
-----END RSA PRIVATE KEY-----
"
}
}
```

2. Enter the following commands to set the permissions on the certificate directory and its files.

```bash
chmod 700 ~/certs/jobs
chmod 644 ~/certs/jobs/*
chmod 600 ~/certs/jobs/private.pem.key
```

3. Run this command to review the permissions on your certificate directories and files.

```
ls -l ~/certs/jobs
```

The output of the command should be the same as what you see here, except the file dates and times will be different.

```
-rw-r--r-- 1 pi pi 1220 Oct 28 13:02 device.pem.crt
-rw------- 1 pi pi 1675 Oct 28 13:02 private.pem.key
-rw-r--r-- 1 pi pi 451 Oct 28 13:02 public.pem.key
```
After you have downloaded the device certificate files to your Raspberry Pi, you’re ready to continue to the section called “Provision your Raspberry Pi to demonstrate jobs” (p. 168).

Create AWS IoT resources to demonstrate AWS IoT jobs

Create the AWS IoT resources for this device.

If you are preparing more than one device, this procedure must be performed for each device.

**To provision your device in AWS IoT:**

In the terminal window on your local host computer that’s connected to your Raspberry Pi:

1. Enter the following command to get the address of the device data endpoint for your AWS account.
   
   ```
   aws iot describe-endpoint --endpoint-type IoT:Data-ATS
   ```
   
   The endpoint value hasn’t changed since the last time you ran this command. Running the command again here makes it easy to find and paste the data endpoint value into the config file used in this tutorial.

   The `describe-endpoint` command returns a response like the following. Record the `endpointAddress` value for later use.

   ```
   {
     "endpointAddress": "a3qjEXxAMPLEffp-ats.iot.us-west-2.amazonaws.com"
   }
   ```

2. Replace `uniqueThingName` with a unique name for your device. If you want to perform this tutorial with multiple devices, give each device its own name. For example, `TestDevice01`, `TestDevice02`, and so on.

   Enter this command to create a new AWS IoT thing resource for your Raspberry Pi.

   ```
   aws iot create-thing --thing-name "uniqueThingName"
   ```

   Because an AWS IoT thing resource is a virtual representation of your device in the cloud, we can create multiple thing resources in AWS IoT to use for different purposes. They can all be used by the same physical IoT device to represent different aspects of the device.

   **Note**

   When you want to secure the policy for multiple devices, you can use `${iot:Thing. ThingName}` instead of the static thing name, `uniqueThingName`.

   These tutorials will only use one thing resource at a time per device. This way, in these tutorials, they represent the different demos so that after you create the AWS IoT resources for a demo, you can go back and repeat the demos using the resources you created specifically for each.

   If your AWS IoT thing resource was created, the command returns a response like this. Record the `thingArn` value for use later when you create the job to run on this device.

   ```
   {
     "thingName": "uniqueThingName",
     "thingArn": "arn:aws:iot:us-west-2:57EXAMPLE833:thing/uniqueThingName",
     "thingId": "8ea78707-32c3-4f8a-9232-14bEXAMPLEfd"
   }
   ```

3. In the terminal window:
a. Open a text editor, such as nano.
b. Copy this JSON document and paste it into your open text editor.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Connect"
            ],
            "Resource": [
                "arn:aws:iot:us-west-2:57EXAMPLE833:client/uniqueThingName"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish"
            ],
            "Resource": [
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Subscribe"
            ],
            "Resource": [
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Receive"
            ],
            "Resource": [
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:DescribeJobExecution",
                "iot:GetPendingJobExecutions",
                "iot:StartNextPendingJobExecution",
                "iot:UpdateJobExecution"
            ],
            "Resource": [
                "arn:aws:iot:us-west-2:57EXAMPLE833:topic/$aws/things/uniqueThingName"
            ]
        }
    ]
}
```
c. In the editor, in the Resource section of every policy statement, replace `us-west-2:57EXAMPLE833` with your AWS Region, a colon character (:) and your 12-digit AWS account number.

d. In the editor, in every policy statement, replace `uniqueThingName` with the thing name you gave this thing resource.

e. Save the file in your text editor as `~/policies/jobs_test_thing_policy.json`.

If you are running this procedure for multiple devices, save the file to this file name on each device.

4. Replace `uniqueThingName` with the thing name for the device, and then run this command to create an AWS IoT policy that is tailored for that device.

```
aws iot create-policy \
--policy-name "JobTestPolicyForuniqueThingName" \
--policy-document "file://~/policies/jobs_test_thing_policy.json"
```

If the policy is created, the command returns a response like this.

```
{
   "policyName": "JobTestPolicyForuniqueThingName",
   "policyDocument": "{\"Version\": "2012-10-17\", \"Statement\": [{\n   \"Effect\": "Allow",
   \"Action\": ["iot:Connect"],
   },{\n   \"Allow\", \"Action\": ["iot:Publish"],
   },{\n   \"Allow\", \"Action\": ["iot:Subscribe"],
   },{\n   \"Allow\", \"Action\": ["iot:Receive"],
   }]
   }\n}
```

5. Replace `uniqueThingName` with the thing name for the device and `certificateArn` with the `certificateArn` value you saved earlier in this section for this device, and then run this command to attach the policy to the device certificate.

```
aws iot attach-policy \
--policy-name "JobTestPolicyForuniqueThingName" \
--target "certificateArn"
```

If successful, this command returns nothing.

6. Replace `uniqueThingName` with the thing name for the device, replace `certificateArn` with the `certificateArn` value that you saved earlier in this section, and then run this command to attach the device certificate to the AWS IoT thing resource.

```
aws iot attach-thing-principal \
--thing-name "uniqueThingName" \
--principal "certificateArn"
```

If successful, this command returns nothing.
After you successfully provisioned your Raspberry Pi, you're ready to repeat this section for another Raspberry Pi in your test or, if all devices have been provisioned, continue to the section called “Configure the AWS IoT Device Client to run the jobs agent” (p. 172).

Configure the AWS IoT Device Client to run the jobs agent

This procedure creates a config file for the AWS IoT Device Client to run the jobs agent:

Note: if you are preparing more than one device, this procedure must be performed on each device.

To create the config file to test the AWS IoT Device Client:

1. In the terminal window on your local host computer that's connected to your Raspberry Pi:
   a. Open a text editor, such as nano.
   b. Copy this JSON document and paste it into your open text editor.

```json
{
  "endpoint": "a3qEXAMPLEaffp-ats.iot.us-west-2.amazonaws.com",
  "cert": "~/certs/jobs/device.pem.crt",
  "key": "~/certs/jobs/private.pem.key",
  "root-ca": "~/certs/AmazonRootCA1.pem",
  "thing-name": "uniqueThingName",
  "logging": {
    "enable-sdk-logging": true,
    "level": "DEBUG",
    "type": "STDOUT",
    "file": ""
  },
  "jobs": {
    "enabled": true,
    "handler-directory": ""
  },
  "tunneling": {
    "enabled": false
  },
  "device-defender": {
    "enabled": false,
    "interval": 300
  },
  "fleet-provisioning": {
    "enabled": false,
    "template-name": "",
    "template-parameters": "",
    "csr-file": "",
    "device-key": ""
  },
  "samples": {
    "pub-sub": {
      "enabled": false,
      "publish-topic": "",
      "publish-file": "",
      "subscribe-topic": "",
      "subscribe-file": ""
    }
  },
  "config-shadow": {
    "enabled": false
  },
  "sample-shadow": {
    "enabled": false,
    "shadow-name": "",
    "shadow-input-file": "",
    "shadow-output-file": ""
}
```
Demonstrate remote actions (jobs)
with the AWS IoT Device Client

Step 1: Configure the device

**c.** Replace the `endpoint` value with device data endpoint value for your AWS account that you found in the section called “Provision your device in AWS IoT Core” (p. 148).

**d.** Replace `uniqueThingName` with the thing name that you used for this device.

**e.** Save the file in your text editor as `~/dc-configs/dc-jobs-config.json`.

2. Run this command to set the file permissions of the new config file.

```
chmod 644 ~/dc-configs/dc-jobs-config.json
```

You won't use the MQTT test client for this test. While the device will exchange jobs-related MQTT messages with AWS IoT, job progress messages are only exchanged with the device running the job. Because job progress messages are only exchanged with the device running the job, you can't subscribe to them from another device, such as the AWS IoT console.

After you save the config file, you're ready to continue to the section called “Step 2: Create and run the job in AWS IoT” (p. 173).

**Step 2: Create and run the job in AWS IoT**

The procedures in this section create a job document and an AWS IoT job resource. After you create the job resource, AWS IoT sends the job document to the specified job targets on which a jobs agent applies the job document to the device or client.

**Procedures in this section**

- Create and store the job's job document (p. 173)
- Run a job in AWS IoT for one IoT device (p. 174)

**Create and store the job's job document**

This procedure creates a simple job document to include in an AWS IoT job resource. This job document displays "Hello world!" on the job target.

**To create and store a job document:**

1. Select the Amazon S3 bucket into which you'll save your job document. If you don't have an existing Amazon S3 bucket to use for this, you'll need to create one. For information about how to create Amazon S3 buckets, see the topics in Getting started with Amazon S3.

2. Create and save the job document for this job
   
   **a.** On your local host computer, open a text editor.
   **b.** Copy and paste this text into the editor.
   ```json
   {  
     "operation": "echo",
     "args": ["Hello world!"]
   }
   ```
   **c.** On the local host computer, save the contents of the editor to a file named `hello-world-job.json`.
   **d.** Confirm the file was saved correctly. Some text editors automatically append `.txt` to the file name when they save a text file. If your editor appended `.txt` to the file name, correct the file name before proceeding.
Demonstrate remote actions (jobs) with the AWS IoT Device Client

3. Replace the `path_to_file` with the path to `hello-world-job.json`, if it's not in your current directory, replace `s3_bucket_name` with the Amazon S3 bucket path to the bucket you selected, and then run this command to put your job document into the Amazon S3 bucket.

```
aws s3api put-object \
  --key hello-world-job.json \ 
  --body path_to_file/hello-world-job.json --bucket s3_bucket_name
```

The job document URL that identifies the job document that you stored in Amazon S3 is determined by replacing the `s3_bucket_name` and `AWS_region` in the following URL. Record the resulting URL to use later as the `job_document_path`.

```
https://s3_bucket_name.s3.AWS_Region.amazonaws.com/hello-world-job.json
```

**Note**
AWS security prevents you from being able to open this URL outside of your AWS account, for example by using a browser. The URL is used by the AWS IoT jobs engine, which has access to the file, by default. In a production environment, you'll need to make sure that your AWS IoT services have permission to access to the job documents stored in Amazon S3.

After you have saved the job document's URL, continue to the section called “Run a job in AWS IoT for one IoT device” (p. 174).

### Run a job in AWS IoT for one IoT device

The procedures in this section start the AWS IoT Device Client on your Raspberry Pi to run the jobs agent on the device to wait for jobs to run. It also creates a job resource in AWS IoT, which will send the job to and run on your IoT device.

**Note**
This procedure runs a job on only a single device.

To start the jobs agent on your Raspberry Pi:

1. In the terminal window on your local host computer that's connected to your Raspberry Pi, run this command to start the AWS IoT Device Client.

```
  cd ~/aws-iot-device-client/build
  ./aws-iot-device-client --config-file ~/dc-configs/dc-jobs-config.json
```

2. In the terminal window, confirm that the AWS IoT Device Client and displays these messages:

```
2021-11-15T18:45:56.708Z [INFO]  {Main.cpp}: Jobs is enabled
::
::

2021-11-15T18:45:56.708Z [INFO]  {Main.cpp}: Client base has been notified that Jobs has started


2021-11-15T18:45:56.708Z [DEBUG] {JobsFeature.cpp}: Attempting to subscribe to startNextPendingJobExecution accepted and rejected

2021-11-15T18:45:56.708Z [DEBUG] {JobsFeature.cpp}: Attempting to subscribe to nextJobChanged events

2021-11-15T18:45:56.708Z [DEBUG] {JobsFeature.cpp}: Attempting to subscribe to updateJobExecutionStatusAccepted for jobId +

2021-11-15T18:45:56.708Z [DEBUG] {JobsFeature.cpp}: Ack received for SubscribeToUpdateJobExecutionAccepted with code {0}

2021-11-15T18:45:56.708Z [DEBUG] {JobsFeature.cpp}: Attempting to subscribe to updateJobExecutionStatusRejected for jobId +
```

174
Demonstrate remote actions (jobs) with the AWS IoT Device Client

3. In the terminal window, after you see this message, continue to the next procedure and create the job resource. Note that it might not be the last entry in the list.

```
2021-11-15T18:45:56.785Z [INFO]  {JobsFeature.cpp}: No pending jobs are scheduled, waiting for the next incoming job
```

To create an AWS IoT job resource

1. On your local host computer:
   a. Replace `job_document_url` with the job document URL from the section called “Create and store the job’s job document” (p. 173).
   b. Replace `thing_arn` with the ARN of the thing resource you created for your device and then run this command.

```
aws iot create-job \
  --job-id hello-world-job-1 \
  --document-source "job_document_url" \
  --targets "thing_arn" \
  --target-selection SNAPSHOT
```

If successful, the command returns a result like this one.

```
{
  "jobId": "hello-world-job-1"
}
```

2. In the terminal window, you should see output from the AWS IoT Device Client like this.

```
2021-11-15T18:02:26.688Z [INFO]  {JobsFeature.cpp}: No pending jobs are scheduled, waiting for the next incoming job
```

```
2021-11-15T18:26.688Z [INFO]  {JobsFeature.cpp}: No pending jobs are scheduled, waiting for the next incoming job
```
3. While the AWS IoT Device Client is running and waiting for a job, you can submit another job by changing the `job-id` value and re-running the `create-job` from Step 1.

When you’re done running jobs, in the terminal window, enter `^C` (control-C) to stop the AWS IoT Device Client.

Tutorial: Cleaning up after running the AWS IoT Device Client tutorials

The procedures in this tutorial walk you through removing the files and resources you created while completing the tutorials in this learning path.

Procedures in this tutorial

- Step 1: Cleaning up your devices after building demos with the AWS IoT Device Client (p. 176)
- Step 2: Cleaning up your AWS account after building demos with the AWS IoT Device Client (p. 178)

Step 1: Cleaning up your devices after building demos with the AWS IoT Device Client

This tutorial describes two options for how to clean up the microSD card after you built the demos in this learning path. Choose the option that provides the level of security that you need.
Note that cleaning the device's microSD card does not remove any AWS IoT resources that you created. To clean up the AWS IoT resources after you clean the device's microSD card, you should review the tutorial on the section called “Cleaning up after building demos with the AWS IoT Device Client” (p. 178).

**Option 1: Cleaning up by rewriting the microSD card**

The easiest and most thorough way to clean the microSD card after completing the tutorials in this learning path is to overwrite the microSD card with a saved image file that you created while preparing your device the first time.

This procedure uses the local host computer to write a saved microSD card image to a microSD card.

**Note**

If your device doesn't use a removable storage medium for its operating system, refer to the procedure for that device.

**To write a new image to the microSD card**

1. On your local host computer, locate the saved microSD card image that you want to write to your microSD card.
2. Insert your microSD card into the local host computer.
3. Using an SD card imaging tool, write selected image file to the microSD card.
4. After writing the Raspberry Pi OS image to the microSD card, eject the microSD card and safely remove it from the local host computer.

Your microSD card is ready to use.

**Option 2: Cleaning up by deleting user directories**

To clean the microSD card after completing the tutorials without rewriting the microSD card image, you can delete the user directories individually. This is not as thorough as rewriting the microSD card from a saved image because it does not remove any system files that might have been installed.

If removing the user directories is sufficiently thorough for you needs, you can follow this procedure.

**To delete this learning path's user directories from your device**

1. Run these commands to delete the user directories, subdirectories, and all their files that were created in this learning path, in the terminal window connected to your device.

   **Note**
   After you delete these directories and files, you won't be able to run the demos without completing the tutorials again.

   ```
   rm -Rf ~/dc-configs
   rm -Rf ~/policies
   rm -Rf ~/messages
   rm -Rf ~/certs
   rm -Rf ~/.aws-iot-device-client
   ```

2. Run these commands to delete the application source directories and files, in the terminal window connected to your device.

   **Note**
   These commands don’t uninstall any programs. They only remove the source files used to build and install them. After you delete these files, the AWS CLI and the AWS IoT Device Client might not work.

   ```
   rm -Rf ~/aws-cli
   ```
Step 2: Cleaning up your AWS account after building demos with the AWS IoT Device Client

These procedures help you identify and remove the AWS resources that you created while completing the tutorials in this learning path.

Clean up AWS IoT resources

This procedure helps you identify and remove the AWS IoT resources that you created while completing the tutorials in this learning path.

AWS IoT resources created in this learning path

<table>
<thead>
<tr>
<th>Tutorial</th>
<th>Thing resource</th>
<th>Policy resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>the section called “Installing and configuring the AWS IoT Device Client” (p. 145)</td>
<td>DevCliTestThing</td>
<td>DevCliTestThingPolicy</td>
</tr>
<tr>
<td>the section called “Demonstrate MQTT message communication with the AWS IoT Device Client” (p. 153)</td>
<td>PubSubTestThing</td>
<td>PubSubTestThingPolicy</td>
</tr>
<tr>
<td>the section called “Demonstrate remote actions (jobs) with the AWS IoT Device Client” (p. 167)</td>
<td>user defined (there could be more than one)</td>
<td>user defined (there could be more than one)</td>
</tr>
</tbody>
</table>

To delete the AWS IoT resources, follow this procedure for each thing resource that you created

1. Replace thing_name with the name of the thing resource you want to delete, and then run this command to list the certificates attached to the thing resource, from the local host computer.

   aws iot list-thing-principals --thing-name thing_name

   This command returns a response like this one that lists the certificates that are attached to thing_name. In most cases, there will only be one certificate in the list.

   ```
   {
     "principals": [
       "arn:aws:iot:us-west-2:57EXAMPLE833:cert/23853eea3cf0edc7f8a69c74abeafa27b2b52823cab5b3e156295e94b26ae8ac"
     ]
   }
   ```

2. For each certificate listed by the previous command:

   a. Replace certificate_ID with the certificate ID from the previous command. The certificate ID is the alphanumeric characters that follow cert/ in the ARN returned by the previous command. Then run this command to inactivate the certificate.
Cleaning up

aws iot update-certificate --new-status INACTIVE --certificate-id certificate_ID

If successful, this command doesn't return anything.

b. Replace certificate_ARN with the certificate ARN from the list of certificates returned earlier, and then run this command to list the policies attached to this certificate.

aws iot list-attached-policies --target certificate_ARN

This command returns a response like this one that lists the policies attached to the certificate. In most cases, there will only be one policy in the list.

```
{
  "policies": [
    {
      "policyName": "DevCliTestThingPolicy",
    }
  ]
}
```

c. For each policy attached to the certificate:

i. Replace policy_name with the policyName value from the previous command, replace certificate_ARN with the certificate's ARN, and then run this command to detach the policy from the certificate.

aws iot detach-policy --policy-name policy_name --target certificate_ARN

If successful, this command doesn't return anything.

ii. Replace policy_name with the policyName value, and then run this command to see if the policy is attached to any more certificates.

aws iot list-targets-for-policy --policy-name policy_name

If the command returns an empty list like this, the policy is not attached to any certificates and you continue to list the policy versions. If there are still certificates attached to the policy, continue with the detach-thing-principal step.

```
{
  "targets": []
}
```

iii. Replace policy_name with the policyName value, and then run this command to check for policy versions. To delete the policy, it must have only one version.

aws iot list-policy-versions --policy-name policy_name

If the policy has only one version, like this example, you can skip to the delete-policy step and delete the policy now.

```
{
  "policyVersions": [
  
  ]
}
```
If the policy has more than one version, like this example, the policy versions with an `isDefaultVersion` value of `false` must be deleted before the policy can be deleted.

```json
{
    "policyVersions": [
        {
            "versionId": "2",
            "isDefaultVersion": true,
            "createDate": "2021-11-18T01:52:04.423000+00:00"
        },
        {
            "versionId": "1",
            "isDefaultVersion": false,
            "createDate": "2021-11-18T01:30:18.083000+00:00"
        }
    ]
}
```

If you need to delete a policy version, replace `policy_name` with the `policyName` value, replace `version_ID` with the `versionId` value from the previous command, and then run this command to delete a policy version.

```
aws iot delete-policy-version --policy-name policy_name --policy-version-id version_ID
```

If successful, this command doesn't return anything.

After you delete a policy version, repeat this step until the policy has only one policy version.

iv. Replace `policy_name` with the `policyName` value, and then run this command to delete the policy.

```
aws iot delete-policy --policy-name policy_name
```

d. Replace `thing_name` with the thing's name, replace `certificate_ARN` with the certificate's ARN, and then run this command to detach the certificate from the thing resource.

```
aws iot detach-thing-principal --thing-name thing_name --principal certificate_ARN
```

If successful, this command doesn't return anything.

e. Replace `certificate_ID` with the certificate ID from the previous command. The certificate ID is the alphanumeric characters that follow `cert/` in the ARN returned by the previous command. Then run this command to delete the certificate resource.

```
aws iot delete-certificate --certificate-id certificate_ID
```

If successful, this command doesn't return anything.

3. Replace `thing_name` with the thing's name, and then run this command to delete the thing.
Cleaning up

Clean up AWS resources

This procedure helps you identify and remove other AWS resources that you created while completing the tutorials in this learning path.

Other AWS resources created in this learning path

<table>
<thead>
<tr>
<th>Tutorial</th>
<th>Resource type</th>
<th>Resource name or ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>the section called “Demonstrate remote actions (jobs) with the</td>
<td>Amazon S3 object</td>
<td>hello-world-job.json</td>
</tr>
<tr>
<td>AWS IoT Device Client” (p. 167)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the section called “Demonstrate remote actions (jobs) with the</td>
<td>AWS IoT job resources</td>
<td>user defined</td>
</tr>
<tr>
<td>AWS IoT Device Client” (p. 167)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To delete the AWS resources created in this learning path

1. To delete the jobs created in this learning path

   a. Run this command to list the jobs in your AWS account.

```bash
aws iot list-jobs
```

The command returns a list of the AWS IoT jobs in your AWS account and AWS Region that looks like this.

```json
{
    "jobs": [
        {
            "jobId": "hello-world-job-2",
            "targetSelection": "SNAPSHOT",
            "status": "COMPLETED",
            "createdAt": "2021-11-16T23:40:36.825000+00:00",
            "lastUpdatedAt": "2021-11-16T23:40:41.375000+00:00",
            "completedAt": "2021-11-16T23:40:41.375000+00:00"
        },
        {
            "jobId": "hello-world-job-1",
            "targetSelection": "SNAPSHOT",
            "status": "COMPLETED",
            "createdAt": "2021-11-16T23:35:26.381000+00:00",
            "lastUpdatedAt": "2021-11-16T23:35:29.239000+00:00",
            "completedAt": "2021-11-16T23:35:29.239000+00:00"
        }
    ]
}
```
b. For each job that you recognize from the list as a job you created in this learning path, replace `jobId` with the `jobId` value of the job to delete, and then run this command to delete an AWS IoT job.

```
aws iot delete-job --job-id jobId
```

If the command is successful, it returns nothing.

2. To delete the job documents you stored in an Amazon S3 bucket in this learning path.

a. Replace `bucket` with the name of the bucket you used, and then run this command to list the objects in the Amazon S3 bucket that you used.

```
aws s3api list-objects --bucket bucket
```

The command returns a list of the Amazon S3 objects in bucket that looks like this.

```
{
    "Contents": [
    {
        "Key": "hello-world-job.json",
        "LastModified": "2021-11-18T03:02:12+00:00",
        "ETag": "868c8bc3f56b5787964764d4b18ed5ef",
        "Size": 54,
        "StorageClass": "STANDARD",
        "Owner": {
            "DisplayName": "EXAMPLE",
            "ID": "e9e3d6ec1EXAMPLEf5bfb5e6bd0a2b6ed03884d1ed392a82ad011c144736a4ee"
        }
    },
    {
        "Key": "iot_job_firmware_update.json",
        "LastModified": "2021-04-13T21:57:07+00:00",
        "ETag": "7c68c591949391791ecf625253658c61",
        "Size": 66,
        "StorageClass": "STANDARD",
        "Owner": {
            "DisplayName": "EXAMPLE",
            "ID": "e9e3d6ec1EXAMPLEf5bfb5e6bd0a2b6ed03884d1ed392a82ad011c144736a4ee"
        }
    },
    {
        "Key": "order66.json",
        "LastModified": "2021-04-13T21:57:07+00:00",
        "ETag": "bca60d5380b80e1a78cc27d321ca9a72",
        "Size": 29,
        "StorageClass": "STANDARD",
        "Owner": {
            "DisplayName": "EXAMPLE",
            "ID": "e9e3d6ec1EXAMPLEf5bfb5e6bd0a2b6ed03884d1ed392a82ad011c144736a4ee"
        }
    }
    ]
}
```

b. For each object that you recognize from the list as an object you created in this learning path, replace `bucket` with the bucket name and `key` with key value of the object to delete, and then run this command to delete an Amazon S3 object.
If the command is successful, it returns nothing.

After you delete all the AWS resources and objects that you created while completing this learning path, you can start over and repeat the tutorials.

Building solutions with the AWS IoT Device SDKs

The tutorials in this section help walk you through the steps to develop an IoT solution that can be deployed to a production environment using AWS IoT.

These tutorials can take more time to complete than those in the section on the section called “Building demos with the AWS IoT Device Client” (p. 133) because they use the AWS IoT Device SDKs and explain the concepts being applied in more detail to help you create secure and reliable solutions.

Start building solutions with the AWS IoT Device SDKs

These tutorials walk you through different AWS IoT scenarios. Where appropriate, the tutorials use the AWS IoT Device SDKs.

Topics

- Tutorial: Connecting a device to AWS IoT Core by using the AWS IoT Device SDK (p. 183)
- Creating AWS IoT rules to route device data to other services (p. 199)
- Retaining device state while the device is offline with Device Shadows (p. 228)
- Tutorial: Creating a custom authorizer for AWS IoT Core (p. 248)
- Tutorial: Monitoring soil moisture with AWS IoT and Raspberry Pi (p. 259)

Tutorial: Connecting a device to AWS IoT Core by using the AWS IoT Device SDK

This tutorial demonstrates how to connect a device to AWS IoT Core so that it can send and receive data to and from AWS IoT. After you complete this tutorial, your device will be configured to connect to AWS IoT Core and you'll understand how devices communicate with AWS IoT.

In this tutorial, you will:

1. the section called “Prepare your device for AWS IoT” (p. 184)
2. the section called “Review the MQTT protocol” (p. 184)
3. the section called “Review the pubsub.py Device SDK sample app” (p. 185)
4. the section called “Connect your device and communicate with AWS IoT Core” (p. 191)
5. the section called “Review the results” (p. 196)

This tutorial takes about an hour to complete.
Before you start this tutorial, make sure that you have:

- **Completed** *Getting started with AWS IoT Core (p. 17)*

  In the section of that tutorial where you must the section called “Configure your device” (p. 41), select the the section called “Connect a Raspberry Pi or other device” (p. 58) option for your device and use the Python language options to configure your device.

  Keep open the terminal window you use in that tutorial because you'll also use it in this tutorial.

- **A device that can run the AWS IoT Device SDK v2 for Python.**

  This tutorial shows how to connect a device to AWS IoT Core by using Python code examples, which require a relatively powerful device.

  If you are working with resource-constrained devices, these code examples might not work on them. In that case, you might have more success by the section called “Using the AWS IoT Device SDK for Embedded C” (p. 196) tutorial.

### Prepare your device for AWS IoT

In *Getting started with AWS IoT Core (p. 17)*, you prepared your device and AWS account so they could communicate. This section reviews the aspects of that preparation that apply to any device connection with AWS IoT Core.

For a device to connect to AWS IoT Core:

1. **You must have an AWS account.**

   The procedure in *Set up your AWS account (p. 18)* describes how to create an AWS account if you don't already have one.

2. In that account, you must have the following **AWS IoT resources** defined for the device in your AWS account and Region.

   The procedure in *Create AWS IoT resources (p. 38)* describes how to create these resources for the device in your AWS account and Region.

   - **A device certificate** registered with AWS IoT and activated to authenticate the device.

     The certificate is often created with, and attached to, an **AWS IoT thing object**. While a thing object is not required for a device to connect to AWS IoT, it makes additional AWS IoT features available to the device.

   - **A policy** attached to the device certificate that authorizes it to connect to AWS IoT Core and perform all the actions that you want it to.

3. **An internet connection** that can access your AWS account's device endpoints.

   The device endpoints are described in *AWS IoT device data and service endpoints (p. 82)* and can be seen in the settings page of the AWS IoT console.

4. **Communication software** such as the AWS IoT Device SDKs provide. This tutorial uses the **AWS IoT Device SDK v2 for Python.**

### Review the MQTT protocol

Before we talk about the sample app, it helps to understand the MQTT protocol. The MQTT protocol offers some advantages over other network communication protocols, such as HTTP, which makes it a popular choice for IoT devices. This section reviews the key aspects of MQTT that apply to this
tutorial. For information about how MQTT compares to HTTP, see Choosing a protocol for your device communication (p. 86).

**MQTT uses a publish/subscribe communication model**

The MQTT protocol uses a publish/subscribe communication model with its host. This model differs from the request/response model that HTTP uses. With MQTT, devices establish a session with the host that is identified by a unique client ID. To send data, devices publish messages identified by topics to a message broker in the host. To receive messages from the message broker, devices subscribe to topics by sending topic filters in subscription requests to the message broker.

**MQTT supports persistent sessions**

The message broker receives messages from devices and publishes messages to devices that have subscribed to them. With persistent sessions (p. 90)—sessions that remain active even when the initiating device is disconnected—devices can retrieve messages that were published while they were disconnected. On the device side, MQTT supports Quality of Service levels (QoS (p. 89)) that ensure the host receives messages sent by the device.

**Review the pubsub.py Device SDK sample app**

This section reviews the pubsub.py sample app from the AWS IoT Device SDK v2 for Python used in this tutorial. Here, we’ll review how it connects to AWS IoT Core to publish and subscribe to MQTT messages. The next section presents some exercises to help you explore how a device connects and communicates with AWS IoT Core.

The pubsub.py sample app demonstrates these aspects of an MQTT connection with AWS IoT Core:

- Communication protocols (p. 185)
- Persistent sessions (p. 188)
- Quality of Service (p. 188)
- Message publish (p. 189)
- Message subscription (p. 189)
- Device disconnection and reconnection (p. 190)

**Communication protocols**

The pubsub.py sample demonstrates an MQTT connection using the MQTT and MQTT over WSS protocols. The AWS common runtime (AWS CRT) library provides the low-level communication protocol support and is included with the AWS IoT Device SDK v2 for Python.

**MQTT**

The pubsub.py sample calls mTLS from path (shown here) in the mqtt_connection_builder to establish a connection with AWS IoT Core by using the MQTT protocol. mTLS from path uses X.509 certificates and TLS v1.2 to authenticate the device. The AWS CRT library handles the lower-level details of that connection.

```python
mqtt_connection = mqtt_connection_builder.mtls_from_path(
    endpoint=args.endpoint,
    cert_filepath=args.cert,
    pri_key_filepath=args.key,
    ca_filepath=args.ca_file,
    client_bootstrap=client_bootstrap,
    on_connection_interrupted=on_connection_interrupted,
    on_connection_resumed=on_connection_resumed,
    client_id=args.client_id,
    clean_session=False,
```
keep_alive_secs=6

endpoint
    Your AWS account's IoT device endpoint
    In the sample app, this value is passed in from the command line.
cert_filepath
    The path to the device's certificate file
    In the sample app, this value is passed in from the command line.
pri_key_filepath
    The path to the device's private key file that was created with its certificate file
    In the sample app, this value is passed in from the command line.
ca_filepath
    The path to the Root CA file. Required only if the MQTT server uses a certificate that's not already in your trust store.
    In the sample app, this value is passed in from the command line.
client_bootstrap
    The common runtime object that handles socket communication activities
    In the sample app, this object is instantiated before the call to mqtt_connection_builder.mtls_from_path.
on_connection_interrupted, on_connection_resumed
    The callback functions to call when the device's connection is interrupted and resumed
client_id
    The ID that uniquely identifies this device in the AWS Region
    In the sample app, this value is passed in from the command line.
clean_session
    Whether to start a new persistent session, or, if one is present, reconnect to an existing one
keep_alive_secs
    The keep alive value, in seconds, to send in the CONNECT request. A ping will automatically be sent at this interval. If the server doesn't receive a ping after 1.5 times this value, it assumes that the connection is lost.

MQTT over WSS

The pubsub.py sample calls websockets_with_default_aws_signing (shown here) in the mqtt_connection_builder to establish a connection with AWS IoT Core using the MQTT protocol over WSS. websockets_with_default_aws_signing creates an MQTT connection over WSS using Signature V4 to authenticate the device.

```
    mqtt_connection = mqtt_connection_builder.websockets_with_default_aws_signing(
        endpoint=args.endpoint,
        client_bootstrap=client_bootstrap,
        region=args.signing_region,
        credentials_provider=credentials_provider,
    )
```
websocket_proxy_options=proxy_options,
ca_filepath=ca_file,
on_connection_interrupted=on_connection_interrupted,
on_connection_resumed=on_connection_resumed,
client_id=client_id,
clean_session=False,
keep_alive_secs=6
)

event

Your AWS account's IoT device endpoint

In the sample app, this value is passed in from the command line.

client_bootstrap

The common runtime object that handles socket communication activities

In the sample app, this object is instantiated before the call to
mqtt_connection_builder.websockets_with_default_aws_signing.

region

The AWS signing Region used by Signature V4 authentication. In pubsub.py, it passes the parameter entered in the command line.

In the sample app, this value is passed in from the command line.

credentials_provider

The AWS credentials provided to use for authentication

In the sample app, this object is instantiated before the call to
mqtt_connection_builder.websockets_with_default_aws_signing.

websocket_proxy_options

HTTP proxy options, if using a proxy host

In the sample app, this value is initialized before the call to
mqtt_connection_builder.websockets_with_default_aws_signing.

c_filepath

The path to the Root CA file. Required only if the MQTT server uses a certificate that's not already in your trust store.

In the sample app, this value is passed in from the command line.

on_connection_interrupted, on_connection_resumed

The callback functions to call when the device's connection is interrupted and resumed

client_id

The ID that uniquely identifies this device in the AWS Region.

In the sample app, this value is passed in from the command line.

clean_session

Whether to start a new persistent session, or, if one is present, reconnect to an existing one

keep_alive_secs

The keep alive value, in seconds, to send in the CONNECT request. A ping will automatically be sent at this interval. If the server doesn't receive a ping after 1.5 times this value, it assumes the connection is lost.
HTTPS

What about HTTPS? AWS IoT Core supports devices that publish HTTPS requests. From a programming perspective, devices send HTTPS requests to AWS IoT Core as would any other application. For an example of a Python program that sends an HTTP message from a device, see the HTTPS code example (p. 107) using Python's `requests` library. This example sends a message to AWS IoT Core using HTTPS such that AWS IoT Core interprets it as an MQTT message.

While AWS IoT Core supports HTTPS requests from devices, be sure to review the information about Choosing a protocol for your device communication (p. 86) so that you can make an informed decision on which protocol to use for your device communications.

Persistent sessions

In the sample app, setting the `clean_session` parameter to `False` indicates that the connection should be persistent. In practice, this means that the connection opened by this call reconnects to an existing persistent session, if one exists. Otherwise, it creates and connects to a new persistent session.

With a persistent session, messages that are sent to the device are stored by the message broker while the device is not connected. When a device reconnects to a persistent session, the message broker sends to the device any stored messages to which it has subscribed.

Without a persistent session, the device will not receive messages that are sent while the device isn't connected. Which option to use depends on your application and whether messages that occur while a device is not connected must be communicated. For more information, see MQTT persistent sessions (p. 90).

Quality of Service

When the device publishes and subscribes to messages, the preferred Quality of Service (QoS) can be set. AWS IoT supports QoS levels 0 and 1 for publish and subscribe operations. For more information about QoS levels in AWS IoT, see MQTT Quality of Service (QoS) options (p. 89).

The AWS CRT runtime for Python defines these constants for the QoS levels that it supports:

**Python Quality of Service levels**

<table>
<thead>
<tr>
<th>MQTT QoS level</th>
<th>Python symbolic value used by SDK</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>QoS level 0</td>
<td><code>mqtt.QoS.AT_MOST_ONCE</code></td>
<td>Only one attempt to send the message will be made, whether it is received or not. The message might not be sent at all, for example, if the device is not connected or there's a network error.</td>
</tr>
<tr>
<td>QoS level 1</td>
<td><code>mqtt.QoS.AT_LEAST_ONCE</code></td>
<td>The message is sent repeatedly until a PUBACK acknowledgement is received.</td>
</tr>
</tbody>
</table>

In the sample app, the publish and subscribe requests are made with a QoS level of 1 (`mqtt.QoS.AT_LEAST_ONCE`).

- QoS on publish
When a device publishes a message with QoS level 1, it sends the message repeatedly until it receives a PUBACK response from the message broker. If the device isn't connected, the message is queued to be sent after it reconnects.

- **QoS on subscribe**

When a device subscribes to a message with QoS level 1, the message broker saves the messages to which the device is subscribed until they can be sent to the device. The message broker resends the messages until it receives a PUBACK response from the device.

**Message publish**

After successfully establishing a connection to AWS IoT Core, devices can publish messages. The pubsub.py sample does this by calling the publish operation of the `mqtt_connection` object.

```python
mqtt_connection.publish(
    topic=args.topic,
    payload=message,
    qos=mqtt.QoS.AT_LEAST_ONCE
)
```

- **topic**
  
  The message's topic name that identifies the message
  
  In the sample app, this is passed in from the command line.

- **payload**
  
  The message payload formatted as a string (for example, a JSON document)
  
  In the sample app, this is passed in from the command line.

  A JSON document is a common payload format, and one that is recognized by other AWS IoT services; however, the data format of the message payload can be anything that the publishers and subscribers agree upon. Other AWS IoT services, however, only recognize JSON, and CBOR, in some cases, for most operations.

- **qos**
  
  The QoS level for this message

**Message subscription**

To receive messages from AWS IoT and other services and devices, devices subscribe to those messages by their topic name. Devices can subscribe to individual messages by specifying a topic name (p. 109), and to a group of messages by specifying a topic filter (p. 110), which can include wild card characters. The pubsub.py sample uses the code shown here to subscribe to messages and register the callback functions to process the message after it's received.

```python
subscribe_future, packet_id = mqtt_connection.subscribe(
    topic=args.topic,
    qos=mqtt.QoS.AT_LEAST_ONCE,
    callback=on_message_received
)
subscribe_result = subscribe_future.result()
```

- **topic**
  
  The topic to subscribe to. This can be a topic name or a topic filter.
In the sample app, this is passed in from the command line.

def on_message_received(topic, payload, **kwargs):
    global received_count
    received_count += 1
    if received_count == args.count:
        received_all_event.set()

In the pubsub.py sample, on_message_received only displays the topic and its payload. It also counts the messages received to end the program after the limit is reached.

Your app would evaluate the topic and the payload to determine what actions to perform.

**Device disconnection and reconnection**

The pubsub.py sample includes callback functions that are called when the device is disconnected and when the connection is re-established. What actions your device takes on these events is application specific.

When a device connects for the first time, it must subscribe to topics to receive. If a device's session is present when it reconnects, its subscriptions are restored, and any stored messages from those subscriptions are sent to the device after it reconnects.

If a device's session no longer exists when it reconnects, it must resubscribe to its subscriptions. Persistent sessions have a limited lifetime and can expire when the device is disconnected for too long.
Connect your device and communicate with AWS IoT Core

This section presents some exercises to help you explore different aspects of connecting your device to AWS IoT Core. For these exercises, you'll use the MQTT test client in the AWS IoT console to see what your device publishes and to publish messages to your device. These exercises use the pubsub.py sample from the AWS IoT Device SDK v2 for Python and build on your experience with Getting started with AWS IoT Core (p. 17) tutorials.

In this section, you’ll:

- Subscribe to wild card topic filters (p. 191)
- Process topic filter subscriptions (p. 192)
- Publish messages from your device (p. 194)

For these exercises, you'll start from the pubsub.py sample program.

**Note**
These exercises assume that you completed the Getting started with AWS IoT Core (p. 17) tutorials and use the terminal window for your device from that tutorial.

Subscribe to wild card topic filters

In this exercise, you’ll modify the command line used to call pubsub.py to subscribe to a wild card topic filter and process the messages received based on the message's topic.

Exercise procedure

For this exercise, imagine that your device contains a temperature control and a light control. It uses these topic names to identify the messages about them.

1. Before starting the exercise, try running this command from the Getting started with AWS IoT Core (p. 17) tutorials on your device to make sure that everything is ready for the exercise.

   ```
   cd ~/aws-iot-device-sdk-python-v2/samples
   python3 pubsub.py --topic topic_1 --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint
   ```

   You should see the same output as you saw in the Getting started tutorial (p. 62).

2. For this exercise, change these command line parameters.

<table>
<thead>
<tr>
<th>Action</th>
<th>Command line parameter</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>add</td>
<td>--message &quot;&quot;</td>
<td>Configure pubsub.py to listen only</td>
</tr>
<tr>
<td>add</td>
<td>--count 2</td>
<td>End the program after receiving two messages</td>
</tr>
<tr>
<td>change</td>
<td>--topic device/+/details</td>
<td>Define the topic filter to subscribe to</td>
</tr>
</tbody>
</table>

Making these changes to the initial command line results in this command line. Enter this command in the terminal window for your device.
Connecting a device to AWS IoT Core by using the AWS IoT Device SDK

The program should display something like this:

```
Connecting to a3qexamplesffp-ats.iot.us-west-2.amazonaws.com with client ID 'test-24d7c8cc-c01-458c-8488-2d05849691e1'...
Connected!
Subscribing to topic 'device/+details'...
Subscribed with QoS.AT_LEAST_ONCE
Waiting for all messages to be received...
```

If you see something like this on your terminal, your device is ready and listening for messages where the topic names start with `device` and end with `/details`. So, let's test that.

3. Here are a couple of messages that your device might receive.

<table>
<thead>
<tr>
<th>Topic name</th>
<th>Message payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>device/temp/details</td>
<td>{ &quot;desiredTemp&quot;: 20, &quot;currentTemp&quot;: 15 }</td>
</tr>
<tr>
<td>device/light/details</td>
<td>{ &quot;desiredLight&quot;: 100, &quot;currentLight&quot;: 50 }</td>
</tr>
</tbody>
</table>

4. Using the MQTT test client in the AWS IoT console, send the messages described in the previous step to your device.

   a. Open the MQTT test client in the AWS IoT console.

   b. In Subscribe to a topic, in the Subscription topic field, enter the topic filter: `device/+details`, and then choose Subscribe to topic.

   c. In the Subscriptions column of the MQTT test client, choose `device/+details`.

   d. For each of the topics in the preceding table, do the following in the MQTT test client:

      1. In Publish, enter the value from the Topic name column in the table.

      2. In the message payload field below the topic name, enter the value from the Message payload column in the table.

      3. Watch the terminal window where pubsub.py is running and, in the MQTT test client, choose Publish to topic.

You should see that the message was received by pubsub.py in the terminal window.

Exercise result

With this, pubsub.py, subscribed to the messages using a wild card topic filter, received them, and displayed them in the terminal window. Notice how you subscribed to a single topic filter, and the callback function was called to process messages having two distinct topics.

Process topic filter subscriptions

Building on the previous exercise, modify the pubsub.py sample app to evaluate the message topics and process the subscribed messages based on the topic.
Exercise procedure

To evaluate the message topic

1. Copy pubsub.py to pubsub2.py.
2. Open pubsub2.py in your favorite text editor or IDE.
3. In pubsub2.py, find the on_message_received function.
4. In on_message_received, insert the following code after the line that starts with
   print("Received message and before the line that starts with global received_count.

   ```python
   topic_parsed = False
   if "/" in topic:
       parsed_topic = topic.split("/")
       if len(parsed_topic) == 3:
           # this topic has the correct format
           if (parsed_topic[0] == 'device') and (parsed_topic[2] == 'details'):
               # this is a topic we care about, so check the 2nd element
               if (parsed_topic[1] == 'temp'):
                   print("Received temperature request: {}".format(payload))
                   topic_parsed = True
               if (parsed_topic[1] == 'light'):
                   print("Received light request: {}".format(payload))
                   topic_parsed = True
           if not topic_parsed:
               print("Unrecognized message topic.")
   ```
5. Save your changes and run the modified program by using this command line.

   ```bash
   python3 pubsub2.py --message "" --count 2 --topic device/+details --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint
   ```
6. In the AWS IoT console, open the MQTT test client.
7. In Subscribe to a topic, in the Subscription topic field, enter the topic filter: device/+details, and then choose Subscribe to topic.
8. In the Subscriptions column of the MQTT test client, choose device/+details.
9. For each of the topics in this table, do the following in the MQTT test client:

<table>
<thead>
<tr>
<th>Topic name</th>
<th>Message payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>device/temp/details</td>
<td>{ &quot;desiredTemp&quot;: 20, &quot;currentTemp&quot;: 15 }</td>
</tr>
<tr>
<td>device/light/details</td>
<td>{ &quot;desiredLight&quot;: 100, &quot;currentLight&quot;: 50 }</td>
</tr>
</tbody>
</table>

   1. In Publish, enter the value from the Topic name column in the table.
2. In the message payload field below the topic name, enter the value from the Message payload column in the table.
3. Watch the terminal window where pubsub.py is running and, in the MQTT test client, choose Publish to topic.

   You should see that the message was received by pubsub.py in the terminal window.
You should see something similar to this in your terminal window.

```
Connecting to a3gexamplesffp-ats.iot.us-west-2.amazonaws.com with client ID 'test-af79eb0-75a2-45a0-b0af-0b0ea74f517'
Connected!
Subscribing to topic 'device/+/details'...
Subscribed with QoS.AT_LEAST_ONCE
Waiting for all messages to be received...
Received message from topic 'device/light/details': b'{ "desiredLight": 100, "currentLight": 50 }'
Received light request: b'{ "desiredLight": 100, "currentLight": 50 }'
Received message from topic 'device/temp/details': b'{ "desiredTemp": 20, "currentTemp": 15 }'
Received temperature request: b'{ "desiredTemp": 20, "currentTemp": 15 }'
2 message(s) received.
Disconnecting...
Disconnected!
```

**Exercise result**

In this exercise, you added code so the sample app would recognize and process multiple messages in the callback function. With this, your device could receive messages and act on them.

Another way for your device to receive and process multiple messages is to subscribe to different messages separately and assign each subscription to its own callback function.

**Publish messages from your device**

You can use the pubsub.py sample app to publish messages from your device. While it will publish messages as it is, the messages can't be read as JSON documents. This exercise modifies the sample app to be able to publish JSON documents in the message payload that can be read by AWS IoT Core.

**Exercise procedure**

In this exercise, the following message will be sent with the device/data topic.

```
{
   "timestamp": 1601048303,
   "sensorId": 28,
   "sensorData": [
      {
         "sensorName": "Wind speed",
         "sensorValue": 34.2211224
      }
   ]
}
```

**To prepare your MQTT test client to monitor the messages from this exercise**

1. In **Subscribe to a topic**, in the **Subscription topic field**, enter the topic filter: **device/data**, and then choose **Subscribe to topic**.
2. In the **Subscriptions** column of the MQTT test client, choose **device/data**.
3. Keep the MQTT test client window open to wait for messages from your device.

**To send JSON documents with the pubsub.py sample app**

1. On your device, copy pubsub.py to pubsub3.py.
2. Edit pubsub3.py to change how it formats the messages it publishes.
   a. Open pubsub3.py in a text editor.
b. Locate this line of code:

\[
\text{message} = 
\text{"{} 
\text{[{}]}".format(message_string, publish_count)}
\]

c. Change it to:

\[
\text{message} = 
\text{"{}".format(message_string)}
\]

d. Locate this line of code:

\[
\text{message_json} = 
\text{json.dumps(message)}
\]

e. Change it to:

\[
\text{message} = 
\text{"{}".json.dumps(json.loads(message))}
\]

f. Save your changes.

3. On your device, run this command to send the message two times.

```bash
python3 pubsub3.py --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --topic device/data --count 2 --message 
{"timestamp":1601048303,"sensorId":28,"sensorData": [{"sensorName":"Wind speed","sensorValue":34.2211224}]}
```

4. In the MQTT test client, check to see that it has interpreted and formatted the JSON document in the message payload, such as this:

By default, `pubsub3.py` also subscribes to the messages it sends. You should see that it received the messages in the app's output. The terminal window should look something like this.

```
Connecting to a3qEXAMPLEsffp-ats.iot.us-west-2.amazonaws.com with client ID 'test-5cf18ae-1e92-4c38-a9d4-7b971af3c52f'...
Connected!
Subscribing to topic 'device/data'...
Subscribed with QoS.AT_LEAST_ONCE
Sending 2 message(s)
Publishing message to topic 'device/data':
{"timestamp":1601048303,"sensorId":28,"sensorData": [{"sensorName":"Wind speed","sensorValue":34.2211224}]}
Received message from topic 'device/data':
\b{"timestamp":1601048303,"sensorId":28,"sensorData": [{"sensorName":"Wind speed","sensorValue":34.2211224}]}
Publishing message to topic 'device/data':
{"timestamp":1601048303,"sensorId":28,"sensorData": [{"sensorName":"Wind speed","sensorValue":34.2211224}]}
Received message from topic 'device/data':
\b{"timestamp":1601048303,"sensorId":28,"sensorData": [{"sensorName":"Wind speed","sensorValue":34.2211224}]}
2 message(s) received.
```
Exercise result

With this, your device can generate messages to send to AWS IoT Core to test basic connectivity and provide device messages for AWS IoT Core to process. For example, you could use this app to send test data from your device to test AWS IoT rule actions.

Review the results

The examples in this tutorial gave you hands-on experience with the basics of how devices can communicate with AWS IoT Core—a fundamental part of your AWS IoT solution. When your devices are able to communicate with AWS IoT Core, they can pass messages to AWS services and other devices on which they can act. Likewise, AWS services and other devices can process information that results in messages sent back to your devices.

When you are ready to explore AWS IoT Core further, try these tutorials:

- the section called “Sending an Amazon SNS notification” (p. 207)
- the section called “Storing device data in a DynamoDB table” (p. 214)
- the section called “Formatting a notification by using an AWS Lambda function” (p. 220)

Tutorial: Using the AWS IoT Device SDK for Embedded C

This section describes how to run the AWS IoT Device SDK for Embedded C.

Procedures in this section

- Step 1: Install the AWS IoT Device SDK for Embedded C (p. 196)
- Step 2: Configure the sample app (p. 197)
- Step 3: Build and run the sample application (p. 198)

Step 1: Install the AWS IoT Device SDK for Embedded C

The AWS IoT Device SDK for Embedded C is generally targeted at resource constrained devices that require an optimized C language runtime. You can use the SDK on any operating system and host it on any processor type (for example, MCUs and MPUs). If you have more memory and processing resources available, we recommend that you use one of the higher order AWS IoT Device and Mobile SDKs (for example, C++, Java, JavaScript, and Python).

In general, the AWS IoT Device SDK for Embedded C is intended for systems that use MCUs or low-end MPUs that run embedded operating systems. For the programming example in this section, we assume your device uses Linux.

Example

1. Download the AWS IoT Device SDK for Embedded C to your device from GitHub.

   ```bash
   ```

   This creates a directory named aws-iot-device-sdk-embedded-c in the current directory.


   ```bash
   cd aws-iot-device-sdk-embedded-c
   ```
3. Install OpenSSL version 1.1.0 or later. The OpenSSL development libraries are usually called "libssl-dev" or "openssl-devel" when installed through a package manager.

```
sudo apt-get install libssl-dev
```

### Step 2: Configure the sample app

The AWS IoT Device SDK for Embedded C includes sample applications for you to try. For simplicity, this tutorial uses the `mqtt_demo_mutual_auth` application, that illustrates how to connect to the AWS IoT Core message broker and subscribe and publish to MQTT topics.

1. Copy the certificate and private key you created in [Getting started with AWS IoT Core (p. 17)](#) into the `build/bin/certificates` directory.

   **Note**
   Device and root CA certificates are subject to expiration or revocation. If these certificates expire or are revoked, you must copy a new CA certificate or private key and device certificate onto your device.

2. You must configure the sample with your personal AWS IoT Core endpoint, private key, certificate, and root CA certificate. Navigate to the `aws-iot-device-sdk-embedded-c/demos/mqtt/mqtt_demo_mutual_auth` directory.

   If you have the AWS CLI installed, you can use this command to find your account's endpoint URL.

   ```
   aws iot describe-endpoint --endpoint-type iot:Data-ATS
   ```

   If you don't have the AWS CLI installed, open your AWS IoT console. From the navigation pane, choose Manage, and then choose Things. Choose the IoT thing for your device, and then choose Interact. Your endpoint is displayed in the HTTPS section of the thing details page.

3. Open the `demo_config.h` file and update the values for the following:

   **AWS_IOT_ENDPOINT**
   Your personal endpoint.

   **CLIENT_CERT_PATH**
   Your certificate file path, for example `certificates/device.pem.crt`.

   **CLIENT_PRIVATE_KEY_PATH**
   Your private key file name, for example `certificates/private.pem.key`.

   For example:

   ```
   // Get from demo_config.h
   // =================================================
   #define AWS_IOT_ENDPOINT               "my-endpoint-ats.iot.us-east-1.amazonaws.com"
   #define AWS_MQTT_PORT                  8883
   #define CLIENT_IDENTIFIER              "testclient"
   #define ROOT_CA_CERT_PATH              "certificates/AmazonRootCA1.crt"
   #define CLIENT_CERT_PATH               "certificates/my-device-cert.pem.crt"
   #define CLIENT_PRIVATE_KEY_PATH        "certificates/my-device-private-key.pem.key"
   // =================================================
   ```

4. Check to see if you have CMake installed on your device by using this command.
cmake --version

If you see the version information for the compiler, you can continue to the next section.

If you get an error or don't see any information, then you'll need to install the cmake package using this command.

sudo apt-get install cmake

Run the cmake --version command again and confirm that CMake has been installed and that you are ready to continue.

5. Check to see if you have the development tools installed on your device by using this command.

gcc --version

If you see the version information for the compiler, you can continue to the next section.

If you get an error or don't see any compiler information, you'll need to install the build-essential package using this command.

sudo apt-get install build-essential

Run the gcc --version command again and confirm that the build tools have been installed and that you are ready to continue.

**Step 3: Build and run the sample application**

**To run the AWS IoT Device SDK for Embedded C sample applications**

1. Navigate to aws-iot-device-sdk-embedded-c and create a build directory.

   mkdir build && cd build

2. Enter the following CMake command to generate the Makefiles needed to build.

   cmake .

3. Enter the following command to build the executable app file.

   make

4. Run the mqtt_demo_mutual_auth app with this command.

   cd bin
   ./mqtt_demo_mutual_auth

   You should see output similar to the following:
Your device is now connected to AWS IoT using the AWS IoT Device SDK for Embedded C.

You can also use the AWS IoT console to view the MQTT messages that the sample app is publishing. For information about how to use the MQTT client in the AWS IoT console, see the section called “View MQTT messages with the AWS IoT MQTT client” (p. 67).

Creating AWS IoT rules to route device data to other services

These tutorials show you how to create and test AWS IoT rules using some of the more common rule actions.

AWS IoT rules send data from your devices to other AWS services. They listen for specific MQTT messages, format the data in the message payloads, and send the result to other AWS services.

We recommend that you try these in the order they are shown here, even if your goal is to create a rule that uses a Lambda function or something more complex. The tutorials are presented in order from basic to complex. They present new concepts incrementally to help you learn the concepts you can use to create the rule actions that don’t have a specific tutorial.

Note

AWS IoT rules help you send the data from your IoT devices to other AWS services. To do that successfully, however, you need a working knowledge of the other services where you want to send data. While these tutorials provide the necessary information to complete the tasks, you might find it helpful to learn more about the services you want to send data to before you use them in your solution. A detailed explanation of the other AWS services is outside of the scope of these tutorials.

Tutorial scenario overview

The scenario for these tutorials is that of a weather sensor device that periodically publishes its data. There are many such sensor devices in this imaginary system. The tutorials in this section, however, focus on a single device while showing how you might accommodate multiple sensors.
The tutorials in this section show you how to use AWS IoT rules to do the following tasks with this imaginary system of weather sensor devices.

- **Tutorial: Republishing an MQTT message (p. 201)**
  
  This tutorial shows how to republish an MQTT message received from the weather sensors as a message that contains only the sensor ID and the temperature value. It uses only AWS IoT Core services and demonstrates a simple SQL query and how to use the MQTT client to test your rule.

- **Tutorial: Sending an Amazon SNS notification (p. 207)**
  
  This tutorial shows how to send an SNS message when a value from a weather sensor device exceeds a specific value. It builds on the concepts presented in the previous tutorial and adds how to work with another AWS service, the [Amazon Simple Notification Service](https://aws.amazon.com/sns/) (Amazon SNS).

  If you're new to Amazon SNS, review its [Getting started](https://aws.amazon.com/sns/getting-started/) exercises before you start this tutorial.

- **Tutorial: Storing device data in a DynamoDB table (p. 214)**
  
  This tutorial shows how to store the data from the weather sensor devices in a database table. It uses the rule query statement and substitution templates to format the message data for the destination service, Amazon DynamoDB.

  If you're new to DynamoDB, review its [Getting started](https://aws.amazon.com/dynamodb/getting-started/) exercises before you start this tutorial.

- **Tutorial: Formatting a notification by using an AWS Lambda function (p. 220)**
  
  This tutorial shows how to call a Lambda function to reformat the device data and then send it as a text message. It adds a Python script and AWS SDK functions in an AWS Lambda function to format with the message payload data from the weather sensor devices and send a text message.

  If you're new to Lambda, review its [Getting started](https://aws.amazon.com/lambda/getting-started/) exercises before you start this tutorial.

### AWS IoT rule overview

All of these tutorials create AWS IoT rules.

For an AWS IoT rule to send the data from a device to another AWS service, it uses:

- A rule query statement that consists of:
  - A SQL SELECT clause that selects and formats the data from the message payload
  - A topic filter (the FROM object in the rule query statement) that identifies the messages to use
  - An optional conditional statement (a SQL WHERE clause) that specifies specific conditions on which to act
  - At least one rule action

Devices publish messages to MQTT topics. The topic filter in the SQL SELECT statement identifies the MQTT topics to apply the rule to. The fields specified in the SQL SELECT statement format the data from the incoming MQTT message payload for use by the rule's actions. For a complete list of rule actions, see [AWS IoT Rule Actions (p. 502)](https://docs.aws.amazon.com/iot/latest/developerguide/iot-core-rules.html).

### Tutorials in this section

- **Tutorial: Republishing an MQTT message (p. 201)**
- **Tutorial: Sending an Amazon SNS notification (p. 207)**
- **Tutorial: Storing device data in a DynamoDB table (p. 214)**
- **Tutorial: Formatting a notification by using an AWS Lambda function (p. 220)**
Tutorial: Republishing an MQTT message

This tutorial demonstrates how to create an AWS IoT rule that publishes an MQTT message when a specified MQTT message is received. The incoming message payload can be modified by the rule before it’s published. This makes it possible to create messages that are tailored to specific applications without the need to alter your device or its firmware. You can also use the filtering aspect of a rule to publish messages only when a specific condition is met.

The messages republished by a rule act like messages sent by any other AWS IoT device or client. Devices can subscribe to the republished messages the same way they can subscribe to any other MQTT message topic.

What you’ll learn in this tutorial:

• How to use simple SQL queries and functions in a rule query statement
• How to use the MQTT client to test an AWS IoT rule

This tutorial takes about 30 minutes to complete.

In this tutorial, you’ll:

• Review MQTT topics and AWS IoT rules (p. 201)
• Step 1: Create an AWS IoT rule to republish an MQTT message (p. 202)
• Step 2: Test your new rule (p. 203)
• Step 3: Review the results and next steps (p. 206)

Before you start this tutorial, make sure that you have:

• Set up your AWS account (p. 18)

You'll need your AWS account and AWS IoT console to complete this tutorial.

• Reviewed View MQTT messages with the AWS IoT MQTT client (p. 67)

Be sure you can use the MQTT client to subscribe and publish to a topic. You'll use the MQTT client to test your new rule in this procedure.

Review MQTT topics and AWS IoT rules

Before talking about AWS IoT rules, it helps to understand the MQTT protocol. In IoT solutions, the MQTT protocol offers some advantages over other network communication protocols, such as HTTP, which makes it a popular choice for use by IoT devices. This section reviews the key aspects of MQTT as they apply to this tutorial. For information about how MQTT compares to HTTP, see Choosing a protocol for your device communication (p. 86).

MQTT protocol

The MQTT protocol uses a publish/subscribe communication model with its host. To send data, devices publish messages that are identified by topics to the AWS IoT message broker. To receive messages from the message broker, devices subscribe to the topics they will receive by sending topic filters in subscription requests to the message broker. The AWS IoT rules engine receives MQTT messages from the message broker.

AWS IoT rules

AWS IoT rules consist of a rule query statement and one or more rule actions. When the AWS IoT rules engine receives an MQTT message, these elements act on the message as follows.
• **Rule query statement**

  The rule's query statement describes the MQTT topics to use, interprets the data from the message payload, and formats the data as described by a SQL statement that is similar to statements used by popular SQL databases. The result of the query statement is the data that is sent to the rule's actions.

• **Rule action**

  Each rule action in a rule acts on the data that results from the rule's query statement. AWS IoT supports many rule actions (p. 502). In this tutorial, however, you'll concentrate on the Republish (p. 564) rule action, which publishes the result of the query statement as an MQTT message with a specific topic.

**Step 1: Create an AWS IoT rule to republish an MQTT message**

The AWS IoT rule that you'll create in this tutorial subscribes to the `device/device_id/data` MQTT topics where `device_id` is the ID of the device that sent the message. These topics are described by a topic filter (p. 110) as `device/+data`, where the + is a wildcard character that matches any string between the two forward slash characters.

When the rule receives a message from a matching topic, it republishes the `device_id` and temperature values as a new MQTT message with the `device/data/temp` topic.

For example, the payload of an MQTT message with the `device/22/data` topic looks like this:

```
{
    "temperature": 28,
    "humidity": 80,
    "barometer": 1013,
    "wind": {
        "velocity": 22,
        "bearing": 255
    }
}
```

The rule takes the `temperature` value from the message payload, and the `device_id` from the topic, and republishes them as an MQTT message with the `device/data/temp` topic and a message payload that looks like this:

```
{
    "device_id": "22",
    "temperature": 28
}
```

With this rule, devices that only need the device's ID and the temperature data subscribe to the `device/data/temp` topic to receive only that information.

**To create a rule that republishes an MQTT message**

1. Open the Rules hub of the AWS IoT console.
2. In Rules, choose Create and start creating your new rule.
3. In the top part of Create a rule:
   a. In Name, enter the rule's name. For this tutorial, name it `republish_temp`.

   Remember that a rule name must be unique within your Account and Region, and it can't have any spaces. We've used an underscore character in this name to separate the two words in the rule's name.
b. In **Description**, describe the rule.

A meaningful description helps you remember what this rule does and why you created it. The description can be as long as needed, so be as detailed as possible.

4. In **Rule query statement** of **Create a rule**:
   a. In **Using SQL version**, select **2016-03-23**.
   b. In the **Rule query statement** edit box, enter the statement:

   ```sql
   SELECT topic(2) as device_id, temperature FROM 'device/+/data'
   ```

   This statement:
   - Listens for MQTT messages with a topic that matches the `device/+/data` topic filter.
   - Selects the second element from the topic string and assigns it to the `device_id` field.
   - Selects the value `temperature` field from the message payload and assigns it to the `temperature` field.

5. In **Set one or more actions**:
   a. To open up the list of rule actions for this rule, choose **Add action**.
   b. In **Select an action**, choose **Republish a message to an AWS IoT topic**.
   c. At the bottom of the action list, choose **Configure action** to open the selected action's configuration page.

6. In **Configure action**:
   a. In **Topic**, enter `device/data/temp`. This is the MQTT topic of the message that this rule will publish.
   b. In **Quality of Service**, choose **0 - The message is delivered zero or more times**.
   c. In **Choose or create a role to grant AWS IoT access to perform this action**:
      i. Choose **Create Role**. The **Create a new role** dialog box opens.
      ii. Enter a name that describes the new role. In this tutorial, use `republish_role`.

      When you create a new role, the correct policies to perform the rule action are created and attached to the new role. If you change the topic of this rule action or use this role in another rule action, you must update the policy for that role to authorize the new topic or action. To update an existing role, choose **Update role** in this section.
      iii. Choose **Create Role** to create the role and close the dialog box.
   d. Choose **Add action** to add the action to the rule and return to the **Create a rule** page.

7. The **Republish a message to an AWS IoT topic** action is now listed in **Set one or more actions**.

   In the new action's tile, below **Republish a message to an AWS IoT topic**, you can see the topic to which your republish action will publish.

   This is the only rule action you'll add to this rule.

8. In **Create a rule**, scroll down to the bottom and choose **Create rule** to create the rule and complete this step.

---

**Step 2: Test your new rule**

To test your new rule, you'll use the MQTT client to publish and subscribe to the MQTT messages used by this rule.
Open the MQTT client in the AWS IoT console in a new window. This will let you edit the rule without losing the configuration of your MQTT client. The MQTT client does not retain any subscriptions or message logs if you leave it to go to another page in the console.

To use the MQTT client to test your rule

1. In the MQTT client in the AWS IoT console, subscribe to the input topics, in this case, device/+\textbackslash data.
   a. In the MQTT client, under Subscriptions, choose Subscribe to a topic.
   b. In Subscription topic, enter the topic of the input topic filter, device/+\textbackslash data.
   c. Keep the rest of the fields at their default settings.
   d. Choose Subscribe to topic.

   In the Subscriptions column, under Publish to a topic, device/+\textbackslash data appears.

2. Subscribe to the topic that your rule will publish: device/data/temp.
   a. Under Subscriptions, choose Subscribe to a topic again, and in Subscription topic, enter the topic of the republished message, device/data/temp.
   b. Keep the rest of the fields at their default settings.
   c. Choose Subscribe to topic.

   In the Subscriptions column, under device/+\textbackslash data, device/data/temp appears.

3. Publish a message to the input topic with a specific device ID, device/22/data. You can't publish to MQTT topics that contain wildcard characters.
   a. In the MQTT client, under Subscriptions, choose Publish to topic.
   b. In the Publish field, enter the input topic name, device/22/data.
   c. Copy the sample data shown here and, in the edit box below the topic name, paste the sample data.

```plaintext
{
    "temperature": 28,
    "humidity": 80,
    "barometer": 1013,
    "wind": {
        "velocity": 22,
        "bearing": 255
    }
}
```
   d. To send your MQTT message, choose Publish to topic.

4. Review the messages that were sent.
   a. In the MQTT client, under Subscriptions, there is a green dot next to the two topics to which you subscribed earlier.

   The green dots indicate that one or more new messages have been received since the last time you looked at them.
   b. Under Subscriptions, choose device/+\textbackslash data to check that the message payload matches what you just published and looks like this:

```plaintext
{
    "temperature": 28,
    "humidity": 80,
    "barometer": 1013,
    "wind": {
```
c. Under Subscriptions, choose device/data/temp to check that your republished message payload looks like this:

```json
{
  "device_id": "22",
  "temperature": 28
}
```

Notice that the device_id value is a quoted string and the temperature value is numeric. This is because the topic() function extracted the string from the input message's topic name while the temperature value uses the numeric value from the input message's payload.

If you want to make the device_id value a numeric value, replace topic(2) in the rule query statement with:

```sql
cast(topic(2) AS DECIMAL)
```

Note that casting the topic(2) value to a numeric value will only work if that part of the topic contains only numeric characters.

5. If you see that the correct message was published to the device/data/temp topic, then your rule worked. See what more you can learn about the Republish rule action in the next section.

If you don't see that the correct message was published to either the device/+/data or device/data/temp topics, check the troubleshooting tips.

Troubleshooting your Republish message rule

Here are some things to check in case you're not seeing the results you expect.

- **You got an error banner**

  If an error appeared when you published the input message, correct that error first. The following steps might help you correct that error.

- **You don't see the input message in the MQTT client**

  Every time you publish your input message to the device/22/data topic, that message should appear in the MQTT client if you subscribed to the device/+/data topic filter as described in the procedure.

Things to check

- **Check the topic filter you subscribed to**

  If you subscribed to the input message topic as described in the procedure, you should see a copy of the input message every time you publish it.

  If you don't see the message, check the topic name you subscribed to and compare it to the topic to which you published. Topic names are case sensitive and the topic to which you subscribed must be identical to the topic to which you published the message payload.

- **Check the message publish function**
In the MQTT client, under Subscriptions, choose device/+/data, check the topic of the publish message, and then choose Publish to topic. You should see the message payload from the edit box below the topic appear in the message list.

- **You don't see your republished message in the MQTT client**

For your rule to work, it must have the correct policy that authorizes it to receive and republish a message and it must receive the message.

**Things to check**

- **Check the AWS Region of your MQTT client and the rule that you created**

  The console in which you're running the MQTT client must be in the same AWS Region as the rule you created.

- **Check the input message topic in the rule query statement**

  For the rule to work, it must receive a message with the topic name that matches the topic filter in the FROM clause of the rule query statement.

  Check the spelling of the topic filter in the rule query statement with that of the topic in the MQTT client. Topic names are case sensitive and the message's topic must match the topic filter in the rule query statement.

- **Check the contents of the input message payload**

  For the rule to work, it must find the data field in the message payload that is declared in the SELECT statement.

  Check the spelling of the temperature field in the rule query statement with that of the message payload in the MQTT client. Field names are case sensitive and the temperature field in the rule query statement must be identical to the temperature field in the message payload.

  Make sure that the JSON document in the message payload is correctly formatted. If the JSON has any errors, such as a missing comma, the rule will not be able to read it.

- **Check the republished message topic in the rule action**

  The topic to which the Republish rule action publishes the new message must match the topic to which you subscribed in the MQTT client.

  Open the rule you created in the console and check the topic to which the rule action will republish the message.

- **Check the role being used by the rule**

  The rule action must have permission to receive the original topic and publish the new topic.

  The policies that authorize the rule to receive message data and republish it are specific to the topics used. If you change the topic used to republish the message data, you must update the rule action's role to update its policy to match the current topic.

  If you suspect this is the problem, edit the Republish rule action and create a new role. New roles created by the rule action receive the authorizations necessary to perform these actions.

**Step 3: Review the results and next steps**

**In this tutorial**

- You used a simple SQL query and a couple of functions in a rule query statement to produce a new MQTT message.
• You created a rule that republished that new message.
• You used the MQTT client to test your AWS IoT rule.

Next steps

After you republish a few messages with this rule, try experimenting with it to see how changing some aspects of the tutorial affect the republished message. Here are some ideas to get you started.

• Change the `device_id` in the input message's topic and observe the effect in the republished message payload.
• Change the fields selected in the rule query statement and observe the effect in the republished message payload.
• Try the next tutorial in this series and learn how to Tutorial: Sending an Amazon SNS notification (p. 207).

The Republish rule action used in this tutorial can also help you debug rule query statements. For example, you can add this action to a rule to see how its rule query statement is formatting the data used by its rule actions.

Tutorial: Sending an Amazon SNS notification

This tutorial demonstrates how to create an AWS IoT rule that sends MQTT message data to an Amazon SNS topic so that it can be sent as an SMS text message.

In this tutorial, you create a rule that sends message data from a weather sensor to all subscribers of an Amazon SNS topic, whenever the temperature exceeds the value set in the rule. The rule detects when the reported temperature exceeds the value set by the rule, and then creates a new message payload that includes only the device ID, the reported temperature, and the temperature limit that was exceeded. The rule sends the new message payload as a JSON document to an SNS topic, which notifies all subscribers to the SNS topic.

What you'll learn in this tutorial:

• How to create and test an Amazon SNS notification
• How to call an Amazon SNS notification from an AWS IoT rule
• How to use simple SQL queries and functions in a rule query statement
• How to use the MQTT client to test an AWS IoT rule

This tutorial takes about 30 minutes to complete.

In this tutorial, you'll:

• Step 1: Create an Amazon SNS topic that sends an SMS text message (p. 208)
• Step 2: Create an AWS IoT rule to send the text message (p. 209)
• Step 3: Test the AWS IoT rule and Amazon SNS notification (p. 210)
• Step 4: Review the results and next steps (p. 213)

Before you start this tutorial, make sure that you have:

• Set up your AWS account (p. 18)
  You'll need your AWS account and AWS IoT console to complete this tutorial.
• Reviewed View MQTT messages with the AWS IoT MQTT client (p. 67)
Be sure you can use the MQTT client to subscribe and publish to a topic. You’ll use the MQTT client to test your new rule in this procedure.

- Reviewed the Amazon Simple Notification Service

If you haven't used Amazon SNS before, review Setting up access for Amazon SNS. If you've already completed other AWS IoT tutorials, your AWS account should already be configured correctly.

**Step 1: Create an Amazon SNS topic that sends an SMS text message**

**To create an Amazon SNS topic that sends an SMS text message**

1. Create an Amazon SNS topic.
   a. Sign in to the Amazon SNS console.
   b. In the left navigation pane, choose Topics.
   c. On the Topics page, choose Create topic.
   d. In Details, choose the Standard type. By default, the console creates a FIFO topic.
   e. In Name, enter the SNS topic name. For this tutorial, enter high_temp_notice.
   f. Scroll to the end of the page and choose Create topic.

   The console opens the new topic's Details page.

2. Create an Amazon SNS subscription.
   
   **Note**
   The phone number that you use in this subscription might incur text messaging charges from the messages you will send in this tutorial.

   a. In the high_temp_notice topic's details page, choose Create subscription.
   b. In Create subscription, in the Details section, in the Protocol list, choose SMS.
   c. In Endpoint, enter the number of a phone that can receive text messages. Be sure to enter it such that it starts with a +, includes the country and area code, and doesn't include any other punctuation characters.
   d. Choose Create subscription.

3. Test the Amazon SNS notification.
   a. In the Amazon SNS console, in the left navigation pane, choose Topics.
   b. To open the topic's details page, in Topics, in the list of topics, choose high_temp_notice.
   c. To open the Publish message to topic page, in the high_temp_notice details page, choose Publish message.
   d. In Publish message to topic, in the Message body section, in Message body to send to the endpoint, enter a short message.
   e. Scroll down to the bottom of the page and choose Publish message.
   f. On the phone with the number you used earlier when creating the subscription, confirm that the message was received.

   If you did not receive the test message, double check the phone number and your phone’s settings.

   Make sure you can publish test messages from the Amazon SNS console before you continue the tutorial.
Step 2: Create an AWS IoT rule to send the text message

The AWS IoT rule that you'll create in this tutorial subscribes to the device/device_id/data MQTT topics where device_id is the ID of the device that sent the message. These topics are described in a topic filter as device/+/data, where the + is a wildcard character that matches any string between the two forward slash characters. This rule also tests the value of the temperature field in the message payload.

When the rule receives a message from a matching topic, it takes the device_id from the topic name, the temperature value from the message payload, and adds a constant value for the limit it's testing, and sends these values as a JSON document to an Amazon SNS notification topic.

For example, an MQTT message from weather sensor device number 32 uses the device/32/data topic and has a message payload that looks like this:

```json
{
    "temperature": 38,
    "humidity": 80,
    "barometer": 1013,
    "wind": {
        "velocity": 22,
        "bearing": 255
    }
}
```

The rule's rule query statement takes the temperature value from the message payload, the device_id from the topic name, and adds the constant max_temperature value to send a message payload that looks like this to the Amazon SNS topic:

```json
{
    "device_id": "32",
    "reported_temperature": 38,
    "max_temperature": 30
}
```

To create an AWS IoT rule to detect an over-limit temperature value and create the data to send to the Amazon SNS topic

1. Open the Rules hub of the AWS IoT console.
2. If this is your first rule, choose Create, or Create a rule.
3. In Create a rule:
   a. In Name, enter temp_limit_notify.
      Remember that a rule name must be unique within your AWS account and Region, and it can't have any spaces. We've used an underscore character in this name to separate the words in the rule's name.
   b. In Description, describe the rule.
      A meaningful description makes it easier to remember what this rule does and why you created it. The description can be as long as needed, so be as detailed as possible.
4. In Rule query statement of Create a rule:
   b. In the Rule query statement edit box, enter the statement:

```
SELECT topic(2) as device_id,
       temperature as reported_temperature,
       209
```
This statement:

- Listens for MQTT messages with a topic that matches the device/+data topic filter and that have a temperature value greater than 30.
- Selects the second element from the topic string and assigns it to the device_id field.
- Selects the value temperature field from the message payload and assigns it to the reported_temperature field.
- Creates a constant value 30 to represent the limit value and assigns it to the max_temperature field.

5. To open up the list of rule actions for this rule, in Set one or more actions, choose Add action.
6. In Select an action, choose Send a message as an SNS push notification.
7. To open the selected action's configuration page, at the bottom of the action list, choose Configure action.
8. In Configure action:
   a. In SNS target, choose Select, find your SNS topic named high_temp_notice, and choose Select.
   b. In Message format, choose RAW.
   c. In Choose or create a role to grant AWS IoT access to perform this action, choose Create Role.
   d. In Create a new role, in Name, enter a unique name for the new role. For this tutorial, use sns_rule_role.
   e. Choose Create role.

If you're repeating this tutorial or reusing an existing role, choose Update role before continuing. This updates the role's policy document to work with the SNS target.
9. Choose Add action and return to the Create a rule page.

   In the new action's tile, below Send a message as an SNS push notification, you can see the SNS topic that your rule will call.

   This is the only rule action you'll add to this rule.
10. To create the rule and complete this step, in Create a rule, scroll down to the bottom and choose Create rule.

**Step 3: Test the AWS IoT rule and Amazon SNS notification**

To test your new rule, you'll use the MQTT client to publish and subscribe to the MQTT messages used by this rule.

Open the MQTT client in the AWS IoT console in a new window. This will let you edit the rule without losing the configuration of your MQTT client. If you leave the MQTT client to go to another page in the console, it won't retain any subscriptions or message logs.

**To use the MQTT client to test your rule**

1. In the MQTT client in the AWS IoT console, subscribe to the input topics, in this case, device/+/data.
   a. In the MQTT client, under Subscriptions, choose Subscribe to a topic.
   b. In Subscription topic, enter the topic of the input topic filter, device/+data.
c. Keep the rest of the fields at their default settings.

d. Choose **Subscribe to topic**.

In the **Subscriptions** column, under **Publish to a topic**, **device/+data** appears.

2. Publish a message to the input topic with a specific device ID, **device/32/data**. You can't publish to MQTT topics that contain wildcard characters.

a. In the MQTT client, under **Subscriptions**, choose **Publish to topic**.

b. In the **Publish** field, enter the input topic name, **device/32/data**.

c. Copy the sample data shown here and, in the edit box below the topic name, paste the sample data.

```
{
  "temperature": 38,
  "humidity": 80,
  "barometer": 1013,
  "wind": {
    "velocity": 22,
    "bearing": 255
  }
}
```

d. Choose **Publish to topic** to publish your MQTT message.

3. Confirm that the text message was sent.

a. In the MQTT client, under **Subscriptions**, there is a green dot next to the topic to which you subscribed earlier.

The green dot indicates that one or more new messages have been received since the last time you looked at them.

b. Under **Subscriptions**, choose **device/+data** to check that the message payload matches what you just published and looks like this:

```
{
  "temperature": 38,
  "humidity": 80,
  "barometer": 1013,
  "wind": {
    "velocity": 22,
    "bearing": 255
  }
}
```

c. Check the phone that you used to subscribe to the SNS topic and confirm the contents of the message payload look like this:

```
{"device_id":"32","reported_temperature":38,"max_temperature":30}
```

Notice that the **device_id** value is a quoted string and the **temperature** value is numeric. This is because the **topic()** function extracted the string from the input message's topic name while the **temperature** value uses the numeric value from the input message's payload.

If you want to make the **device_id** value a numeric value, replace **topic(2)** in the rule query statement with:

```
cast(topic(2) AS DECIMAL)
```
Note that casting the topic value to a numeric, DECIMAL value will only work if that part of the topic contains only numeric characters.

4. Try sending an MQTT message in which the temperature does not exceed the limit.
   a. In the MQTT client, under Subscriptions, choose Publish to topic.
   b. In the Publish field, enter the input topic name, device/33/data.
   c. Copy the sample data shown here and, in the edit box below the topic name, paste the sample data.

   ```json
   {
       "temperature": 28,
       "humidity": 80,
       "barometer": 1013,
       "wind": {
           "velocity": 22,
           "bearing": 255
       }
   }
   
   d. To send your MQTT message, choose Publish to topic.

   You should see the message that you sent in the device/+data subscription. However, because the temperature value is below the max temperature in the rule query statement, you shouldn't receive a text message.

   If you don't see the correct behavior, check the troubleshooting tips.

Troubleshooting your SNS message rule

Here are some things to check, in case you're not seeing the results you expect.

- **You got an error banner**

  If an error appeared when you published the input message, correct that error first. The following steps might help you correct that error.

- **You don't see the input message in the MQTT client**

  Every time you publish your input message to the device/22/data topic, that message should appear in the MQTT client, if you subscribed to the device/+data topic filter as described in the procedure.

Things to check

- **Check the topic filter you subscribed to**

  If you subscribed to the input message topic as described in the procedure, you should see a copy of the input message every time you publish it.

  If you don't see the message, check the topic name you subscribed to and compare it to the topic to which you published. Topic names are case sensitive and the topic to which you subscribed must be identical to the topic to which you published the message payload.

- **Check the message publish function**

  In the MQTT client, under Subscriptions, choose device/+data, check the topic of the publish message, and then choose Publish to topic. You should see the message payload from the edit box below the topic appear in the message list.
• **You don't receive an SMS message**

For your rule to work, it must have the correct policy that authorizes it to receive a message and send an SNS notification, and it must receive the message.

**Things to check**

• **Check the AWS Region of your MQTT client and the rule that you created**

The console in which you're running the MQTT client must be in the same AWS Region as the rule you created.

• **Check that the temperature value in the message payload exceeds the test threshold**

If the temperature value is less than or equal to 30, as defined in the rule query statement, the rule will not perform any of its actions.

• **Check the input message topic in the rule query statement**

For the rule to work, it must receive a message with the topic name that matches the topic filter in the FROM clause of the rule query statement.

Check the spelling of the topic filter in the rule query statement with that of the topic in the MQTT client. Topic names are case sensitive and the message's topic must match the topic filter in the rule query statement.

• **Check the contents of the input message payload**

For the rule to work, it must find the data field in the message payload that is declared in the SELECT statement.

Check the spelling of the temperature field in the rule query statement with that of the message payload in the MQTT client. Field names are case sensitive and the temperature field in the rule query statement must be identical to the temperature field in the message payload.

Make sure that the JSON document in the message payload is correctly formatted. If the JSON has any errors, such as a missing comma, the rule will not be able to read it.

• **Check the republished message topic in the rule action**

The topic to which the Republish rule action publishes the new message must match the topic to which you subscribed in the MQTT client.

Open the rule you created in the console and check the topic to which the rule action will republish the message.

• **Check the role being used by the rule**

The rule action must have permission to receive the original topic and publish the new topic.

The policies that authorize the rule to receive message data and republish it are specific to the topics used. If you change the topic used to republish the message data, you must update the rule action's role to update its policy to match the current topic.

If you suspect this is the problem, edit the Republish rule action and create a new role. New roles created by the rule action receive the authorizations necessary to perform these actions.

**Step 4: Review the results and next steps**

**In this tutorial:**

• You created and tested an Amazon SNS notification topic and subscription.
• You used a simple SQL query and functions in a rule query statement to create a new message for your notification.
• You created an AWS IoT rule to send an Amazon SNS notification that used your customized message payload.
• You used the MQTT client to test your AWS IoT rule.

Next steps

After you send a few text messages with this rule, try experimenting with it to see how changing some aspects of the tutorial affect the message and when it's sent. Here are some ideas to get you started.

• Change the device_id in the input message's topic and observe the effect in the text message contents.
• Change the fields selected in the rule query statement and observe the effect in the text message contents.
• Change the test in the rule query statement to test for a minimum temperature instead of a maximum temperature. Remember to change the name of max_temperature!
• Add a republish rule action to send an MQTT message when an SNS notification is sent.
• Try the next tutorial in this series and learn how to Tutorial: Storing device data in a DynamoDB table (p. 214).

Tutorial: Storing device data in a DynamoDB table

This tutorial demonstrates how to create an AWS IoT rule that sends message data to a DynamoDB table.

In this tutorial, you create a rule that sends message data from an imaginary weather sensor device to a DynamoDB table. The rule formats the data from many weather sensors such that they can be added to a single database table.

What you'll learn in this tutorial

• How to create a DynamoDB table
• How to send message data to a DynamoDB table from an AWS IoT rule
• How to use substitution templates in an AWS IoT rule
• How to use simple SQL queries and functions in a rule query statement
• How to use the MQTT client to test an AWS IoT rule

This tutorial takes about 30 minutes to complete.

In this tutorial, you'll:

• Step 1: Create the DynamoDB table for this tutorial (p. 215)
• Step 2: Create an AWS IoT rule to send data to the DynamoDB table (p. 215)
• Step 3: Test the AWS IoT rule and DynamoDB table (p. 217)
• Step 4: Review the results and next steps (p. 219)

Before you start this tutorial, make sure that you have:

• Set up your AWS account (p. 18)

You'll need your AWS account and AWS IoT console to complete this tutorial.
Step 1: Create the DynamoDB table for this tutorial

In this tutorial, you'll create a DynamoDB table with these attributes to record the data from the imaginary weather sensor devices:

- `sample_time` is a primary key and describes the time the sample was recorded.
- `device_id` is a sort key and describes the device that provided the sample
- `device_data` is the data received from the device and formatted by the rule query statement

To create the DynamoDB table for this tutorial

1. Open the [DynamoDB console](https://aws.amazon.com/dynamodb/) and then choose Create table.
2. In Create table:
   a. In Table name, enter the table name: `wx_data`.
   b. In Partition key, enter `sample_time`, and in the option list next to the field, choose Number.
   c. In Sort key, enter `device_id`, and in the option list next to the field, choose Number.
   d. At the bottom of the page, choose Create.

You'll define `device_data` later, when you configure the DynamoDB rule action.

Step 2: Create an AWS IoT rule to send data to the DynamoDB table

In this step, you'll use the rule query statement to format the data from the imaginary weather sensor devices to write to the database table.

A sample message payload received from a weather sensor device looks like this:

```json
{
  "temperature": 28,
  "humidity": 80,
  "barometer": 1013,
  "wind": {
    "velocity": 22,
    "bearing": 255
  }
}
```

For the database entry, you'll use the rule query statement to flatten the structure of the message payload to look like this:

```json
{
  "temperature": 28,
  "humidity": 80,
  "barometer": 1013,
  "sample_time": null,
  "device_id": null,
  "device_data": null
}
```
"wind_velocity": 22,
"wind_bearing": 255
}

In this rule, you’ll also use a couple of Substitution templates (p. 648). Substitution templates are expressions that let you insert dynamic values from functions and message data.

To create the AWS IoT rule to send data to the DynamoDB table

1. Open the Rules hub of the AWS IoT console. Alternatively, you can open the AWS IoT homepage within the AWS Management Console and navigate to Message routing>Rules.
2. To start creating your new rule in Rules, choose Create rule.
3. In Rule properties:
   a. In Rule name, enter wx_data_ddb.
      Remember that a rule name must be unique within your AWS account and Region, and it can’t have any spaces. We’ve used an underscore character in this name to separate the two words in the rule’s name.
   b. In Rule description, describe the rule.
      A meaningful description makes it easier to remember what this rule does and why you created it. The description can be as long as needed, so be as detailed as possible.
4. Choose Next to continue.
5. In SQL statement:
   b. In the SQL statement edit box, enter the statement:

   ```sql
   SELECT temperature, humidity, barometer,
       wind.velocity as wind_velocity,
       wind.bearing as wind_bearing,
   FROM 'device/+/data'
   ```

   This statement:
   • Listens for MQTT messages with a topic that matches the device/+/data topic filter.
   • Formats the elements of the wind attribute as individual attributes.
   • Passes the temperature, humidity, and barometer attributes unchanged.
6. Choose Next to continue.
7. In Rule actions:
   a. To open the list of rule actions for this rule, in Action 1, choose DynamoDB.
   b. In Table name, choose the name of the DynamoDB table you created in a previous step: wx_data.
      The Partition key type and Sort key type fields are filled with the values from your DynamoDB table.
   c. In Partition key, enter sample_time.
   d. In Partition key value, enter ${timestamp()}.

   This is the first of the Substitution templates (p. 648) you’ll use in this rule. Instead of using a value from the message payload, it will use the value returned from the timestamp function. To learn more, see timestamp (p. 640) in the AWS IoT Core Developer Guide.
e. In **Sort key**, enter `device_id`.

f. In **Sort key value**, enter `{{cast(topic(2) AS DECIMAL)}`.

This is the second one of the Substitution templates (p. 648) you'll use in this rule. It inserts the value of the second element in topic name, which is the device's ID, after it casts it to a DECIMAL value to match the numeric format of the key. To learn more about topics, see `topic` (p. 640) in the AWS IoT Core Developer Guide. Or to learn more about casting, see `cast` (p. 604) in the AWS IoT Core Developer Guide.

g. In **Write message data to this column**, enter `device_data`.

This will create the `device_data` column in the DynamoDB table.

h. Leave **Operation** blank.

i. In **IAM role**, choose *Create new role*.

j. In the **Create role** dialog box, for **Role name**, enter `wx_ddb_role`. This new role will automatically contain a policy with a prefix of "aws-iot-rule" that will allow the `wx_data_ddb` rule to send data to the `wx_data` DynamoDB table you created.

k. In **IAM role**, choose `wx_ddb_role`.

l. At the bottom of the page, choose **Next**.

8. At the bottom of the **Review and create** page, choose **Create** to create the rule.

---

**Step 3: Test the AWS IoT rule and DynamoDB table**

To test the new rule, you'll use the MQTT client to publish and subscribe to the MQTT messages used in this test.

Open the MQTT client in the AWS IoT console in a new window. This will let you edit the rule without losing the configuration of your MQTT client. The MQTT client does not retain any subscriptions or message logs if you leave it to go to another page in the console. You'll also want a separate console window open to the DynamoDB Tables hub in the AWS IoT console to view the new entries that your rule sends.

**To use the MQTT client to test your rule**

1. In the **MQTT client in the AWS IoT console**, subscribe to the input topic, `device/+/data`.
   
   a. In the MQTT client, choose **Subscribe to a topic**.
   
   b. For **Topic filter**, enter the topic of the input topic filter, `device/+/data`.
   
   c. Choose **Subscribe**.

2. Now, publish a message to the input topic with a specific device ID, `device/22/data`. You can't publish to MQTT topics that contain wildcard characters.

   a. In the MQTT client, choose **Publish to a topic**.
   
   b. For **Topic name**, enter the input topic name, `device/22/data`.
   
   c. For **Message payload**, enter the following sample data.

   ```json
   {
   "temperature": 28,
   "humidity": 80,
   "barometer": 1013,
   "wind": {
   "velocity": 22,
   "bearing": 255
   }
   }
   ```
To publish the MQTT message, choose Publish.

Now, in the MQTT client, choose Subscribe to a topic. In the Subscribe column, choose the device/+/data subscription. Confirm that the sample data from the previous step appears there.

3. Check to see the row in the DynamoDB table that your rule created.

a. In the DynamoDB Tables hub in the AWS IoT console, choose wx_data, and then choose the Items tab.

If you're already on the Items tab, you might need to refresh the display by choosing the refresh icon in the upper-right corner of the table's header.

b. Notice that the sample_time values in the table are links and open one. If you just sent your first message, it will be the only one in the list.

This link displays all the data in that row of the table.

c. Expand the device_data entry to see the data that resulted from the rule query statement.

d. Explore the different representations of the data that are available in this display. You can also edit the data in this display.

e. After you have finished reviewing this row of data, to save any changes you made, choose Save, or to exit without saving any changes, choose Cancel.

If you don't see the correct behavior, check the troubleshooting tips.

**Troubleshooting your DynamoDB rule**

Here are some things to check in case you're not seeing the results you expect.

* You got an error banner

If an error appeared when you published the input message, correct that error first. The following steps might help you correct that error.

* You don't see the input message in the MQTT client

Every time you publish your input message to the device/22/data topic, that message should appear in the MQTT client if you subscribed to the device/+/data topic filter as described in the procedure.

**Things to check**

* Check the topic filter you subscribed to

If you subscribed to the input message topic as described in the procedure, you should see a copy of the input message every time you publish it.

If you don't see the message, check the topic name you subscribed to and compare it to the topic to which you published. Topic names are case sensitive and the topic to which you subscribed must be identical to the topic to which you published the message payload.

* Check the message publish function

In the MQTT client, under Subscriptions, choose device/+/data, check the topic of the publish message, and then choose Publish to topic. You should see the message payload from the edit box below the topic appear in the message list.

* You don't see your data in the DynamoDB table

The first thing to do is to refresh the display by choosing the refresh icon in the upper-right corner of the table's header. If that doesn't display the data you're looking for, check the following.
Things to check

- **Check the AWS Region of your MQTT client and the rule that you created**

  The console in which you’re running the MQTT client must be in the same AWS Region as the rule you created.

- **Check the input message topic in the rule query statement**

  For the rule to work, it must receive a message with the topic name that matches the topic filter in the FROM clause of the rule query statement.

  Check the spelling of the topic filter in the rule query statement with that of the topic in the MQTT client. Topic names are case sensitive and the message’s topic must match the topic filter in the rule query statement.

- **Check the contents of the input message payload**

  For the rule to work, it must find the data field in the message payload that is declared in the SELECT statement.

  Check the spelling of the `temperature` field in the rule query statement with that of the message payload in the MQTT client. Field names are case sensitive and the `temperature` field in the rule query statement must be identical to the `temperature` field in the message payload.

  Make sure that the JSON document in the message payload is correctly formatted. If the JSON has any errors, such as a missing comma, the rule will not be able to read it.

- **Check the key and field names used in the rule action**

  The field names used in the topic rule must match those found in the JSON message payload of the published message.

  Open the rule you created in the console and check the field names in the rule action configuration with those used in the MQTT client.

- **Check the role being used by the rule**

  The rule action must have permission to receive the original topic and publish the new topic.

  The policies that authorize the rule to receive message data and update the DynamoDB table are specific to the topics used. If you change the topic or DynamoDB table name used by the rule, you must update the rule action’s role to update its policy to match.

  If you suspect this is the problem, edit the rule action and create a new role. New roles created by the rule action receive the authorizations necessary to perform these actions.

**Step 4: Review the results and next steps**

After you send a few messages to the DynamoDB table with this rule, try experimenting with it to see how changing some aspects from the tutorial affect the data written to the table. Here are some ideas to get you started.

- Change the `device_id` in the input message’s topic and observe the effect on the data. You could use this to simulate receiving data from multiple weather sensors.

- Change the fields selected in the rule query statement and observe the effect on the data. You could use this to filter the data stored in the table.

- Add a republish rule action to send an MQTT message for each row added to the table. You could use this for debugging.
After you have completed this tutorial, check out the section called "Formatting a notification by using an AWS Lambda function" (p. 220).

**Tutorial: Formatting a notification by using an AWS Lambda function**

This tutorial demonstrates how to send MQTT message data to an AWS Lambda action for formatting and sending to another AWS service. In this tutorial, the AWS Lambda action uses the AWS SDK to send the formatted message to the Amazon SNS topic you created in the tutorial about how to the section called "Sending an Amazon SNS notification" (p. 207).

In the tutorial about how to the section called "Sending an Amazon SNS notification" (p. 207), the JSON document that resulted from the rule's query statement was sent as the body of the text message. The result was a text message that looked something like this example:

```
{"device_id":"32","reported_temperature":38,"max_temperature":30}
```

In this tutorial, you'll use an AWS Lambda rule action to call an AWS Lambda function that formats the data from the rule query statement into a friendlier format, such as this example:

```
Device 32 reports a temperature of 38, which exceeds the limit of 30.
```

The AWS Lambda function you'll create in this tutorial formats the message string by using the data from the rule query statement and calls the SNS _publish_ function of the AWS SDK to create the notification.

**What you'll learn in this tutorial**

- How to create and test an AWS Lambda function
- How to use the AWS SDK in an AWS Lambda function to publish an Amazon SNS notification
- How to use simple SQL queries and functions in a rule query statement
- How to use the MQTT client to test an AWS IoT rule

This tutorial takes about 45 minutes to complete.

**In this tutorial, you'll:**

- [Step 1: Create an AWS Lambda function that sends a text message](p. 221)
- [Step 2: Create an AWS IoT rule with an AWS Lambda rule action](p. 223)
- [Step 3: Test the AWS IoT rule and AWS Lambda rule action](p. 224)
- [Step 4: Review the results and next steps](p. 228)

**Before you start this tutorial, make sure that you have:**

- [Set up your AWS account](p. 18)
  
  You'll need your AWS account and AWS IoT console to complete this tutorial.

- [Reviewed View MQTT messages with the AWS IoT MQTT client](p. 67)
  
  Be sure you can use the MQTT client to subscribe and publish to a topic. You'll use the MQTT client to test your new rule in this procedure.

- [Completed the other rules tutorials in this section]
This tutorial requires the SNS notification topic you created in the tutorial about how to the section called “Sending an Amazon SNS notification” (p. 207). It also assumes that you’ve completed the other rules-related tutorials in this section.

- **Reviewed the AWS Lambda overview**

  If you haven't used AWS Lambda before, review AWS Lambda and Getting started with Lambda to learn its terms and concepts.

**Step 1: Create an AWS Lambda function that sends a text message**

The AWS Lambda function in this tutorial receives the result of the rule query statement, inserts the elements into a text string, and sends the resulting string to Amazon SNS as the message in a notification.

Unlike the tutorial about how to the section called “Sending an Amazon SNS notification” (p. 207), which used an AWS IoT rule action to send the notification, this tutorial sends the notification from the Lambda function by using a function of the AWS SDK. The actual Amazon SNS notification topic used in this tutorial, however, is the same one that you used in the tutorial about how to the section called “Sending an Amazon SNS notification” (p. 207).

**To create an AWS Lambda function that sends a text message**

1. Create a new AWS Lambda function.
   a. In the AWS Lambda console, choose Create function.
   b. In Create function, select Use a blueprint.
      
      Search for and select the hello-world-python blueprint, and then choose Configure.
   c. In Basic information:
      i. In Function name, enter the name of this function, format-high-temp-notification.
      ii. In Execution role, choose Create a new role from AWS policy templates.
      iii. In Role name, enter the name of the new role, format-high-temp-notification-role.
      iv. In Policy templates - optional, search for and select Amazon SNS publish policy.
   d. Choose Create function.

2. Modify the blueprint code to format and send an Amazon SNS notification.
   a. After you created your function, you should see the format-high-temp-notification details page. If you don't, open it from the Lambda Functions page.
   b. In the format-high-temp-notification details page, choose the Configuration tab and scroll to the Function code panel.
   c. In the Function code window, in the Environment pane, choose the Python file, lambda_function.py.
   d. In the Function code window, delete all of the original program code from the blueprint and replace it with this code.

```python
import boto3
#
#   expects event parameter to contain:
#   {
#     "device_id": "32",
#     "reported_temperature": 38,
#     "max_temperature": 50,
```
def lambda_handler(event, context):
    # Create an SNS client to send notification
    sns = boto3.client('sns')

    # Format text message from data
    message_text = 'Device {0} reports a temperature of {1}, which exceeds the limit of {2}.
    '.format(
        str(event['device_id']),
        str(event['reported_temperature']),
        str(event['max_temperature'])
    )

    # Publish the formatted message
    response = sns.publish(
        TopicArn = event['notify_topic_arn'],
        Message = message_text
    )

    return response

e. Choose Deploy.

3. In a new window, look up the Amazon Resource Name (ARN) of your Amazon SNS topic from the tutorial about how to the section called "Sending an Amazon SNS notification" (p. 207).

a. In a new window, open the Topics page of the Amazon SNS console.
b. In the Topics page, find the high_temp_notice notification topic in the list of Amazon SNS topics.
c. Find the ARN of the high_temp_notice notification topic to use in the next step.

4. Create a test case for your Lambda function.

a. In the Lambda Functions page of the console, on the format-high-temp-notification details page, choose Select a test event in the upper right corner of the page (even though it looks disabled), and then choose Configure test events.
b. In Configure test event, choose Create new test event.
c. In Event name, enter SampleRuleOutput.
d. In the JSON editor below Event name, paste this sample JSON document. This is an example of what your AWS IoT rule will send to the Lambda function.

```json
{
    "device_id": "32",
    "reported_temperature": 38,
    "max_temperature": 30,
    "notify_topic_arn": "arn:aws:sns:us-east-1:57EXAMPLE833:high_temp_notice"
}
```
e. Refer to the window that has the ARN of the high_temp_notice notification topic and copy the ARN value.
f. Replace the `notify_topic_arn` value in the JSON editor with the ARN from your notification topic.

Keep this window open so you can use this ARN value again when you create the AWS IoT rule.

g. Choose **Create**.

5. Test the function with sample data.

   a. In the `format-high-temp-notification` details page, in the upper-right corner of the page, confirm that **SampleRuleOutput** appears next to the **Test** button. If it doesn't, choose it from the list of available test events.

   b. To send the sample rule output message to your function, choose **Test**.

If the function and the notification both worked, you will get a text message on the phone that subscribed to the notification.

If you didn't get a text message on the phone, check the result of the operation. In the **Function code** panel, in the **Execution result** tab, review the response to find any errors that occurred. Don't continue to the next step until your function can send the notification to your phone.

**Step 2: Create an AWS IoT rule with an AWS Lambda rule action**

In this step, you’ll use the rule query statement to format the data from the imaginary weather sensor device to send to a Lambda function, which will format and send a text message.

A sample message payload received from the weather devices looks like this:

```json
{
  "temperature": 28,
  "humidity": 80,
  "barometer": 1013,
  "wind": {
    "velocity": 22,
    "bearing": 255
  }
}
```

In this rule, you’ll use the rule query statement to create a message payload for the Lambda function that looks like this:

```json
{
  "device_id": "32",
  "reported_temperature": 38,
  "max_temperature": 30,
  "notify_topic_arn": "arn:aws:sns:us-east-1:57EXAMPLE833:high_temp_notice"
}
```

This contains all the information the Lambda function needs to format and send the correct text message.

**To create the AWS IoT rule to call a Lambda function**

1. Open the **Rules hub of the AWS IoT console**.
2. To start creating your new rule in **Rules**, choose **Create**.
3. In the top part of **Create a rule**:
   a. In **Name**, enter the rule's name, **wx_friendly_text**.
Remember that a rule name must be unique within your AWS account and Region, and it can't have any spaces. We've used an underscore character in this name to separate the two words in the rule's name.

b. In **Description**, describe the rule.

A meaningful description makes it easier to remember what this rule does and why you created it. The description can be as long as needed, so be as detailed as possible.

4. In **Rule query statement** of Create a rule:


   b. In the **Rule query statement** edit box, enter the statement:

   ```sql
   SELECT
       cast(topic(2) AS DECIMAL) as device_id,
       temperature as reported_temperature,
       30 as max_temperature,
       'arn:aws:sns:us-east-1:57EXAMPLE833:high_temp_notice' as notify_topic_arn
   FROM 'device/+/data' WHERE temperature > 30
   ```

   This statement:
   
   - Listens for MQTT messages with a topic that matches the `device/+/data` topic filter and that have a temperature value greater than 30.
   - Selects the second element from the topic string, converts it to a decimal number, and then assigns it to the `device_id` field.
   - Selects the value of the `temperature` field from the message payload and assigns it to the `reported_temperature` field.
   - Creates a constant value, 30, to represent the limit value and assigns it to the `max_temperature` field.
   - Creates a constant value for the `notify_topic_arn` field.
   
   c. Refer to the window that has the **ARN** of the `high_temp_notice` notification topic and copy the ARN value.

   d. Replace the ARN value (`arn:aws:sns:us-east-1:57EXAMPLE833:high_temp_notice`) in the rule query statement editor with the ARN of your notification topic.

5. In **Set one or more actions**:

   a. To open up the list of rule actions for this rule, choose **Add action**.

   b. In **Select an action**, choose **Send a message to a Lambda function**.

   c. To open the selected action's configuration page, at the bottom of the action list, choose **Configure action**.

6. In **Configure action**:

   a. In **Function name**, choose **Select**.

   b. Choose **format-high-temp-notification**.

   c. At the bottom of **Configure action**, choose **Add action**.

   d. To create the rule, at the bottom of **Create a rule**, choose **Create rule**.

**Step 3: Test the AWS IoT rule and AWS Lambda rule action**

To test your new rule, you'll use the MQTT client to publish and subscribe to the MQTT messages used by this rule.
Open the MQTT client in the AWS IoT console in a new window. Now you can edit the rule without losing the configuration of your MQTT client. If you leave the MQTT client to go to another page in the console, you'll lose your subscriptions or message logs.

To use the MQTT client to test your rule

1. In the MQTT client in the AWS IoT console, subscribe to the input topics, in this case, device/+\(/
data.
   a. In the MQTT client, under Subscriptions, choose Subscribe to a topic.
   b. In Subscription topic, enter the topic of the input topic filter, device/+\(/
data.
   c. Keep the rest of the fields at their default settings.
   d. Choose Subscribe to topic.

   In the Subscriptions column, under Publish to a topic, device/+\(/
data appears.

2. Publish a message to the input topic with a specific device ID, device/32/data. You can't publish to MQTT topics that contain wildcard characters.
   a. In the MQTT client, under Subscriptions, choose Publish to topic.
   b. In the Publish field, enter the input topic name, device/32/data.
   c. Copy the sample data shown here and, in the edit box below the topic name, paste the sample data.

```json
{
    "temperature": 38,
    "humidity": 80,
    "barometer": 1013,
    "wind": {
        "velocity": 22,
        "bearing": 255
    }
}
```

   d. To publish your MQTT message, choose Publish to topic.

3. Confirm that the text message was sent.
   a. In the MQTT client, under Subscriptions, there is a green dot next to the topic to which you subscribed earlier.

   The green dot indicates that one or more new messages have been received since the last time you looked at them.

   b. Under Subscriptions, choose device/+\(/
data to check that the message payload matches what you just published and looks like this:

```json
{
    "temperature": 38,
    "humidity": 80,
    "barometer": 1013,
    "wind": {
        "velocity": 22,
        "bearing": 255
    }
}
```

   c. Check the phone that you used to subscribe to the SNS topic and confirm the contents of the message payload look like this:
Device 32 reports a temperature of 38, which exceeds the limit of 30.

If you change the topic ID element in the message topic, remember that casting the `topic(2)` value to a numeric value will only work if that element in the message topic contains only numeric characters.

4. Try sending an MQTT message in which the temperature does not exceed the limit.
   a. In the MQTT client, under Subscriptions, choose Publish to topic.
   b. In the Publish field, enter the input topic name, device/33/data.
   c. Copy the sample data shown here and, in the edit box below the topic name, paste the sample data.

   ```json
   {
     "temperature": 28,
     "humidity": 80,
     "barometer": 1013,
     "wind": {
       "velocity": 22,
       "bearing": 255
     }
   }
   ```
   d. To send your MQTT message, choose Publish to topic.

   You should see the message that you sent in the device/+data subscription; however, because the temperature value is below the max temperature in the rule query statement, you shouldn't receive a text message.

   If you don't see the correct behavior, check the troubleshooting tips.

Troubleshooting your AWS Lambda rule and notification

Here are some things to check, in case you're not seeing the results you expect.

- **You got an error banner**

  If an error appeared when you published the input message, correct that error first. The following steps might help you correct that error.

- **You don't see the input message in the MQTT client**

  Every time you publish your input message to the device/32/data topic, that message should appear in the MQTT client, if you subscribed to the device/+data topic filter as described in the procedure.

  **Things to check**

  - **Check the topic filter you subscribed to**

    If you subscribed to the input message topic as described in the procedure, you should see a copy of the input message every time you publish it.

    If you don't see the message, check the topic name you subscribed to and compare it to the topic to which you published. Topic names are case sensitive and the topic to which you subscribed must be identical to the topic to which you published the message payload.

  - **Check the message publish function**
In the MQTT client, under **Subscriptions**, choose **device/+data**, check the topic of the publish message, and then choose **Publish to topic**. You should see the message payload from the edit box below the topic appear in the message list.

- **You don't receive an SMS message**

For your rule to work, it must have the correct policy that authorizes it to receive a message and send an SNS notification, and it must receive the message.

**Things to check**

- **Check the AWS Region of your MQTT client and the rule that you created**

The console in which you're running the MQTT client must be in the same AWS Region as the rule you created.

- **Check that the temperature value in the message payload exceeds the test threshold**

If the temperature value is less than or equal to 30, as defined in the rule query statement, the rule will not perform any of its actions.

- **Check the input message topic in the rule query statement**

For the rule to work, it must receive a message with the topic name that matches the topic filter in the FROM clause of the rule query statement.

Check the spelling of the topic filter in the rule query statement with that of the topic in the MQTT client. Topic names are case sensitive and the message's topic must match the topic filter in the rule query statement.

- **Check the contents of the input message payload**

For the rule to work, it must find the data field in the message payload that is declared in the SELECT statement.

Check the spelling of the temperature field in the rule query statement with that of the message payload in the MQTT client. Field names are case sensitive and the temperature field in the rule query statement must be identical to the temperature field in the message payload.

Make sure that the JSON document in the message payload is correctly formatted. If the JSON has any errors, such as a missing comma, the rule will not be able to read it.

- **Check the Amazon SNS notification**

In Step 1: Create an Amazon SNS topic that sends an SMS text message (p. 208), refer to step 3 that describes how to test the Amazon SNS notification and test the notification to make sure the notification works.

- **Check the Lambda function**

In Step 1: Create an AWS Lambda function that sends a text message (p. 221), refer to step 5 that describes how to test the Lambda function using test data and test the Lambda function.

- **Check the role being used by the rule**

The rule action must have permission to receive the original topic and publish the new topic.

The policies that authorize the rule to receive message data and republish it are specific to the topics used. If you change the topic used to republish the message data, you must update the rule action's role to update its policy to match the current topic.

If you suspect this is the problem, edit the Republish rule action and create a new role. New roles created by the rule action receive the authorizations necessary to perform these actions.
Step 4: Review the results and next steps

In this tutorial:

- You created an AWS IoT rule to call a Lambda function that sent an Amazon SNS notification that used your customized message payload.
- You used a simple SQL query and functions in a rule query statement to create a new message payload for your Lambda function.
- You used the MQTT client to test your AWS IoT rule.

Next steps

After you send a few text messages with this rule, try experimenting with it to see how changing some aspects of the tutorial affect the message and when it's sent. Here are some ideas to get you started.

- Change the `device_id` in the input message's topic and observe the effect in the text message contents.
- Change the fields selected in the rule query statement, update the Lambda function to use them in a new message, and observe the effect in the text message contents.
- Change the test in the rule query statement to test for a minimum temperature instead of a maximum temperature. Update the Lambda function to format a new message and remember to change the name of `max_temperature`.
- To learn more about how to find errors that might occur while you're developing and using AWS IoT rules, see Monitoring AWS IoT (p. 439).

Retaining device state while the device is offline with Device Shadows

These tutorials show you how to use the AWS IoT Device Shadow service to store and update the state information of a device. The Shadow document, which is a JSON document, shows the change in the device's state based on the messages published by a device, local app, or service. In this tutorial, the Shadow document shows the change in the color of a light bulb. These tutorials also show how the shadow stores this information even when the device is disconnected from the internet, and passes the latest state information back to the device when it comes back online and requests this information.

We recommend that you try these tutorials in the order they're shown here, starting with the AWS IoT resources you need to create and the necessary hardware setup, which also helps you learn the concepts incrementally. These tutorials show how to configure and connect a Raspberry Pi device for use with AWS IoT. If you don't have the required hardware, you can follow these tutorials by adapting them to a device of your choice or by creating a virtual device with Amazon EC2 (p. 41).

Tutorial scenario overview

The scenario for these tutorials is a local app or service that changes the color of a light bulb and that publishes its data to reserved shadow topics. These tutorials are similar to the Device Shadow functionality described in the interactive getting started tutorial (p. 20) and are implemented on a Raspberry Pi device. The tutorials in this section focus on a single, classic shadow while showing how you might accommodate named shadows or multiple devices.

The following tutorials will help you learn how to use the AWS IoT Device Shadow service.

- Tutorial: Preparing your Raspberry Pi to run the shadow application (p. 230)
This tutorial shows how to set up a Raspberry Pi device for connecting with AWS IoT. You'll also create an AWS IoT policy document and a thing resource, download the certificates, and then attach the policy to that thing resource. This tutorial takes about 30 minutes to complete.

- **Tutorial: Installing the Device SDK and running the sample application for Device Shadows (p. 235)**

  This tutorial shows how to install the required tools, software, and the AWS IoT Device SDK for Python, and then run the sample shadow application. This tutorial builds on concepts presented in Connect a Raspberry Pi or other device (p. 58) and takes 20 minutes to complete.

- **Tutorial: Interacting with Device Shadow using the sample app and the MQTT test client (p. 241)**

  This tutorial shows how you use the shadow.py sample app and AWS IoT console to observe the interaction between AWS IoT Device Shadows and the state changes of the light bulb. The tutorial also shows how to send MQTT messages to the Device Shadow's reserved topics. This tutorial can take 45 minutes to complete.

### AWS IoT Device Shadow overview

A Device Shadow is a persistent, virtual representation of a device that is managed by a thing resource (p. 269) you create in the AWS IoT registry. The Shadow document is a JSON or a JavaScript notation doc that is used to store and retrieve the current state information for a device. You can use the shadow to get and set the state of a device over MQTT topics or HTTP REST APIs, regardless of whether the device is connected to the internet.

A Shadow document contains a `state` property that describes these aspects of the device's state:

- **desired**: Apps specify the desired states of device properties by updating the desired object.
- **reported**: Devices report their current state in the reported object.
- **delta**: AWS IoT reports differences between the desired and the reported state in the delta object.

Here is an example of a Shadow state document.

```json
{
  "state": {
    "desired": {
      "color": "green"
    },
    "reported": {
      "color": "blue"
    },
    "delta": {
      "color": "green"
    }
  }
}
```

To update a device's Shadow document, you can use the reserved MQTT topics (p. 120), the Device Shadow REST APIs (p. 682) that support the GET, UPDATE, and DELETE operations with HTTP, and the AWS IoT CLI.

In the previous example, say you want to change the desired color to yellow. To do this, send a request to the UpdateThingShadow (p. 683) API or publish a message to the Update (p. 689) topic, $aws/things/THING_NAME/shadow/update.

```json
{
  "state": {
    "desired": {
      "color": "yellow"
    }
  }
}
```
Retaining device state while the device is offline with Device Shadows

Updates affect only the fields specified in the request. After successfully updating the Device Shadow, AWS IoT publishes the new desired state to the delta topic, $aws/things/THING_NAME/shadow/delta. The Shadow document in this case looks like this:

```json
{
    "state": {
        "desired": {
            "color": yellow
        },
        "reported": {
            "color": green
        },
        "delta": {
            "color": yellow
        }
    }
}
```

The new state is then reported to the AWS IoT Device Shadow using the Update topic $aws/things/THING_NAME/shadow/update with the following JSON message:

```json
{
    "state": {
        "reported": {
            "color": yellow
        }
    }
}
```

If you want to get the current state information, send a request to the GetThingShadow (p. 683) API or publish an MQTT message to the Get (p. 687) topic, $aws/things/THING_NAME/shadow/get.

For more information about using the Device Shadow service, see AWS IoT Device Shadow service (p. 657).

For more information about using Device Shadows in devices, apps, and services, see Using shadows in devices (p. 660) and Using shadows in apps and services (p. 663).

For information about interacting with AWS IoT shadows, see Interacting with shadows (p. 675).

For information about the MQTT reserved topics and HTTP REST APIs, see Device Shadow MQTT topics (p. 686) and Device Shadow REST API (p. 682).

**Tutorial: Preparing your Raspberry Pi to run the shadow application**

This tutorial demonstrates how to set up and configure a Raspberry Pi device and create the AWS IoT resources that a device requires to connect and exchange MQTT messages.

**Note**

If you're planning to the section called “Create a virtual device with Amazon EC2” (p. 41), you can skip this page and continue to the section called “Configure your device” (p. 41). You'll create these resources when you create your virtual thing. If you would like to use a different device instead of the Raspberry Pi, you can try to follow these tutorials by adapting them to a device of your choice.
In this tutorial, you'll learn how to:

- Set up a Raspberry Pi device and configure it for use with AWS IoT.
- Create an AWS IoT policy document, which authorizes your device to interact with AWS IoT services.
- Create a thing resource in AWS IoT the X.509 device certificates, and then attach the policy document.

The thing is the virtual representation of your device in the AWS IoT registry. The certificate authenticates your device to AWS IoT Core, and the policy document authorizes your device to interact with AWS IoT.

How to run this tutorial

To run the shadow.py sample application for Device Shadows, you'll need a Raspberry Pi device that connects to AWS IoT. We recommend that you follow this tutorial in the order it's presented here, starting with setting up the Raspberry Pi and its accessories, and then creating a policy and attaching the policy to a thing resource that you create. You can then follow this tutorial by using the graphical user interface (GUI) supported by the Raspberry Pi to open the AWS IoT console on the device's web browser, which also makes it easier to download the certificates directly to your Raspberry Pi for connecting to AWS IoT.

Before you start this tutorial, make sure that you have:

- An AWS account. If you don't have one, complete the steps described in Set up your AWS account (p. 18) before you continue. You'll need your AWS account and AWS IoT console to complete this tutorial.
- The Raspberry Pi and its necessary accessories. You'll need:
  - A Raspberry Pi 3 Model B or more recent model. This tutorial might work on earlier versions of the Raspberry Pi, but we haven't tested it.
  - Raspberry Pi OS (32-bit) or later. We recommend using the latest version of the Raspberry Pi OS. Earlier versions of the OS might work, but we haven't tested it.
  - An Ethernet or Wi-Fi connection.
  - Keyboard, mouse, monitor, cables, and power supplies.

This tutorial takes about 30 minutes to complete.

Step 1: Set up and configure Raspberry Pi device

In this section, we'll configure a Raspberry Pi device for use with AWS IoT.

Important
Adapting these instructions to other devices and operating systems can be challenging. You'll need to understand your device well enough to be able to interpret these instructions and apply them to your device. If you encounter difficulties, you might try one of the other device options as an alternative, such as Create a virtual device with Amazon EC2 (p. 41) or Use your Windows or Linux PC or Mac as an AWS IoT device (p. 49).

You'll need to configure your Raspberry Pi such that it can start the operating system (OS), connect to the internet, and allow you to interact with it at a command line interface. You can also use the graphical user interface (GUI) supported with the Raspberry Pi to open the AWS IoT console and run the rest of this tutorial.

To set up the Raspberry Pi

1. Insert the SD card into the MicroSD card slot on the Raspberry Pi. Some SD cards come pre-loaded with an installation manager that prompts you with a menu to install the OS after booting up the board. You can also use the Raspberry Pi imager to install the OS on your card.
2. Connect an HDMI TV or monitor to the HDMI cable that connects to the HDMI port of the Raspberry Pi.
3. Connect the keyboard and mouse to the USB ports of the Raspberry Pi and then plug in the power adapter to boot up the board.

After the Raspberry Pi boots up, if the SD card came pre-loaded with the installation manager, a menu appears to install the operating system. If you have trouble installing the OS, you can try the following steps. For more information about setting up the Raspberry Pi, see Setting up your Raspberry Pi.

**If you're having trouble setting up the Raspberry Pi:**

- Check whether you inserted the SD card before booting up the board. If you plug in the SD card after booting up the board, the installation menu might not appear.
- Make sure that the TV or monitor is turned on and the correct input is selected.
- Ensure that you are using Raspberry Pi compatible software.

After you have installed and configured the Raspberry Pi OS, open the Raspberry Pi’s web browser and navigate to the AWS IoT Core console to continue the rest of the steps in this tutorial.

If you can open the AWS IoT Core console, you're Raspberry Pi is ready and you can continue to the section called “Provisioning your device in AWS IoT” (p. 232).

If you’re having trouble or need additional help, see Getting help for your Raspberry Pi.

**Tutorial: Provisioning your device in AWS IoT**

This section creates the AWS IoT Core resources that your tutorial will use.

**Steps to provision your device in AWS IoT**

- **Step 1: Create an AWS IoT policy for the Device Shadow** (p. 232)
- **Step 2: Create a thing resource and attach the policy to the thing** (p. 234)
- **Step 3: Review the results and next steps** (p. 234)

**Step 1: Create an AWS IoT policy for the Device Shadow**

X.509 certificates authenticate your device with AWS IoT Core. AWS IoT policies are attached to the certificate that permits the device to perform AWS IoT operations, such as subscribing or publishing to MQTT reserved topics used by the Device Shadow service. Your device presents its certificate when it connects and sends messages to AWS IoT Core.

In this procedure, you'll create a policy that allows your device to perform the AWS IoT operations necessary to run the example program. We recommend that you create a policy that grants only the permissions required to perform the task. You create the AWS IoT policy first, and then attach it to the device certificate that you'll create later.

**To create an AWS IoT policy**

1. On the left menu, choose Secure, and then choose Policies. If your account has existing policies, choose Create, otherwise, on the You don’t have a policy yet page, choose Create a policy.
2. On the Create a policy page:
   a. Enter a name for the policy in the Name field (for example, My_Device_Shadow_policy). Do not use personally identifiable information in your policy names.
   b. In the policy document, you describe connect, subscribe, receive, and publish actions that give the device permission to publish and subscribe to the MQTT reserved topics.
Copy the following sample policy and paste it in your policy document. Replace thingname with the name of the thing that you'll create (for example, My_light_bulb), region with the AWS IoT Region where you're using the services, and account with your AWS account number. For more information about AWS IoT policies, see AWS IoT Core policies (p. 336).

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Publish"],
      "Resource": [
      ]
    },
    {
      "Effect": "Allow",
      "Action": ["iot:Receive"],
      "Resource": [
      ]
    },
    {
      "Effect": "Allow",
      "Action": ["iot:Subscribe"],
      "Resource": [
      ]
    },
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"],
    }
  ]
}
```
Step 2: Create a thing resource and attach the policy to the thing

Devices connected to AWS IoT can be represented by thing resources in the AWS IoT registry. A thing resource represents a specific device or logical entity, such as the light bulb in this tutorial.

To learn how to create a thing in AWS IoT, follow the steps described in Create a thing object (p. 40). Here are some key things to note as you follow the steps in that tutorial:

1. Choose Create a single thing, and in the Name field, enter a name for the thing that is the same as the thingname (for example, My_light_bulb) you specified when you created the policy earlier.

   Note
   Do not use personally identifiable information in your thing name. The thing name can appear in unencrypted communications and reports.

2. We recommend that you download each of the certificate files on the Certificate created! page into a location where you can easily find them. You'll need to install these files for running the sample application.

   We recommend that you download the files into a certs subdirectory in your home directory on the Raspberry Pi and name each of them with a simpler name as suggested in the following table.

   Certificate file names

<table>
<thead>
<tr>
<th>File</th>
<th>File path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root CA certificate</td>
<td>~/certs/Amazon-root-CA-1.pem</td>
</tr>
<tr>
<td>Device certificate</td>
<td>~/certs/device.pem.crt</td>
</tr>
<tr>
<td>Private key</td>
<td>~/certs/private.pem.key</td>
</tr>
</tbody>
</table>

3. After you activate the certificate to enable connections to AWS IoT, choose Attach a policy and make sure you attach the policy that you created earlier (for example, My_Device_Shadow_policy) to the thing.

   After you've created a thing, you can see your thing resource displayed in the list of things in the AWS IoT console.

Step 3: Review the results and next steps

In this tutorial, you learned how to:

- Set up and configure the Raspberry Pi device.
- Create an AWS IoT policy document that authorizes your device to interact with AWS IoT services.
- Create a thing resource and associated X.509 device certificate, and attach the policy document to it.

Next steps

You can now install the AWS IoT device SDK for Python, run the shadow.py sample application, and use Device Shadows to control the state. For more information about how to run this tutorial, see Tutorial: Installing the Device SDK and running the sample application for Device Shadows (p. 235).
Tutorial: Installing the Device SDK and running the sample application for Device Shadows

This section shows how you can install the required software and the AWS IoT Device SDK for Python and run the `shadow.py` sample application to edit the Shadow document and control the shadow's state.

In this tutorial, you'll learn how to:

- Use the installed software and AWS IoT Device SDK for Python to run the sample app.
- Learn how entering a value using the sample app publishes the desired value in the AWS IoT console.
- Review the `shadow.py` sample app and how it uses the MQTT protocol to update the shadow's state.

Before you run this tutorial:

You must have set up your AWS account, configured your Raspberry Pi device, and created an AWS IoT thing and policy that gives the device permissions to publish and subscribe to the MQTT reserved topics of the Device Shadow service. For more information, see Tutorial: Preparing your Raspberry Pi to run the shadow application (p. 230).

You must have also installed Git, Python, and the AWS IoT Device SDK for Python. This tutorial builds on the concepts presented in the tutorial Connect a Raspberry Pi or other device (p. 58). If you haven't tried that tutorial, we recommend that you follow the steps described in that tutorial to install the certificate files and Device SDK and then come back to this tutorial to run the `shadow.py` sample app.

In this tutorial, you'll:

- **Step 1:** Run the `shadow.py` sample app (p. 235)
- **Step 2:** Review the `shadow.py` Device SDK sample app (p. 238)
- **Step 3:** Troubleshoot problems with the `shadow.py` sample app (p. 239)
- **Step 4:** Review the results and next steps (p. 240)

This tutorial takes about 20 minutes to complete.

**Step 1: Run the `shadow.py` sample app**

Before you run the `shadow.py` sample app, you'll need the following information in addition to the names and location of the certificate files that you installed.

**Application parameter values**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Where to find the value</th>
</tr>
</thead>
</table>
| `your-iot-thing-name` | Name of the AWS IoT thing that you created earlier in the section called “Step 2: Create a thing resource and attach the policy to the thing” (p. 234).  
To find this value, in the AWS IoT console, choose Manage, and then choose Things. |

**your-iot-endpoint**  
The `your-iot-endpoint` value has a format of: `endpoint_id-ats.iot.region.amazonaws.com`, for example, a3qj468EXAMPLE-ats.iot.us-west-2.amazonaws.com. To find this value:
Install and run the sample app

1. Navigate to the sample app directory.

   ```
   cd ~/aws-iot-device-sdk-python-v2/samples
   ```

2. In the command line window, replace `your-iot-endpoint` and `your-iot-thing-name` as indicated and run this command.

   ```
   python3 shadow.py --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint --thing_name your-iot-thing-name
   ```

3. Observe that the sample app:
   1. Connects to the AWS IoT service for your account.
   2. Subscribes to Delta events and Update and Get responses.
   3. Prompts you to enter a desired value in the terminal.
   4. Displays output similar to the following:

   ```
   Connecting to a3qEXAMPLEffp-ats.iot.us-west-2.amazonaws.com with client ID 'test-0c8ae2ff-cc87-49d2-a82a-ae7ba1d0ca5a'...
   Connected!
   Subscribing to Delta events...
   Subscribing to Update responses...
   Subscribing to Get responses...
   Requesting current shadow state...
   Launching thread to read user input...
   Finished getting initial shadow state.
   Shadow contains reported value 'off'.
   Enter desired value:
   ```

   **Note**
   If you're having trouble running the `shadow.py` sample app, review the section called “Step 3: Troubleshoot problems with the shadow.py sample app” (p. 239). To get additional information that might help you correct the problem, add the `--verbosity debug` parameter to the command line so the sample app displays detailed messages about what it's doing.

Enter values and observe the updates in Shadow document

You can enter values in the terminal to specify the desired value, which also updates the reported value. Say you enter the color `yellow` in the terminal. The reported value is also updated to the color `yellow`. The following shows the messages displayed in the terminal:

```
Enter desired value:
```
When you publish this update request, AWS IoT creates a default, classic shadow for the thing resource. You can observe the update request that you published to the reported and desired values in the AWS IoT console by looking at the Shadow document for the thing resource that you created (for example, My_light_bulb). To see the update in the Shadow document:

1. In the AWS IoT console, choose Manage and then choose Things.
2. In the list of things displayed, select the thing that you created, choose Shadows, and then choose Classic Shadow.

The Shadow document should look similar to the following, showing the reported and desired values set to the color yellow. You see these values in the Shadow state section of the document.

```
{
  "desired": {
    "welcome": "aws-iot",
    "color": "yellow"
  },
  "reported": {
    "welcome": "aws-iot",
    "color": "yellow"
  }
}
```

You also see a Metadata section that contains the timestamp information and version number of the request.

You can use the state document version to ensure you are updating the most recent version of a device's Shadow document. If you send another update request, the version number increments by 1. When you supply a version with an update request, the service rejects the request with an HTTP 409 conflict response code if the current version of the state document doesn't match the version supplied.

```
{
  "metadata": {
    "desired": {
      "welcome": {
        "timestamp": 1620156892
      },
      "color": {
        "timestamp": 1620156893
      }
    },
    "reported": {
      "welcome": {
        "timestamp": 1620156892
      },
      "color": {
        "timestamp": 1620156893
      }
    }
  },
  "version": 10
}
```
To learn more about the Shadow document and observe changes to the state information, proceed to the next tutorial Tutorial: Interacting with Device Shadow using the sample app and the MQTT test client (p. 241) as described in the Step 4: Review the results and next steps (p. 240) section of this tutorial. Optionally, you can also learn about the shadow.py sample code and how it uses the MQTT protocol in the following section.

**Step 2: Review the shadow.py Device SDK sample app**

This section reviews the shadow.py sample app from the AWS IoT Device SDK v2 for Python used in this tutorial. Here, we'll review how it connects to AWS IoT Core by using the MQTT and MQTT over WSS protocol. The AWS common runtime (AWS-CRT) library provides the low-level communication protocol support and is included with the AWS IoT Device SDK v2 for Python.

While this tutorial uses MQTT and MQTT over WSS, AWS IoT supports devices that publish HTTPS requests. For an example of a Python program that sends an HTTP message from a device, see the HTTPS code example (p. 107) using Python's requests library.

For information about how you can make an informed decision about which protocol to use for your device communications, review the Choosing a protocol for your device communication (p. 86).

**MQTT**

The shadow.py sample calls mtls_from_path (shown here) in the mqtt_connection_builder to establish a connection with AWS IoT Core by using the MQTT protocol. mtls_from_path uses X.509 certificates and TLS v1.2 to authenticate the device. The AWS-CRT library handles the lower-level details of that connection.

```python
mqtt_connection = mqtt_connection_builder.mtls_from_path(
    endpoint=args.endpoint,
    cert_filepath=args.cert,
    pri_key_filepath=args.key,
    ca_filepath=args.ca_file,
    client_bootstrap=client_bootstrap,
    on_connection_interrupted=on_connection_interrupted,
    on_connection_resumed=on_connection_resumed,
    client_id=args.client_id,
    clean_session=False,
    keep_alive_secs=6
)
```

- endpoint is your AWS IoT endpoint that you passed in from the command line and client_id is the ID that uniquely identifies this device in the AWS Region.
- cert_filepath, pri_key_filepath, and ca_filepath are the paths to the device's certificate and private key files, and the root CA file.
- client_bootstrap is the common runtime object that handles socket communication activities, and is instantiated prior to the call to mqtt_connection_builder.mtls_from_path.
- on_connection_interrupted and on_connection_resumed are callback functions to call when the device's connection is interrupted and resumed.
- clean_session is whether to start a new, persistent session, or if one is present, reconnect to an existing one. keep_alive_secs is the keep alive value, in seconds, to send in the CONNECT request. A ping will automatically be sent at this interval. The server assumes that the connection is lost if it doesn't receive a ping after 1.5 times this value.

The shadow.py sample also calls websockets_with_default_aws_signing in the mqtt_connection_builder to establish a connection with AWS IoT Core using MQTT protocol over WSS. MQTT over WSS also uses the same parameters as MQTT and takes these additional parameters:
Retaining device state while the device is offline with Device Shadows

- **region** is the AWS signing Region used by Signature V4 authentication, and **credentials_provider** is the AWS credentials provided to use for authentication. The Region is passed from the command line, and the credentials_provider object is instantiated just prior to the call to `mqtt_connection_builder.websockets_with_default_aws_signing`.

- **websocket_proxy_options** is the HTTP proxy options, if using a proxy host. In the `shadow.py` sample app, this value is instantiated just prior to the call to `mqtt_connection_builder.websockets_with_default_aws_signing`.

**Subscribe to Shadow topics and events**

The `shadow.py` sample attempts to establish a connection and waits to be fully connected. If it's not connected, commands are queued up. Once connected, the sample subscribes to delta events and update and get messages, and publishes messages with a Quality of Service (QoS) level of 1 (`mqtt.QoS.AT_LEAST_ONCE`).

When a device subscribes to a message with QoS level 1, the message broker saves the messages that the device is subscribed to until they can be sent to the device. The message broker resends the messages until it receives a `PUBACK` response from the device.

For more information about the MQTT protocol, see [Review the MQTT protocol](p. 184) and [MQTT](p. 88).

For more information about how MQTT, MQTT over WSS, persistent sessions, and QoS levels that are used in this tutorial, see [Review the pubsub.py Device SDK sample app](p. 185).

**Step 3: Troubleshoot problems with the `shadow.py` sample app**

When you run the `shadow.py` sample app, you should see some messages displayed in the terminal and a prompt to enter a desired value. If the program throws an error, then to debug the error, you can start by checking whether you ran the correct command for your system.

In some cases, the error message might indicate connection issues and look similar to: **Host name was invalid for dns resolution** or **Connection was closed unexpectedly**. In such cases, here are some things you can check:

- **Check the endpoint address in the command**

  Review the endpoint argument in the command you entered to run the sample app, (for example, `a3qEXAMPLEffp-ats.iot.us-west-2.amazonaws.com`) and check this value in the AWS IoT console.

  To check whether you used the correct value:
  1. In the AWS IoT console, choose Manage and then choose Things.
  2. Choose the thing you created for your sample app (for example, `My_light_bulb`) and then choose Interact.

  On the thing details page, your endpoint is displayed in the HTTPS section. You should also see a message that says: **This thing already appears to be connected**.

- **Check certificate activation**

  Certificates authenticate your device with AWS IoT Core.

  To check whether your certificate is active:
  1. In the AWS IoT console, choose Manage and then choose Things.
  2. Choose the thing you created for your sample app (for example, `My_light_bulb`) and then choose Security.
3. Select the certificate and then, from the certificate's details page, choose Actions.

If in the dropdown list Activate isn't available and you can only choose Deactivate, your certificate is active. If not, choose Activate and rerun the sample program.

If the program still doesn't run, check the certificate file names in the certs folder.

- **Check the policy attached to the thing resource**

While certificates authenticate your device, AWS IoT policies permit the device to perform AWS IoT operations, such as subscribing or publishing to MQTT reserved topics.

To check whether the correct policy is attached:

1. Find the certificate as described previously, and then choose Policies.
2. Choose the policy displayed and check whether it describes the connect, subscribe, receive, and publish actions that give the device permission to publish and subscribe to the MQTT reserved topics.

For a sample policy, see [Step 1: Create an AWS IoT policy for the Device Shadow](p. 232).

If you see error messages that indicate trouble connecting to AWS IoT, it could be because of the permissions you're using for the policy. If that's the case, we recommend that you start with a policy that provides full access to AWS IoT resources and then rerun the sample program. You can either edit the current policy, or choose the current policy, choose Detach, and then create another policy that provides full access and attach it to your thing resource. You can later restrict the policy to only the actions and policies you need to run the program.

```json
{
"Version": "2012-10-17",
"Statement": [
{
"Effect": "Allow",
"Action": [
"iot:*",
"Resource": "*"
]
}
]
}
```

- **Check your Device SDK installation**

If the program still doesn't run, you can reinstall the Device SDK to make sure that your SDK installation is complete and correct.

**Step 4: Review the results and next steps**

In this tutorial, you learned how to:

- Install the required software, tools, and the AWS IoT Device SDK for Python.
- Understand how the sample app, shadow.py, uses the MQTT protocol for retrieving and updating the shadow's current state.
- Run the sample app for Device Shadows and observe the update to the Shadow document in the AWS IoT console. You also learned to troubleshoot any issues and fix errors when running the program.
You can now run the shadow.py sample application and use Device Shadows to control the state. You can observe the updates to the Shadow document in the AWS IoT Console and observe delta events that the sample app responds to. Using the MQTT test client, you can subscribe to the reserved shadow topics and observe messages received by the topics when running the sample program. For more information about how to run this tutorial, see Tutorial: Interacting with Device Shadow using the sample app and the MQTT test client (p. 241).

**Tutorial: Interacting with Device Shadow using the sample app and the MQTT test client**

To interact with the shadow.py sample app, enter a value in the terminal for the desired value. For example, you can specify colors that resemble the traffic lights and AWS IoT responds to the request and updates the reported values.

**In this tutorial, you'll learn how to:**

- Use the shadow.py sample app to specify desired states and update the shadow's current state.
- Edit the Shadow document to observe delta events and how the shadow.py sample app responds to it.
- Use the MQTT test client to subscribe to shadow topics and observe updates when you run the sample program.

**Before you run this tutorial, you must have:**

Set up your AWS account, configured your Raspberry Pi device, and created an AWS IoT thing and policy. You must have also installed the required software, Device SDK, certificate files, and run the sample program in the terminal. For more information, see the previous tutorials Tutorial: Preparing your Raspberry Pi to run the shadow application (p. 230) and Step 1: Run the shadow.py sample app (p. 235). You must complete these tutorials if you haven't already.

**In this tutorial, you'll:**

- Step 1: Update desired and reported values using shadow.py sample app (p. 241)
- Step 2: View messages from the shadow.py sample app in the MQTT test client (p. 243)
- Step 3: Troubleshoot errors with Device Shadow interactions (p. 247)
- Step 4: Review the results and next steps (p. 247)

This tutorial takes about 45 minutes to complete.

**Step 1: Update desired and reported values using shadow.py sample app**

In the previous tutorial Step 1: Run the shadow.py sample app (p. 235), you learned how to observe a message published to the Shadow document in the AWS IoT console when you enter a desired value as described in the section Tutorial: Installing the Device SDK and running the sample application for Device Shadows (p. 235).

In the previous example, we set the desired color to yellow. After you enter each value, the terminal prompts you to enter another desired value. If you again enter the same value (yellow), the app recognizes this and prompts you to enter a new desired value.

```
Enter desired value: yellow
Local value is already 'yellow'.
Enter desired value:
```
Now, say that you enter the color green. AWS IoT responds to the request and updates the reported value to green. This is how the update happens when the desired state is different from the reported state, causing a delta.

**How the shadow.py sample app simulates Device Shadow interactions:**

1. Enter a desired value (say yellow) in the terminal to publish the desired state.
2. As the desired state is different from the reported state (say the color green), a delta occurs, and the app that is subscribed to the delta receives this message.
3. The app responds to the message and updates its state to the desired value, yellow.
4. The app then publishes an update message with the new reported value of the device's state, yellow.

Following shows the messages displayed in the terminal that shows how the update request is published.

```text
Enter desired value:
green
Changed local shadow value to 'green'.
Updating reported shadow value to 'green'...
Update request published.
Finished updating reported shadow value to 'green'.
```

In the AWS IoT console, the Shadow document reflects the updated value to green for both the reported and desired fields, and the version number is incremented by 1. For example, if the previous version number was displayed as 10, the current version number will display as 11.

**Note**
Deleting a shadow doesn't reset the version number to 0. You'll see that the shadow version is incremented by 1 when you publish an update request or create another shadow with the same name.

**Edit the Shadow document to observe delta events**

The shadow.py sample app is also subscribed to delta events, and responds when there is a change to the desired value. For example, you can change the desired value to the color red. To do this, in the AWS IoT console, edit the Shadow document by clicking **Edit** and then set the desired value to red in the JSON, while keeping the reported value to green. Before you save the changes, keep the terminal on the Raspberry Pi open as you'll see messages displayed in the terminal when the change occurs.

```json
{
  "desired": {
    "welcome": "aws-iot",
    "color": "red"
  },
  "reported": {
    "welcome": "aws-iot",
    "color": "green"
  }
}
```

After you save the new value, the shadow.py sample app responds to this change and displays messages in the terminal indicating the delta. You should then see the following messages appear below the prompt for entering the desired value.

```text
Enter desired value:
Received shadow delta event.
Delta reports that desired value is 'red'. Changing local value...
Changed local shadow value to 'red'.
Updating reported shadow value to 'red'...
```
Finished updating reported shadow value to 'red'.
Enter desired value:
Update request published.
Finished updating reported shadow value to 'red'.

Step 2: View messages from the `shadow.py` sample app in the MQTT test client

You can use the MQTT test client in the AWS IoT console to monitor MQTT messages that are passed in your AWS account. By subscribing to reserved MQTT topics used by the Device Shadow service, you can observe the messages received by the topics when running the sample app.

If you haven't already used the MQTT test client, you can review View MQTT messages with the AWS IoT MQTT client (p. 67). This helps you learn how to use the MQTT test client in the AWS IoT console to view MQTT messages as they pass through the message broker.

1. Open the MQTT test client

   Open the MQTT test client in the AWS IoT console in a new window so that you can observe the messages received by the MQTT topics without losing the configuration of your MQTT test client. The MQTT test client doesn't retain any subscriptions or message logs if you leave it to go to another page in the console. For this section of the tutorial, you can have the Shadow document of your AWS IoT thing and the MQTT test client open in separate windows to more easily observe the interaction with Device Shadows.

2. Subscribe to the MQTT reserved Shadow topics

   You can use the MQTT test client to enter the names of the Device Shadow's MQTT reserved topics and subscribe to them to receive updates when running the `shadow.py` sample app. To subscribe to the topics:
   a. In the MQTT test client in the AWS IoT console, choose Subscribe to a topic.
   b. In the Topic filter section, enter: $aws/things/thingname/shadow/update/#. Here, thingname is the name of the thing resource that you created earlier (for example, My_light_bulb).
   c. Keep the default values for the additional configuration settings, and then choose Subscribe.

   By using the # wildcard in the topic subscription, you can subscribe to multiple MQTT topics at the same time and observe all the messages that are exchanged between the device and its Shadow in a single window. For more information about the wildcard characters and their use, see MQTT topics (p. 109).

3. Run `shadow.py` sample program and observe messages

   In your command line window of the Raspberry Pi, if you've disconnected the program, run the sample app again and watch the messages in the MQTT test client in the AWS IoT console.
   a. Run the following command to restart the sample program. Replace `your-iot-thing-name` and `your-iot-endpoint` with the names of the AWS IoT thing that you created earlier (for example, My_light_bulb), and the endpoint to interact with the device.

   ```bash
   cd ~/aws-iot-device-sdk-python-v2/samples
   python3 shadow.py --ca_file ~/certs/Amazon-root-CA-1.pem --cert ~/certs/device.pem.crt --key ~/certs/private.pem.key --endpoint your-iot-endpoint --thing_name your-iot-thing-name
   ```

   The `shadow.py` sample app then runs and retrieves the current shadow state. If you've deleted the shadow or cleared the current states, the program sets the current value to off and then prompts you to enter a desired value.
Connecting to a3qEXAMPLEfp-atp.ats.iot.us-west-2.amazonaws.com with client ID 'test-0c8ae2ff-cc87-49d2-a82a-ae7bald0ca5a'...
Connected!
Subscribing to Delta events...
Subscribing to Update responses...
Subscribing to Get responses...
Requesting current shadow state...
Launching thread to read user input...
Finished getting initial shadow state.
Shadow document lacks 'color' property. Setting defaults...
Changed local shadow value to 'off'.
Updating reported shadow value to 'off'...
Update request published.
Finished updating reported shadow value to 'off'...
Enter desired value:

On the other hand, if the program was running and you restarted it, you'll see the latest color value reported in the terminal. In the MQTT test client, you'll see an update to the topics $aws/things/thingname/shadow/get and $aws/things/thingname/shadow/get/accepted.

Suppose that the latest color reported was green. Following shows the contents of the $aws/things/thingname/shadow/get/accepted JSON file.

```json
{
  "state": {
    "desired": {
      "welcome": "aws-iot",
      "color": "green"
    },
    "reported": {
      "welcome": "aws-iot",
      "color": "green"
    }
  },
  "metadata": {
    "desired": {
      "welcome": {
        "timestamp": 1620156892
      },
      "color": {
        "timestamp": 1620161643
      }
    },
    "reported": {
      "welcome": {
        "timestamp": 1620156892
      },
      "color": {
        "timestamp": 1620161643
      }
    }
  },
  "version": 10,
  "timestamp": 1620173908
}
```

b. Enter a desired value in the terminal, such as yellow. The shadow.py sample app responds and displays the following messages in the terminal that show the change in the reported value to yellow.
Enter desired value: yellow
Changed local shadow value to 'yellow'.
Updating reported shadow value to 'yellow'...
Update request published.
Finished updating reported shadow value to 'yellow'.

In the MQTT test client in the AWS IoT console, under Subscriptions, you see that the following topics received a message:

- $aws/things/thingname/shadow/update: shows that both desired and updated values change to the color yellow.
- $aws/things/thingname/shadow/update/accepted: shows the current values of the desired and reported states and their metadata and version information.
- $aws/things/thingname/shadow/update/documents: shows the previous and current values of the desired and reported states and their metadata and version information.

As the document $aws/things/thingname/shadow/update/documents also contains information that is contained in the other two topics, we can review it to see the state information. The previous state shows the reported value set to green, its metadata and version information, and the current state that shows the reported value updated to yellow.

```json
{
    "previous": {
        "state": {
            "desired": {
                "welcome": "aws-iot",
                "color": "green"
            },
            "reported": {
                "welcome": "aws-iot",
                "color": "green"
            }
        },
        "metadata": {
            "desired": {
                "welcome": {
                    "timestamp": 1617297888
                },
                "color": {
                    "timestamp": 1617297898
                }
            },
            "reported": {
                "welcome": {
                    "timestamp": 1617297888
                },
                "color": {
                    "timestamp": 1617297898
                }
            }
        },
        "version": 10
    },
    "current": {
        "state": {
            "desired": {
                "welcome": "aws-iot",
                "color": "yellow"
            }
        }
    }
}
```
Retaining device state while the device is offline with Device Shadows

c. Now, if you enter another desired value, you see further changes to the reported values and message updates received by these topics. The version number also increments by 1. For example, if you enter the value green, the previous state reports the value yellow and the current state reports the value green.

4. **Edit Shadow document to observe delta events**

To observe changes to the delta topic, edit the Shadow document in the AWS IoT console. For example, you can change the desired value to the color red. To do this, in the AWS IoT console, choose Edit and then set the desired value to red in the JSON, while keeping the reported value set to green. Before you save the change, keep the terminal open as you'll see the delta message reported in the terminal.

```
{
  "desired": {
    "welcome": "aws-iot",
    "color": "red"
  },
  "reported": {
    "welcome": "aws-iot",
    "color": "green"
  }
}
```

The shadow.py sample app responds to this change and displays messages in the terminal indicating the delta. In the MQTT test client, the update topics will have received a message showing changes to the desired and reported values.

You also see that the topic `$aws/things/thingname/shadow/update/delta` received a message. To see the message, choose this topic, which is listed under Subscriptions.

```
{
  "version": 13,
}
```
Step 3: Troubleshoot errors with Device Shadow interactions

When you run the Shadow sample app, you might encounter issues with observing interactions with the Device Shadow service.

If the program runs successfully and prompts you to enter a desired value, you should be able to observe the Device Shadow interactions by using the Shadow document and the MQTT test client as described previously. However, if you're unable to see the interactions, here are some things you can check:

- **Check the thing name and its shadow in the AWS IoT console**

  If you don't see the messages in the Shadow document, review the command and make sure it matches the thing name in the AWS IoT console. You can also check whether you have a classic shadow by choosing your thing resource and then choosing Shadows. This tutorial focuses primarily on interactions with the classic shadow.

  You can also confirm that the device you used is connected to the internet. In the AWS IoT console, choose the thing you created earlier, and then choose Interact. On the thing details page, you should see a message here that says: This thing already appears to be connected.

- **Check the MQTT reserved topics you subscribed to**

  If you don't see the messages appear in the MQTT test client, check whether the topics you subscribed to are formatted correctly. MQTT Device Shadow topics have a format `$aws/things/thingname/shadow` and might have update, get, or delete following it depending on actions you want to perform on the shadow. This tutorial uses the topic `$aws/things/thingname/shadow/#` so make sure you entered it correctly when subscribing to the topic in the Topic filter section of the test client.

  As you enter the topic name, make sure that the thingname is the same as the name of the AWS IoT thing that you created earlier. You can also subscribe to additional MQTT topics to see if an update has been successfully performed. For example, you can subscribe to the topic `$aws/things/thingname/shadow/update/rejected` to receive a message whenever an update request failed so that you can debug connection issues. For more information about the reserved topics, see the section called “Shadow topics” (p. 120) and Device Shadow MQTT topics (p. 686).

Step 4: Review the results and next steps

In this tutorial, you learned how to:

- Use the shadow.py sample app to specify desired states and update the shadow's current state.
- Edit the Shadow document to observe delta events and how the shadow.py sample app responds to it.
- Use the MQTT test client to subscribe to shadow topics and observe updates when you run the sample program.
Next steps

You can subscribe to additional MQTT reserved topics to observe updates to the shadow application. For example, if you only subscribe to the topic `aws/things/thingname/shadow/update/accepted`, you'll see only the current state information when an update is successfully performed.

You can also subscribe to additional shadow topics to debug issues or learn more about the Device Shadow interactions and also debug any issues with the Device Shadow interactions. For more information, see the section called “Shadow topics” (p. 120) and Device Shadow MQTT topics (p. 686).

You can also choose to extend your application by using named shadows or by using additional hardware connected with the Raspberry Pi for the LEDs and observe changes to their state using messages sent from the terminal.

For more information about the Device Shadow service and using the service in devices, apps, and services, see AWS IoT Device Shadow service (p. 657), Using shadows in devices (p. 660), and Using shadows in apps and services (p. 663).

Tutorial: Creating a custom authorizer for AWS IoT Core

This tutorial demonstrates the steps to create, validate, and use Custom Authentication by using the AWS CLI. Optionally, using this tutorial, you can use Postman to send data to AWS IoT Core by using the HTTP Publish API.

This tutorial show you how to create a sample Lambda function that implements the authorization and authentication logic and a custom authorizer using the create-authorizer call with token signing enabled. The authorizer is then validated using the test-invoke-authorizer, and finally you can send data to AWS IoT Core by using the HTTP Publish API to a test MQTT topic. Sample request will specify the authorizer to invoke by using the x-amz-customauthorizer-name header and pass the token-key-name and x-amz-customauthorizer-signature in request headers.

What you'll learn in this tutorial:

• How to create a Lambda function to be a custom authorizer handler
• How to create a custom authorizer using the AWS CLI with token signing enabled
• How to test your custom authorizer using the test-invoke-authorizer command
• How to publish an MQTT topic by using Postman and validate the request with your custom authorizer

This tutorial takes about 60 minutes to complete.

In this tutorial, you'll:

• Step 1: Create a Lambda function for your custom authorizer (p. 249)
• Step 2: Create a public and private key pair for your custom authorizer (p. 252)
• Step 3: Create a customer authorizer resource and its authorization (p. 252)
• Step 4: Test the authorizer by calling test-invoke-authorizer (p. 255)
• Step 5: Test publishing MQTT message using Postman (p. 256)
• Step 6: View messages in MQTT test client (p. 258)
• Step 7: Review the results and next steps (p. 258)
• Step 8: Clean up (p. 259)

Before you start this tutorial, make sure that you have:

• Set up your AWS account (p. 18)
You'll need your AWS account and AWS IoT console to complete this tutorial.

The account you use for this tutorial works best when it includes at least these AWS managed policies:

- IAMFullAccess
- AWSIoTFullAccess
- AWSLambda_FullAccess

**Important**

The IAM policies used in this tutorial are more permissive than you should follow in a production implementation. In a production environment, make sure that your account and resource policies grant only the necessary permissions.

When you create IAM policies for production, determine what access users and roles need, and then design the policies that allow them to perform only those tasks. For more information, see [Security best practices in IAM](#).

- Installed the AWS CLI

For information about how to install the AWS CLI, see [Installing the AWS CLI](#). This tutorial requires AWS CLI version aws-cli/2.1.3 Python/3.7.4 Darwin/18.7.0 exe/x86_64 or later.

- OpenSSL tools

The examples in this tutorial use [LibreSSL 2.6.5](#). You can also use [OpenSSL v1.1.1i](#) tools for this tutorial.

- Reviewed the AWS Lambda overview

If you haven't used AWS Lambda before, review [AWS Lambda](#) and [Getting started with Lambda](#) to learn its terms and concepts.

- Reviewed how to build requests in Postman

For more information, see [Building requests](#).

- Removed custom authorizers from previous tutorial

Your AWS account can have only a limited number of custom authorizers configured at one time. For information about how to remove a custom authorizer, see the section called “Step 8: Clean up” (p. 259).

### Step 1: Create a Lambda function for your custom authorizer

Custom authentication in AWS IoT Core uses [authorizer resources](#) that you create to authenticate and authorize clients. The function you'll create in this section authenticates and authorizes clients as they connect to AWS IoT Core and access AWS IoT resources.

The Lambda function does the following:

- If a request comes from test-invoke-authorizer, it returns an IAM policy with a Deny action.
- If a request comes from Passport using HTTP and the actionToken parameter has a value of allow, it returns an IAM policy with an Allow action. Otherwise, it returns an IAM policy with a Deny action.

**To create the Lambda function for your custom authorizer**

1. In the Lambda console, open Functions.
2. Choose Create function.
3. Confirm Author from scratch is selected.
4. Under Basic information:
a. In **Function name**, enter `custom-auth-function`.

b. In **Runtime**, confirm Node.js 18.x

5. Choose **Create function**.

Lambda creates a Node.js function and an **execution role** that grants the function permission to upload logs. The Lambda function assumes the execution role when you invoke your function and uses the execution role to create credentials for the AWS SDK and to read data from event sources.

6. To see the function's code and configuration in the **AWS Cloud9** editor, choose `custom-auth-function` in the designer window, and then choose `index.js` in the navigation pane of the editor.

For scripting languages such as Node.js, Lambda includes a basic function that returns a success response. You can use the **AWS Cloud9** editor to edit your function as long as your source code doesn't exceed 3 MB.

7. Replace the `index.js` code in the editor with the following code:

```javascript
// A simple Lambda function for an authorizer. It demonstrates
// How to parse a CLI and Http password to generate a response.
exports const handler = async (event, context, callback) => {

    //Http parameter to initiate allow/deny request
    const HTTP_PARAM_NAME='actionToken';
    const ALLOW_ACTION = 'Allow';
    const DENY_ACTION = 'Deny';

    //Event data passed to Lambda function
    var event_str = JSON.stringify(event);
    console.log('Complete event :'+ event_str);

    //Read protocolData from the event json passed to Lambda function
    var protocolData = event.protocolData;
    console.log('protocolData value---> ' + protocolData);

    //Get the dynamic account ID from function's ARN to be used
    // as full resource for IAM policy
    var ACCOUNT_ID = context.invokedFunctionArn.split(':')[4];
    console.log("ACCOUNT_ID---"+ACCOUNT_ID);

    //Get the dynamic region from function's ARN to be used
    // as full resource for IAM policy
    var REGION = context.invokedFunctionArn.split(':')[3];
    console.log("REGION---"+REGION);

    //protocolData data will be undefined if testing is done via CLI.
    // This will help to test the set up.
    if (protocolData === undefined) {
        //If CLI testing, pass deny action as this is for testing purpose only.
        console.log('Using the test-invoke-authorizer cli for testing only');
        callback(null, generateAuthResponse(DENY_ACTION,ACCOUNT_ID,REGION));
    } else{

        //Http Testing from Postman
        //Get the query string from the request
        var queryString = event.protocolData.http.queryString;
        console.log('queryString values -- ' + queryString);
        /*
        global URLSearchParams
        */
        const params = new URLSearchParams(queryString);
        var action = params.get(HTTP_PARAM_NAME);

        //If testing, pass deny action as this is for testing purpose only.
        console.log('Using the test-invoke-authorizer cli for testing only');
        callback(null, generateAuthResponse(DENY_ACTION,ACCOUNT_ID,REGION));
    }
};
```
if(action!=null && action.toLowerCase() === 'allow'){
    callback(null, generateAuthResponse(ALLOW_ACTION,ACCOUNT_ID,REGION));
}else{
    callback(null, generateAuthResponse(DENY_ACTION,ACCOUNT_ID,REGION));
}
}

// Helper function to generate the authorization IAM response.
var generateAuthResponse = function(effect,ACCOUNT_ID,REGION) {
    var full_resource = "arn:aws:iot:"+ REGION + ":" + ACCOUNT_ID + ":*";
    console.log("full_resource---"+full_resource);
    var authResponse = {};
    authResponse.isAuthenticated = true;
    authResponse.principalId = 'principalId';
    var policyDocument = {};
    policyDocument.Version = '2012-10-17';
    policyDocument.Statement = [];
    var statement = {};
    statement.Action = 'iot:*';
    statement.Effect = effect;
    statement.Resource = full_resource;
    policyDocument.Statement[0] = statement;
    authResponse.policyDocuments = [policyDocument];
    authResponse.disconnectAfterInSeconds = 3600;
    authResponse.refreshAfterInSeconds = 600;
    console.log('custom auth policy function called from http');
    console.log('authResponse --> ' + JSON.stringify(authResponse));
    console.log(authResponse.policyDocuments[0]);
    return authResponse;
};

8. Choose **Deploy**.
9. After **Changes deployed** appears above the editor:
   a. Scroll to the **Function overview** section above the editor.
   b. Copy the **Function ARN** and save it to use later in this tutorial.
10. Test your function.
    a. Choose the **Test** tab.
    b. Using the default test settings, choose **Invoke**.
    c. If the test succeeded, in the **Execution results**, open the **Details** view. You should see the policy document that the function returned.

If the test failed or you don't see a policy document, review the code to find and correct the errors.
Step 2: Create a public and private key pair for your custom authorizer

Your custom authorizer requires a public and private key to authenticate it. The commands in this section use OpenSSL tools to create this key pair.

**To create the public and private key pair for your custom authorizer**

1. Create the private key file.
   ```bash
   openssl genrsa -out private-key.pem 4096
   ```

2. Verify the private key file you just created.
   ```bash
   openssl rsa -check -in private-key.pem -noout
   ```
   If the command doesn't display any errors, the private key file is valid.

3. Create the public key file.
   ```bash
   openssl rsa -in private-key.pem -pubout -out public-key.pem
   ```

4. Verify the public key file.
   ```bash
   openssl pkey -inform PEM -pubin -in public-key.pem -noout
   ```
   If the command doesn't display any errors, the public key file is valid.

Step 3: Create a customer authorizer resource and its authorization

The AWS IoT custom authorizer is the resource that ties together all the elements created in the previous steps. In this section, you'll create a custom authorizer resource and give it permission to run the Lambda function you created earlier. You can create a custom authorizer resource by using the AWS IoT console, the AWS CLI, or the AWS API.

For this tutorial, you only need to create one custom authorizer. This section describes how to create by using the AWS IoT console and the AWS CLI, so you can use the method that is most convenient for you. There's no difference between the custom authorizer resources created by either method.

Create a customer authorizer resource

Choose one of these options to create your custom authorizer resource

- Create a custom authorizer by using the AWS IoT console (p. 252)
- Create a custom authorizer using the AWS CLI (p. 253)

To create a custom authorizer (console)

1. Open the Custom authorizer page of the AWS IoT console, and choose Create Authorizer.
2. In Create Authorizer:
   a. In Authorizer name, enter my-new-authorizer.
   b. In Authorizer status, check Active.
c. In **Authorizer function**, choose the Lambda function you created earlier.

d. In **Token validation - optional:**

i. Toggle on **Token validation**.

ii. In **Token key name**, enter `tokenKeyName`.

iii. Choose **Add key**.

iv. In **Key name**, enter `FirstKey`.

v. In **Public key**, enter the contents of the public-key.pem file. Be sure to include the lines from the file with `-----BEGIN PUBLIC KEY-----` and `-----END PUBLIC KEY-----` and don't add or remove any line feeds, carriage returns, or other characters from the file contents. The string that you enter should look something like this example.

```
-----BEGIN PUBLIC KEY-----
MIICiDANBgkqhkiG9w0BAQEFAAOCAg8AMIICCgKCAgEAvEBzOk4vhN+3Lgs1vEwt
sLCQnv5tDamas3bmlTrvq2gjrJ6KXGTGQChqArAjl1a9dkS9+maaXC3vc6xxz9
QPu/vQo65tyzz1MsKdmfGxMq3jEJXAMPLE0mqyUKPP5mff58k6eP5fxAnzB90q
lg2Hioefp5US05AnpuRAjYKofKjb2zvtn6N26/hV+7fTBvcE1f0csaa15/Rk4pHDS
oaY0GHIS1nveypgsC8n9r2z91P9Wq6PG/sq5DNJXjMy1e692hQqu1N69b6n59w8
Fhedsa6b2x6zklYfzewnqNkPMLMFn5x1vvhst/Tf/1LVCS5+vq8A08UG0fZvm
QeqAMAF7wqgDMXcEgkSVU8yids2m56q5CLMvD35q8Lqzpey95N9010c1vdwvc
KrJ1tgv6WhvQgRusnwnLpg686m6ze5sRmBvN308zcobLmgJ01bw9KkcUdklW
vg26HEjqBvY701EXAMPLEPTZhqvK6Ei1H6xpHsXx6BHnft58J21PvqJyXhasoa
/NN7I72bj/euAb41IVtmX8j92x1d31iM5L8HulJ1uzn52Q+VcVNT2vd74MFpFMC
8bt61vdAnitTheirZ6+F0VSBJPu7pZQoLmgEp5zLMTf+kF12y0mGAP08Rblvrd9
JWUBCG0bqcLQPeQyjS0FUCWAeAAAA==
------END PUBLIC KEY-----
```

3. Choose **Create authorizer**.

4. If the custom authorizer resource was created, you'll see the list of custom authorizers and your new custom authorizer should appear in the list and you can continue to the next section to test it.

   If you see an error, review the error and try to create your custom authorizer again and double-check the entries. Note that each custom authorizer resource must have a unique name.

---

To create a custom authorizer (AWS CLI)

1. Substitute your values for `authorizer-function-arn` and `token-signing-public-keys`, and then run the following command:

```bash
aws iot create-authorizer --authorizer-name "my-new-authorizer" --token-key-name "tokenKeyName" --status ACTIVE --no-signing-disabled --authorizer-function-arn "arn:aws:lambda:Region:57EXAMPLEB33:function:custom-auth-function" --token-signing-public-keys FirstKey="-----BEGIN PUBLIC KEY-----
MIICiDANBgkqhkiG9w0BAQEFAAOCAg8AMIICCgKCAgEAvEBzOk4vhN+3Lgs1vEwt
sLCQnv5tDamas3bmlTrvq2gjrJ6KXGTGQChqArAjl1a9dkS9+maaXC3vc6xxz9
QPu/vQo65tyzz1MsKdmfGxMq3jEJXAMPLE0mqyUKPP5mff58k6eP5fxAnzB90q
lg2Hioefp5US05AnpuRAjYKofKjb2zvtn6N26/hV+7fTBvcE1f0csaa15/Rk4pHDS
oaY0GHIS1nveypgsC8n9r2z91P9Wq6PG/sq5DNJXjMy1e692hQqu1N69b6n59w8
Fhedsa6b2x6zklYfzewnqNkPMLMFn5x1vvhst/Tf/1LVCS5+vq8A08UG0fZvm
QeqAMAF7wqgDMXcEgkSVU8yids2m56q5CLMvD35q8Lqzpey95N9010c1vdwvc
KrJ1tgv6WhvQgRusnwnLpg686m6ze5sRmBvN308zcobLmgJ01bw9KkcUdklW
vg26HEjqBvY701EXAMPLEPTZhqvK6Ei1H6xpHsXx6BHnft58J21PvqJyXhasoa
/NN7I72bj/euAb41IVtmX8j92x1d31iM5L8HulJ1uzn52Q+VcVNT2vd74MFpFMC
8bt61vdAnitTheirZ6+F0VSBJPu7pZQoLmgEp5zLMTf+kF12y0mGAP08Rblvrd9
JWUBCG0bqcLQPeQyjS0FUCWAeAAAA==
------END PUBLIC KEY-----"
```
```
Where:

- The `authorizer-function-arn` value is the Amazon Resource Name (ARN) of the Lambda function you created for your custom authorizer.
- The `token-signing-public-keys` value includes the name of the key, `FirstKey`, and the contents of the `public-key.pem` file. Be sure to include the lines from the file with `-----BEGIN PUBLIC KEY-----` and `-----END PUBLIC KEY-----` and don’t add or remove any line feeds, carriage returns, or other characters from the file contents.

Note: be careful entering the public key as any alteration to the public key value makes it unusable.

2. If the custom authorizer is created, the command returns the name and ARN of the new resource, such as the following.

```
{
  "authorizerName": "my-new-authorizer",
  "authorizerArn": "arn:aws:iot:Region:57EXAMPLE833:authorizer/my-new-authorizer"
}
```

Save the `authorizerArn` value for use in the next step.

Remember that each custom authorizer resource must have a unique name.

Authorize the custom authorizer resource

In this section, you'll grant permission the custom authorizer resource that you just created permission to run the Lambda function. To grant the permission, you can use the `add-permission` CLI command.

Grant permission to your Lambda function using the AWS CLI

1. After inserting your values, enter the following command. Note that the `statement-id` value must be unique. Replace `Id-1234` with another value if you have run this tutorial before or if you get a ResourceConflictException error.

```
aws lambda add-permission \
--function-name "custom-auth-function" \
--principal "iot.amazonaws.com" \
--action "lambda:InvokeFunction" \
--statement-id "Id-1234" \
--source-arn authorizerArn
```

2. If the command succeeds, it returns a permission statement, such as this example. You can continue to the next section to test the custom authorizer.

```
{
```

If the command doesn't succeed, it returns an error, such as this example. You'll need to review and correct the error before you continue.
Creating a custom authorizer for AWS IoT Core

An error occurred (AccessDeniedException) when calling the AddPermission operation:
User: arn:aws:iam::57EXAMPLE833:user/EXAMPLE-1 is not authorized to perform:

Step 4: Test the authorizer by calling test-invoke-authorizer

With all the resources defined, in this section, you’ll call test-invoke-authorizer from the command line to test the authorization pass.

Note that when invoking the authorizer from the command line, protocolData is not defined, so the authorizer will always return a DENY document. This test does, however, confirm that your custom authorizer and Lambda function are configured correctly—even if it doesn’t fully test the Lambda function.

To test your custom authorizer and its Lambda function by using the AWS CLI

1. In the directory that has the private-key.pem file you created in a previous step, run the following command.

   ```bash
   echo -n "tokenKeyValue" | openssl dgst -sha256 -sign private-key.pem | openssl base64 -A
   ```

   This command creates a signature string to use in the next step. The signature string looks something like this:

   ```text
dBwykzlbf+fo+Jm5GsdwoGr8dyC2qB/IYlefJ1jr+rbCvmu9J14KHA9A9D+V+MMwu09YSA8+64Y3Gt4t0ykPZqn9mm
   VBlwyxp+0bDzh8hmqUHA5fwi3fPjBvC4cWuLQNqBZzwCvslv7i2IMjEg
   +CPv0zrT1jr9B1kGPoDxWkjaeeh
   bQHHTo357TegKs9p30Uf4TxypNmFswAS5k7QIc01n4BIyRTm90yZ9R4bdJhSnhig1JePejg6n0U8VMGCEF09jGj
   +szEHfgAUAIWx1VQGj16BU1XkP0GsiTawheLkujITEAMPLEC3aHKYKY
   +dvTvDthkTyHqB8Qmhjz0J0kqgBt29V
   QJCbBR11N/P5+vCvn1sXwpjlyB5jKysU9vG860E864AtifUhvSuLr/F3VTV8ITq3aXiUvctspaCi6ca
   +tsDuX
   F3LzcwQXFYSUy9u2U5XKwhn+sto6KcpkNldW0U8gL3+k0zxtmnhQ8egAejd5iylx230iqcXososjPha7JDbWM5o
   +K
   EWcKTe911mokDz5s4jJx1vmJTV5x1s1i491A1w4n1DAk1a0s2U2Unm236EXAMPLEL0tyh7h
   +fJFeo21AQVHF
   xR1XsPqiVKS1ZUIClaZwpzh/orD3plpiWF8gB10gkJIDGP9ghxj2k7zwGmWpMK9o=
   ```

   Copy this signature string to use in the next step. Be careful not to include any extra characters or leave any out.

2. In this command, replace the token-signature value with the signature string from the previous step and run this command to test your authorizer.

   ```bash
   aws iot test-invoke-authorizer \
   --authorizer-name my-new-authorizer \n   --token tokenKeyValue \n   --token-signature dBwykzlbf+fo+Jm5GsdwoGr8dyC2qB/IYlefJ1jr+rbCvmu9J14KHA9A9D+V+MMwu09YSA8+64Y3Gt4t0ykPZqn9mm
   +CPv0zrT1jr9B1kGPoDxWkjaeeh
   bQHHTo357TegKs9p30Uf4TxypNmFswAS5k7QIc01n4BIyRTm90yZ9R4bdJhSnhig1JePejg6n0U8VMGCEF09jGj
   +szEHfgAUAIWx1VQGj16BU1XkP0GsiTawheLkujITEAMPLEC3aHKYKY
   +dvTvDthkTyHqB8Qmhjz0J0kqgBt29V
   QJCbBR11N/P5+vCvn1sXwpjlyB5jKysU9vG860E864AtifUhvSuLr/F3VTV8ITq3aXiUvctspaCi6ca
   +tsDuX
   F3LzcwQXFYSUy9u2U5XKwhn+sto6KcpkNldW0U8gL3+k0zxtmnhQ8egAejd5iylx230iqcXososjPha7JDbWM5o
   ```

255
If the command is successful, it returns the information generated by your customer authorizer function, such as this example.

```
{
   "isAuthenticated": true,
   "principalId": "principalId",
   "policyDocuments": [
   ],
   "refreshAfterInSeconds": 600,
   "disconnectAfterInSeconds": 3600
}
```

If the command returns an error, review the error and double-check the commands you used in this section.

**Step 5: Test publishing MQTT message using Postman**

1. To get your device data endpoint from the command line, call `describe-endpoint` as shown here

   ```bash
   aws iot describe-endpoint --output text --endpoint-type iot:Data-ATS
   ```

   Save this address for use as the `device_data_endpoint_address` in a later step.

2. Open a new Postman window and create a new HTTP POST request.

   a. From your computer, open the Postman app.
   b. In Postman, in the File menu, choose New....
   c. In the New dialog box, choose Request.
   d. In Save request,
      i. In Request name enter Custom authorizer test request.
      ii. In Select a collection or folder to save to: choose or create a collection into which to save this request.
      iii. Choose Save to collection_name.

3. Create the POST request to test your custom authorizer.

   a. In the request method selector next to the URL field, choose POST.
   b. In the URL field, create the URL for your request by using the following URL with the `device_data_endpoint_address` from the `describe-endpoint` command in a previous step.

   ```
   https://device_data_endpoint_address:443/topics/test/cust-auth/topic?qos=0&actionToken=allow
   ```

   Note that this URL includes the `actionToken=allow` query parameter that will tell your Lambda function to return a policy document that allows access to AWS IoT. After you enter the URL, the query parameters also appear in the Params tab of Postman.

c. In the Auth tab, in the Type field, choose No Auth.

d. In the Headers tab:
Creating a custom authorizer for AWS IoT Core

i. If there's a **Host** key that's checked, uncheck this one.

ii. At the bottom of the list of headers add these new headers and confirm they are checked. Replace the **Host** value with your `device_data_endpoint_address` and the **x-amz-customauthorizer-signature** value with the signature string that you used with the `test-invoke-authorize` command in the previous section.

<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x-amz-customauthorizer-name</td>
<td><code>my-new-authorizer</code></td>
</tr>
<tr>
<td>Host</td>
<td><code>device_data_endpoint_address</code></td>
</tr>
<tr>
<td>tokenKeyName</td>
<td><code>tokenKeyValue</code></td>
</tr>
<tr>
<td>x-amz-customauthorizer-signature</td>
<td><code>dBwykzlb+fo+JmSGdwoGr8dyC2qB/IyLefJjr+rbCvmu9Jl4KHA99DG+V/MMWu09YSA86+64Y3Gt4t0ykpZqn9mnVBIwwyp+0bDZh8hmqUAUH3fw13fPjBvCa44cwwuLQNqBZzbCvslu+CPY0zzWt1jr9BikgGPDxWkjaeehbQHHTd357Te6Ks9P+d1vTvdthKtYHBq8Mhzj0kggbt29QVJCB8R1IN/P5+vcVmi5XWPPlyB5jKyS9uVg08REoey64AtizfUhvSuLi7r/F3VV8I7tQp3aXiUtcespACi6ca+tsDuXf3LzCwQQY/YSUy0zu5XkWn+sto6KckpNLkD0wU8gl3+kOzxrthnQ8gEajdStylx230+KEWcTe91I1mokDr5sJ4JXixvnJTVsx1i49Ialw4en+flFeloZtA1WQFHXRLXsPqivKvlSIUCLaZWpR/0rDjplpiWfBgiOgkJIDGP9ghXIIk7zWrGmwpMK9o=</code></td>
</tr>
</tbody>
</table>

4. In the Body tab:

i. In the data format option box, choose **Raw**.

ii. In the data type list, choose **JavaScript**.

iii. In the text field, enter this JSON message payload for your test message:

```json
{
  "data_mode": "test",
  "vibration": 200,
  "temperature": 40
}
```

Choose **Send** to send the request.

If the request was successful, it returns:

```json
{
  "message": "OK",
  "traceId": "ff35c33f-409a-ea90-b06f-fbEXAMPLE25c"
}
```

The successful response indicates that your custom authorizer allowed the connection to AWS IoT and that the test message was delivered to broker in AWS IoT Core.

If it returns an error, review error message, the `device_data_endpoint_address`, the signature string, and the other header values.

Keep this request in Postman for use in the next section.
Step 6: View messages in MQTT test client

In the previous step, you sent simulated device messages to AWS IoT by using Postman. The successful response indicated that your custom authorizer allowed the connection to AWS IoT and that the test message was delivered to broker in AWS IoT Core. In this section, you’ll use the MQTT test client in the AWS IoT console to see the message contents from that message as other devices and services might.

To see the test messages authorized by your custom authorizer

1. In the AWS IoT console, open the MQTT test client.
2. In the Subscribe to topic tab, in Topic filter, enter test/cust-auth/topic, which is the message topic used in the Postman example from the previous section.
3. Choose Subscribe.
   
   Keep this window visible for the next step.
4. In Postman, in the request you created for the previous section, choose Send.
   
   Review the response to make sure it was successful. If not, troubleshoot the error as the previous section describes.
5. In the MQTT test client, you should see a new entry that shows the message topic and, if expanded, the message payload from the request you sent from Postman.

If you don’t see your messages in the MQTT test client, here are some things to check:

- Make sure your Postman request returned successfully. If AWS IoT rejects the connection and returns an error, the message in the request doesn't get passed to the message broker.
- Make sure the AWS account and AWS Region used to open the AWS IoT console are the same as you’re using in the Postman URL.
- Make sure you’ve entered the topic correctly in the MQTT test client. The topic filter is case-sensitive. If in doubt, you can also subscribe to the # topic, which subscribes to all MQTT messages that pass through the message broker the AWS account and AWS Region used to open the AWS IoT console.

Step 7: Review the results and next steps

In this tutorial:

- You created a Lambda function to be a custom authorizer handler
- You created a custom authorizer with token signing enabled
- You tested your custom authorizer using the test-involve-authorizer command
- You published an MQTT topic by using Postman and validate the request with your custom authorizer
- You used the MQTT test client to view the messages sent from your Postman test

Next steps

After you send some messages from Postman to verify that the custom authorizer is working, try experimenting to see how changing different aspects of this tutorial affect the results. Here are some examples to get you started.

- Change the signature string so that it's no longer valid to see how unauthorized connection attempts are handled. You should get an error response, such as this one, and the message should not appear in the MQTT test client.
Step 8: Clean up

If you'd like repeat this tutorial, you might need to remove some of your custom authorizers. Your AWS account can have only a limited number of custom authorizers configured at one time and you can get a LimitExceededException when you try to add a new one without removing an existing custom authorizer.

To remove a custom authorizer (console)

1. Open the Custom authorizer page of the AWS IoT console, and in the list of custom authorizers, find the custom authorizer to remove.
2. Open the Custom authorizer details page and, from the Actions menu, choose Edit.
3. Uncheck the Activate authorizer, and then choose Update.

   You can't delete a custom authorizer while it's active.
4. From the Custom authorizer details page, open the Actions menu, and choose Delete.

To remove a custom authorizer (AWS CLI)

1. List the custom authorizers that you have installed and find the name of the custom authorizer you want to delete.

   ```bash
   aws iot list-authorizers
   ```

2. Set the custom authorizer to inactive by running this command after replacing Custom_Auth_Name with the authorizerName of the custom authorizer to delete.

   ```bash
   aws iot update-authorizer --status INACTIVE --authorizer-name Custom_Auth_Name
   ```

3. Delete the custom authorizer by running this command after replacing Custom_Auth_Name with the authorizerName of the custom authorizer to delete.

   ```bash
   aws iot delete-authorizer --authorizer-name Custom_Auth_Name
   ```

Tutorial: Monitoring soil moisture with AWS IoT and Raspberry Pi

This tutorial shows you how to use a Raspberry Pi, a moisture sensor, and AWS IoT to monitor the soil moisture level for a house plant or garden. The Raspberry Pi runs code that reads the moisture level and temperature from the sensor and then sends the data to AWS IoT. You create a rule in AWS IoT that sends an email to an address subscribed to an Amazon SNS topic when the moisture level falls below a threshold.

Note

This tutorial might not be up to date. Some references might have been superseded since this topic was originally published.
Contents

- Prerequisites (p. 260)
- Setting up AWS IoT (p. 260)
  - Step 1: Create the AWS IoT policy (p. 261)
  - Step 2: Create the AWS IoT thing, certificate, and private key (p. 262)
  - Step 3: Create an Amazon SNS topic and subscription (p. 262)
  - Step 4: Create an AWS IoT rule to send an email (p. 263)
- Setting up your Raspberry Pi and moisture sensor (p. 264)

Prerequisites

To complete this tutorial, you need:

- An AWS account.
- An IAM user with administrator permissions.
- A development computer running Windows, macOS, Linux, or Unix to access the AWS IoT console.
- A Raspberry Pi 3B or 4B running the latest Raspbian OS. For installation instructions, see Installing operating system images on the Raspberry Pi website.
- A monitor, keyboard, mouse, and Wi-Fi network or Ethernet connection for your Raspberry Pi.
- A Raspberry Pi-compatible moisture sensor. The sensor used in this tutorial is an Adafruit STEMMA I2C Capacitive Moisture Sensor with a JST 4-pin to female socket cable header.

Setting up AWS IoT

To complete this tutorial, you need to create the following resources. To connect a device to AWS IoT, you create an IoT thing, a device certificate, and an AWS IoT policy.

- An AWS IoT thing.
  
  A thing represents a physical device (in this case, your Raspberry Pi) and contains static metadata about the device.
- A device certificate.
  
  All devices must have a device certificate to connect to and authenticate with AWS IoT.
- An AWS IoT policy.
  
  Each device certificate has one or more AWS IoT policies associated with it. These policies determine which AWS IoT resources the device can access.
- An AWS IoT root CA certificate.
  
  Devices and other clients use an AWS IoT root CA certificate to authenticate the AWS IoT server with which they are communicating. For more information, see Server authentication (p. 298).
- An AWS IoT rule.
  
  A rule contains a query and one or more rule actions. The query extracts data from device messages to determine if the message data should be processed. The rule action specifies what to do if the data matches the query.
- An Amazon SNS topic and topic subscription.
  
  The rule listens for moisture data from your Raspberry Pi. If the value is below a threshold, it sends a message to the Amazon SNS topic. Amazon SNS sends that message to all email addresses subscribed to the topic.
Step 1: Create the AWS IoT policy

Create an AWS IoT policy that allows your Raspberry Pi to connect and send messages to AWS IoT.

1. In the AWS IoT console, if a Get started button appears, choose it. Otherwise, in the navigation pane, expand Security, and then choose Policies.
2. If a You don't have any policies yet dialog box appears, choose Create a policy. Otherwise, choose Create.
3. Enter a name for the AWS IoT policy (for example, MoistureSensorPolicy).
4. In the Add statements section, replace the existing policy with the following JSON. Replace region and account with your AWS Region and AWS account number.

```json
{
   "Version": "2012-10-17",
   "Statement": [{
      "Effect": "Allow",
      "Action": "iot:Connect",
   },
   {
      "Effect": "Allow",
      "Action": "iot:Publish",
                    ]
   },
   {
      "Effect": "Allow",
      "Action": "iot:Receive",
                    ]
   },
   {
      "Effect": "Allow",
      "Action": "iot:Subscribe",
                    ]
   }
}
```
Step 2: Create the AWS IoT thing, certificate, and private key

Create a thing in the AWS IoT registry to represent your Raspberry Pi.

1. In the [AWS IoT console](https://aws.amazon.com/iot), in the navigation pane, choose Manage, and then choose Things.
2. If a You don't have any things yet dialog box is displayed, choose Register a thing. Otherwise, choose Create.
3. On the Creating AWS IoT things page, choose Create a single thing.
4. On the Add your device to the device registry page, enter a name for your IoT thing (for example, RaspberryPi), and then choose Next. You can't change the name of a thing after you create it. To change a thing's name, you must create a new thing, give it the new name, and then delete the old thing.
5. On the Add a certificate for your thing page, choose Create certificate.
6. Choose the Download links to download the certificate, private key, and root CA certificate.
   
   **Important**
   This is the only time you can download your certificate and private key.
7. To activate the certificate, choose Activate. The certificate must be active for a device to connect to AWS IoT.
8. Choose Attach a policy.
9. For Add a policy for your thing, choose MoistureSensorPolicy, and then choose Register Thing.

Step 3: Create an Amazon SNS topic and subscription

Create an Amazon SNS topic and subscription.

1. From the [AWS SNS console](https://aws.amazon.com/sns), in the navigation pane, choose Topics, and then choose Create topic.
2. Enter a name for the topic (for example, MoistureSensorTopic).
3. Enter a display name for the topic (for example, Moisture Sensor Topic). This is the name displayed for your topic in the Amazon SNS console.
4. Choose Create topic.
5. In the Amazon SNS topic detail page, choose Create subscription.
6. For Protocol, choose Email.
7. For Endpoint, enter your email address.
8. Choose Create subscription.
9. Open your email client and look for a message with the subject MoistureSensorTopic. Open the email and click the Confirm subscription link.
Important
You won't receive any email alerts from this Amazon SNS topic until you confirm the subscription.

You should receive an email message with the text you typed.

Step 4: Create an AWS IoT rule to send an email

An AWS IoT rule defines a query and one or more actions to take when a message is received from a device. The AWS IoT rules engine listens for messages sent by devices and uses the data in the messages to determine if some action should be taken. For more information, see Rules for AWS IoT (p. 494).

In this tutorial, your Raspberry Pi publishes messages on aws/things/RaspberryPi/shadow/update. This is an internal MQTT topic used by devices and the Thing Shadow service. The Raspberry Pi publishes messages that have the following form:

```json
{
   "reported": {
      "moisture": moisture-reading,
      "temp": temperature-reading
   }
}
```

You create a query that extracts the moisture and temperature data from the incoming message. You also create an Amazon SNS action that takes the data and sends it to Amazon SNS topic subscribers if the moisture reading is below a threshold value.

Create an Amazon SNS rule

1. In the AWS IoT console, choose Message routing and then choose Rules. If a You don't have any rules yet dialog box appears, choose Create a rule. Otherwise, choose Create rule.

2. In the Rule properties page, enter a Rule name such as MoistureSensorRule, and provide a short Rule description such as Sends an alert when soil moisture level readings are too low.

3. Choose Next and configure your SQL statement. Choose SQL version as 2016-03-23, and enter the following AWS IoT SQL query statement:

   ```sql
   SELECT * FROM '$aws/things/RaspberryPi/shadow/update/accepted' WHERE state.reported.moisture < 400
   ```

   This statement triggers the rule action when the moisture reading is less than 400.

   Note
   You might have to use a different value. After you have the code running on your Raspberry Pi, you can see the values that you get from your sensor by touching the sensor, placing it in water, or placing it in a planter.

4. Choose Next and attach rule actions. For Action 1, choose Simple Notification Service. The description for this rule action is Send a message as an SNS push notification.

5. For SNS topic, choose LowMoistureTopic, and leave the Message format as RAW. For IAM role, choose Create a new role. Enter a name for the role, for example, LowMoistureTopicRole, and then choose Create role.

6. Choose Next to review and then choose Create to create the rule.
Setting up your Raspberry Pi and moisture sensor

Insert your microSD card into the Raspberry Pi, connect your monitor, keyboard, mouse, and, if you're not using Wi-Fi, Ethernet cable. Do not connect the power cable yet.

Connect the JST jumper cable to the moisture sensor. The other side of the jumper has four wires:

- Green: I2C SCL
- White: I2C SDA
- Red: power (3.5 V)
- Black: ground

Hold the Raspberry Pi with the Ethernet jack on the right. In this orientation, there are two rows of GPIO pins at the top. Connect the wires from the moisture sensor to the bottom row of pins in the following order. Starting at the left-most pin, connect red (power), white (SDA), and green (SCL). Skip one pin, and then connect the black (ground) wire. For more information, see Python Computer Wiring.

Attach the power cable to the Raspberry Pi and plug the other end into a wall socket to turn it on.

Configure your Raspberry Pi

1. On Welcome to Raspberry Pi, choose Next.
2. Choose your country, language, timezone, and keyboard layout. Choose Next.
3. Enter a password for your Raspberry Pi, and then choose Next.
4. Choose your Wi-Fi network, and then choose Next. If you aren't using a Wi-Fi network, choose Skip.
5. Choose Next to check for software updates. When the updates are complete, choose Restart to restart your Raspberry Pi.

After your Raspberry Pi starts up, enable the I2C interface.

1. In the upper left corner of the Raspbian desktop, click the Raspberry icon, choose Preferences, and then choose Raspberry Pi Configuration.
2. On the Interfaces tab, for I2C, choose Enable.
3. Choose OK.

The libraries for the Adafruit STEMMA moisture sensor are written for CircuitPython. To run them on a Raspberry Pi, you need to install the latest version of Python 3.

1. Run the following commands from a command prompt to update your Raspberry Pi software:
   
   ```
   sudo apt-get update
   sudo apt-get upgrade
   ```

2. Run the following command to update your Python 3 installation:
   ```
   sudo pip3 install --upgrade setuptools
   ```

3. Run the following command to install the Raspberry Pi GPIO libraries:
   ```
   pip3 install RPI.GPIO
   ```

4. Run the following command to install the Adafruit Blinka libraries:
   ```
   pip3 install adafruit-blinka
   ```
For more information, see Installing CircuitPython Libraries on Raspberry Pi.

5. Run the following command to install the Adafruit Seesaw libraries:

```
sudo pip3 install adafruit-circuitpython-seesaw
```

6. Run the following command to install the AWS IoT Device SDK for Python:

```
pip3 install AWSIoTPythonSDK
```

Your Raspberry Pi now has all of the required libraries. Create a file called `moistureSensor.py` and copy the following Python code into the file:

```python
from adafruit_seesaw.seesaw import Seesaw
from AWSIoTPythonSDK.MQTTLib import AWSIoTMQTTShadowClient
from board import SCL, SDA
import logging
import time
import json
import argparse
import busio

# Shadow JSON schema:
#
# 
# {  
#   "state": {  
#       "desired":{  
#         "moisture":<INT VALUE>,  
#         "temp":<INT VALUE>  
#       }  
#   }  
# }
#
#
# Function called when a shadow is updated
def customShadowCallback_Update(payload, responseStatus, token):
    # Display status and data from update request
    if responseStatus == "timeout":
        print("Update request " + token + " time out!")
    if responseStatus == "accepted":
        payloadDict = json.loads(payload)
        print("Update request with token: " + token + " accepted!")
        print("moisture: " + str(payloadDict["state"])["reported"]["moisture"]))
        print("temperature: " + str(payloadDict["state"])["reported"]["temp"]))
        print("~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

    if responseStatus == "rejected":
        print("Update request " + token + " rejected!")

# Function called when a shadow is deleted
def customShadowCallback_Delete(payload, responseStatus, token):
    # Display status and data from delete request
    if responseStatus == "timeout":
        print("Delete request " + token + " time out!")
    if responseStatus == "accepted":
        print("Delete request with token: " + token + " accepted!")
        print("~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

265
if responseStatus == "rejected":
    print("Delete request " + token + " rejected!")

# Read in command-line parameters
def parseArgs():
    parser = argparse.ArgumentParser()
    parser.add_argument("-e", "--endpoint", action="store", required=True, dest="host", help="Your device data endpoint")
    parser.add_argument("-r", "--rootCA", action="store", required=True, dest="rootCAPath", help="Root CA file path")
    parser.add_argument("-c", "--cert", action="store", dest="certificatePath", help="Certificate file path")
    parser.add_argument("-k", "--key", action="store", dest="privateKeyPath", help="Private key file path")
    parser.add_argument("-p", "--port", action="store", dest="port", type=int, help="Port number override")
    parser.add_argument("-n", "--thingName", action="store", dest="thingName", default="Bot", help="Targeted thing name")
    parser.add_argument("-id", "--clientId", action="store", dest="clientId", default="basicShadowUpdater", help="Targeted client id")
    args = parser.parse_args()
    return args

# Configure logging
# AWSIoTMQTTShadowClient writes data to the log
def configureLogging():
    logger = logging.getLogger("AWSIoTPythonSDK.core")
    logger.setLevel(logging.DEBUG)
    streamHandler = logging.StreamHandler()
    formatter = logging.Formatter('%(asctime)s - %(name)s - %(levelname)s - %(message)s')
    streamHandler.setFormatter(formatter)
    logger.addHandler(streamHandler)

    # Parse command line arguments
    args = parseArgs()

    if not args.certificatePath or not args.privateKeyPath:
        parser.error("Missing credentials for authentication.")
        exit(2)

    # If no --port argument is passed, default to 8883
    if not args.port:
        args.port = 8883

    # Init AWSIoTMQTTShadowClient
    myAWSIoTMQTTShadowClient = None
    myAWSIoTMQTTShadowClient = AWSIoTMQTTShadowClient(args.clientId)
    myAWSIoTMQTTShadowClient.configureEndpoint(args.host, args.port)
    myAWSIoTMQTTShadowClient.configureCredentials(args.rootCAPath, args.privateKeyPath,
    args.certificatePath)

    # AWSIoTMQTTShadowClient connection configuration
    myAWSIoTMQTTShadowClient.configureAutoReconnectBackoffTime(1, 32, 20)
    myAWSIoTMQTTShadowClient.configureConnectDisconnectTimeout(10) # 10 sec
    myAWSIoTMQTTShadowClient.configureMQTTOperationTimeout(5) # 5 sec

    # Initialize Raspberry Pi's I2C interface
    i2c_bus = busio.I2C(SCL, SDA)
# Initialize SeeSaw, Adafruit's Circuit Python library
ss = Seesaw(i2c_bus, addr=0x36)

# Connect to AWS IoT
myAWSIoTMQTTShadowClient.connect()

# Create a device shadow handler, use this to update and delete shadow document
deviceShadowHandler = myAWSIoTMQTTShadowClient.createShadowHandlerWithName(args.thingName, True)

# Delete current shadow JSON doc
deviceShadowHandler.shadowDelete(customShadowCallback_Delete, 5)

# Read data from moisture sensor and update shadow while True:
    # read moisture level through capacitive touch pad
    moistureLevel = ss.moisture_read()

    # read temperature from the temperature sensor
    temp = ss.get_temp()

    # Display moisture and temp readings
    print("Moisture Level: ".format(moistureLevel))
    print("Temperature: ".format(temp))

    # Create message payload
    payload = {"state":{"reported":{"moisture":str(moistureLevel),"temp":str(temp)}}}

    # Update shadow
    deviceShadowHandler.shadowUpdate(json.dumps(payload), customShadowCallback_Update, 5)
    time.sleep(1)

Save the file to a place you can find it. Run moistureSensor.py from the command line with the following parameters:

endpoint
    Your custom AWS IoT endpoint. For more information, see Device Shadow REST API (p. 682).
rootCA
    The full path to your AWS IoT root CA certificate.
cert
    The full path to your AWS IoT device certificate.
key
    The full path to your AWS IoT device certificate private key.
thingName
    Your thing name (in this case, RaspberryPi).
clientId
    The MQTT client ID. Use RaspberryPi.

The command line should look like this:

python3 moistureSensor.py --endpoint your-endpoint --rootCA ~/certs/AmazonRootCA1.pem --cert ~/certs/raspberrypi-certificate.pem.crt --key ~/certs/raspberrypi-private.pem.key --thingName RaspberryPi --clientId RaspberryPi
Try touching the sensor, putting it in a planter, or putting it in a glass of water to see how the sensor responds to various levels of moisture. If needed, you can change the threshold value in the MoistureSensorRule. When the moisture sensor reading goes below the value specified in your rule's SQL query statement, AWS IoT publishes a message to the Amazon SNS topic. You should receive an email message that contains the moisture and temperature data.

After you have verified receipt of email messages from Amazon SNS, press **CTRL+C** to stop the Python program. It is unlikely that the Python program will send enough messages to incur charges, but it is a best practice to stop the program when you are done.
Managing devices with AWS IoT

AWS IoT provides a registry that helps you manage things. A thing is a representation of a specific device or logical entity. It can be a physical device or sensor (for example, a light bulb or a switch on a wall). It can also be a logical entity like an instance of an application or physical entity that does not connect to AWS IoT but is related to other devices that do (for example, a car that has engine sensors or a control panel).

Information about a thing is stored in the registry as JSON data. Here is an example thing:

```json
{
    "version": 3,
    "thingName": "MyLightBulb",
    "defaultClientId": "MyLightBulb",
    "thingTypeName": "LightBulb",
    "attributes": {
        "model": "123",
        "wattage": "75"
    }
}
```

Things are identified by a name. Things can also have attributes, which are name-value pairs you can use to store information about the thing, such as its serial number or manufacturer.

A typical device use case involves the use of the thing name as the default MQTT client ID. Although we don't enforce a mapping between a thing's registry name and its use of MQTT client IDs, certificates, or shadow state, we recommend you choose a thing name and use it as the MQTT client ID for both the registry and the Device Shadow service. This provides organization and convenience to your IoT fleet without removing the flexibility of the underlying device certificate model or shadows.

You don't need to create a thing in the registry to connect a device to AWS IoT. Adding things to the registry allows you to manage and search for devices more easily.

How to manage things with the registry

You use the AWS IoT console, AWS IoT API, or the AWS CLI to interact with the registry. The following sections show how to use the CLI to work with the registry.

When naming your thing objects:

- You should not use personally identifiable information in your thing name. The thing name can appear in unencrypted communications and reports.

Create a thing

The following command shows how to use the AWS IoT `create-thing` command from the CLI to create a thing. You can't change a thing's name after you create it. To change a thing's name, you must create a new thing, give it the new name, and then delete the old thing.

```
$ aws iot create-thing --thing-name "MyLightBulb" --attribute-payload "{"attributes": {
    "wattage": "75",
    "model": "123"}}"
```
The `CreateThing` command displays the name and Amazon Resource Name (ARN) of your new thing:

```json
{
   "thingArn": "arn:aws:iot:us-east-1:123456789012:thing/MyLightBulb",
   "thingName": "MyLightBulb",
   "thingId": "12345678abcdefgh12345678ijklmnop12345678"
}
```

**Note**
We don't recommend using personally identifiable information in your thing names.

For more information, see `create-thing` from the AWS CLI Command Reference.

### List things

You can use the `ListThings` command to list all things in your account:

```
$ aws iot list-things
```

```json
[
   {
      "attributes": {
         "model": "123",
         "wattage": "75"
      },
      "version": 1,
      "thingName": "MyLightBulb"
   },
   {
      "attributes": {
         "numOfStates": "3"
      },
      "version": 11,
      "thingName": "MyWallSwitch"
   }
]
```

You can use the `ListThings` command to search for all things of a specific thing type:

```
$ aws iot list-things --thing-type-name "LightBulb"
```

```json
[
   {
      "thingTypeName": "LightBulb",
      "attributes": {
         "model": "123",
         "wattage": "75"
      },
      "version": 1,
      "thingName": "MyRGBLight"
   },
   {
      "thingTypeName": "LightBulb",
      "attributes": {
         "model": "123",
```
Describe things

You can use the **ListThings** command to search for all things that have an attribute with a specific value. This command searches up to three attributes.

```bash
$ aws iot list-things --attribute-name "wattage" --attribute-value "75"
```

```
{
  "things": [
    {
      "thingTypeName": "StopLight",
      "attributes": {
        "model": "123",
        "wattage": "75"
      },
      "version": 3,
      "thingName": "MyLightBulb"
    },
    {
      "thingTypeName": "LightBulb",
      "attributes": {
        "model": "123",
        "wattage": "75"
      },
      "version": 1,
      "thingName": "MyRGBLight"
    },
    {
      "thingTypeName": "LightBulb",
      "attributes": {
        "model": "123",
        "wattage": "75"
      },
      "version": 1,
      "thingName": "MySecondLightBulb"
    }
  ]
}
```

For more information, see [list-things](https://docs.aws.amazon.com/cli/latest/reference/iot/list-things.html) from the AWS CLI Command Reference.

### Describe things

You can use the **DescribeThing** command to display more detailed information about a thing:

```bash
$ aws iot describe-thing --thing-name "MyLightBulb"
```

```json
{
  "version": 3,
  "thingName": "MyLightBulb",
  "thingArn": "arn:aws:iot:us-east-1:123456789012:thing/MyLightBulb",
  "thingId": "12345678abcdefgh12345678",
  "defaultClientId": "MyLightBulb",
  "thingTypeName": "StopLight",
  "attributes": {
    "model": "123",
    "wattage": "75"
  }
}
```
Update a thing

You can use the UpdateThing command to update a thing. Note that this command updates only the thing’s attributes. You can’t change a thing’s name. To change a thing’s name, you must create a new thing, give it the new name, and then delete the old thing.

```
$ aws iot update-thing --thing-name "MyLightBulb" --attribute-payload "{"attributes": {"wattage": "150", "model": "456"}}"
```

The UpdateThing command does not produce output. You can use the DescribeThing command to see the result:

```
$ aws iot describe-thing --thing-name "MyLightBulb"
{
   "attributes": {
      "model": "456",
      "wattage": "150"
   },
   "version": 2,
   "thingName": "MyLightBulb"
}
```

For more information, see update-thing from the AWS CLI Command Reference.

Delete a thing

You can use the DeleteThing command to delete a thing:

```
$ aws iot delete-thing --thing-name "MyThing"
```

This command returns successfully with no error if the deletion is successful or you specify a thing that doesn’t exist.

For more information, see delete-thing from the AWS CLI Command Reference.

Attach a principal to a thing

A physical device must have an X.509 certificate to communicate with AWS IoT. You can associate the certificate on your device with the thing in the registry that represents your device. To attach a certificate to your thing, use the AttachThingPrincipal command:

```
$ aws iot attach-thing-principal --thing-name "MyLightBulb" --principal "arn:aws:iot:us-east-1:123456789012:cert/a0c01f5835079de0a7514643d68ef8414ab739a1e94ee4162977b02b12842847"
```

The AttachThingPrincipal command does not produce any output.

For more information, see attach-thing-principal from the AWS CLI Command Reference.
**Detach a principal from a thing**

You can use the **DetachThingPrincipal** command to detach a certificate from a thing:

```
$ aws iot detach-thing-principal --thing-name "MyLightBulb" --principal "arn:aws:iot:us-east-1:123456789012:cert/a0c01f5835079de0a7514643d68ef8414ab739a1e94ee4162977b02b12842847"
```

The **DetachThingPrincipal** command doesn't produce any output.

For more information, see [detach-thing-principal](https://docs.aws.amazon.com/cli/latest/reference/iot/detach-thing-principal.html) from the AWS CLI Command Reference.

---

**Thing types**

Thing types allow you to store description and configuration information that is common to all things associated with the same thing type. This simplifies the management of things in the registry. For example, you can define a LightBulb thing type. All things associated with the LightBulb thing type share a set of attributes: serial number, manufacturer, and wattage. When you create a thing of type LightBulb (or change the type of an existing thing to LightBulb) you can specify values for each of the attributes defined in the LightBulb thing type.

Although thing types are optional, their use makes it easier to discover things.

- Things with a thing type can have up to 50 attributes.
- Things without a thing type can have up to three attributes.
- A thing can be associated with only one thing type.
- There is no limit on the number of thing types you can create in your account.

Thing types are immutable. You can't change a thing type name after it has been created. You can deprecate a thing type at any time to prevent new things from being associated with it. You can also delete thing types that have no things associated with them.

**Create a thing type**

You can use the **CreateThingType** command to create a thing type:

```
$ aws iot create-thing-type
   --thing-type-name "LightBulb" --thing-type-properties
   "thingTypeDescription=light bulb type, searchableAttributes=wattage,model"
```

The **CreateThingType** command returns a response that contains the thing type and its ARN:

```
{
   "thingTypeName": "LightBulb",
   "thingTypeId": "df9c2d8c-894d-46a9-8192-9068d01b2886",
   "thingTypeArn": "arn:aws:iot:us-west-2:123456789012:thingtype/LightBulb"
}
```

**List thing types**

You can use the **ListThingTypes** command to list thing types:
Describe a thing type

You can use the `DescribeThingType` command to get information about a thing type:

```
$ aws iot describe-thing-type --thing-type-name "LightBulb"
```

The `DescribeThingType` command returns information about the specified type:

```
{
   "thingTypeProperties": {
      "searchableAttributes": [
         "model",
         "wattage"
      ],
      "thingTypeDescription": "light bulb type"
   },
   "thingId": "df9c2d8c-894d-46a9-8192-9068d01b2886",
   "thingName": "LightBulb",
   "thingMetadata": {
      "deprecated": false,
      "creationDate": 1544466338.399
   }
}
```

Associate a thing type with a thing

You can use the `CreateThing` command to specify a thing type when you create a thing:

```
$ aws iot create-thing --thing-name "MyLightBulb" --thing-type-name "LightBulb" --attribute-payload "{"attributes": {"wattage": "75", "model": "123"}}"
```

You can use the `UpdateThing` command at any time to change the thing type associated with a thing:
Deprecate a thing type

Thing types are immutable. They can't be changed after they are defined. You can, however, deprecate a thing type to prevent users from associating any new things with it. All existing things associated with the thing type are unchanged.

To deprecate a thing type, use the `DeprecateThingType` command:

```
$ aws iot deprecate-thing-type --thing-type-name "myThingType"
```

You can use the `DescribeThingType` command to see the result:

```
$ aws iot describe-thing-type --thing-type-name "StopLight":

{
  "thingTypeName": "StopLight",
  "thingTypeProperties": {
    "searchableAttributes": [
      "wattage",
      "numOfLights",
      "model"
    ],
    "thingTypeDescription": "traffic light type",
    "thingTypeMetadata": {
      "deprecated": true,
      "creationDate": 1468425854308,
      "deprecationDate": 1468446026349
    }
  }
}
```

Deprecating a thing type is a reversible operation. You can undo a deprecation by using the `--undo-deprecate` flag with the `DeprecateThingType` CLI command:

```
$ aws iot deprecate-thing-type --thing-type-name "myThingType" --undo-deprecate
```

You can use the `DescribeThingType` CLI command to see the result:

```
$ aws iot describe-thing-type --thing-type-name "StopLight":

{
  "thingTypeName": "StopLight",
  "thingTypeArn": "arn:aws:iot:us-east-1:123456789012:thingtype/StopLight",
  "thingTypeId": "12345678abcdefgh12345678ijklmnop12345678",
  "thingTypeProperties": {
    "searchableAttributes": [
      "wattage",
      "numOfLights",
      "model"
    ]
  }
}
```
Delete a thing type

You can delete thing types only after they have been deprecated. To delete a thing type, use the `DeleteThingType` command:

```
$ aws iot delete-thing-type --thing-type-name "StopLight"
```

**Note**
You must wait five minutes after you deprecate a thing type before you can delete it.

Static thing groups

Static thing groups allow you to manage several things at once by categorizing them into groups. Static thing groups contain a group of things that are managed by using the console, CLI, or the API. **Dynamic thing groups (p. 285)**, on the other hand, contain things that match a specified query. Static thing groups can also contain other static thing groups — you can build a hierarchy of groups. You can attach a policy to a parent group and it is inherited by its child groups, and by all of the things in the group and in its child groups. This makes control of permissions easy for large numbers of things.

**Note**
Thing group policies don't allow access to AWS IoT Greengrass data plane operations. To allow a thing access to an AWS IoT Greengrass data plane operation, add the permission to an AWS IoT policy that you attach to the thing's certificate. For more information, see [Device authentication and authorization](https://docs.aws.amazon.com/iot/greengrass/latest/developer-guide/device-auth-authorization.html) in the *AWS IoT Greengrass developer guide*.

Here are the things you can do with static thing groups:

- Create, describe or delete a group.
- Add a thing to a group, or to more than one group.
- Remove a thing from a group.
- List the groups you have created.
- List all child groups of a group (its direct and indirect descendants.)
- List the things in a group, including all the things in its child groups.
- List all ancestor groups of a group (its direct and indirect parents.)
- Add, delete or update the attributes of a group. (Attributes are name-value pairs you can use to store information about a group.)
- Attach or detach a policy to or from a group.
- List the policies attached to a group.
- List the policies inherited by a thing (by virtue of the policies attached to its group, or one of its parent groups.)
- Create jobs that are sent to and executed on every thing in a group and its child groups. See [Jobs (p. 704)](https://docs.aws.amazon.com/iot/latest/developerguide/jobs.html).
Create a static thing group

Note
When a thing is attached to a static thing group to which an AWS IoT Core policy is attached to, the thing name must match the client ID.

Here are some limitations of static thing groups:

- A group can have at most one direct parent.
- If a group is a child of another group, you must specify this at the time it is created.
- You can't change a group's parent later, so be sure to plan your group hierarchy and create a parent group before you create any child groups it contains.
- The number of groups to which a thing can belong is limited.
- You can't add a thing to more than one group in the same hierarchy. (In other words, you can't add a thing to two groups that share a common parent.)
- You can't rename a group.
- Thing group names can't contain international characters, such as ü, é and ñ.
- You should not use personally identifiable information in your thing group name. The thing group name can appear in unencrypted communications and reports.

Attaching and detaching policies to groups can enhance the security of your AWS IoT operations in a number of significant ways. The per-device method of attaching a policy to a certificate, which is then attached to a thing, is time consuming and makes it difficult to quickly update or change policies across a fleet of devices. Having a policy attached to the thing's group saves steps when it is time to rotate the certificates on a thing. And policies are dynamically applied to things when they change group membership, so you aren't required to re-create a complex set of permissions each time a device changes membership in a group.

Create a static thing group

Use the CreateThingGroup command to create a static thing group:

```
$ aws iot create-thing-group --thing-group-name LightBulbs
```

The CreateThingGroup command returns a response that contains the static thing group's name, ID, and ARN:

```
{
  "thingGroupName": "LightBulbs",
  "thingGroupId": "abcdefgh12345678ijklmnop12345678qrstuvwx",
  "thingGroupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/LightBulbs"
}
```

Note
We don't recommend using personally identifiable information in your thing group names.

Here is an example that specifies a parent of the static thing group when it is created:

```
$ aws iot create-thing-group --thing-group-name RedLights --parent-group-name LightBulbs
```

As before, the CreateThingGroup command returns a response that contains the static thing group's name, ID, and ARN:

```
{
  "thingGroupName": "RedLights",
}
```
**Describe a thing group**

You can use the `DescribeThingGroup` command to get information about a thing group:

```bash
$ aws iot describe-thing-group --thing-group-name RedLights
```

The `DescribeThingGroup` command returns information about the specified group:

```json
{
  "thingGroupName": "RedLights",
  "thingGroupId": "12345678abcdefgh12345678ijklmnop12345678",
  "version": 1,
  "thingGroupMetadata": {
    "creationDate": 1478299948.882,
    "parentGroupName": "Lights",
    "rootToParentThingGroups": [
      {
        "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/ShinyObjects",
        "groupName": "ShinyObjects"
      },
      {
        "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/LightBulbs",
        "groupName": "LightBulbs"
      }
    ]
  },
  "thingGroupProperties": {
    "attributePayload": {
      "attributes": {
        "brightness": "3400_lumens"
      }
    },
    "thingGroupDescription": "string"
  }
}
```

**Add a thing to a static thing group**

You can use the `AddThingToThingGroup` command to add a thing to a static thing group:

```bash
$ aws iot add-thing-to-thing-group --thing-name MyLightBulb --thing-group-name RedLights
```
Remove a thing from a static thing group

You can use the `RemoveThingFromThingGroup` command to remove a thing from a group:

```bash
$ aws iot remove-thing-from-thing-group --thing-name MyLightBulb --thing-group-name RedLights
```

The `RemoveThingFromThingGroup` command does not produce any output.

List things in a thing group

You can use the `ListThingsInThingGroup` command to list the things that belong to a group:

```bash
$ aws iot list-things-in-thing-group --thing-group-name LightBulbs
```

The `ListThingsInThingGroup` command returns a list of the things in the given group:

```json
{
    "things": [
        "TestThingA"
    ]
}
```

With the `--recursive` parameter, you can list things belonging to a group and those in any of its child groups:

```bash
$ aws iot list-things-in-thing-group --thing-group-name LightBulbs --recursive
```

```json
{
    "things": [
        "TestThingA",
        "MyLightBulb"
    ]
}
```

**Note**

This operation is eventually consistent. In other words, changes to the thing group might not be reflected immediately.

List thing groups

You can use the `ListThingGroups` command to list your account's thing groups:

```bash
$ aws iot list-thing-groups
```
The **ListThingGroups** command returns a list of the thing groups in your AWS account:

```json
{
   "thingGroups": [
   {
      "groupName": "LightBulbs",
      "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/LightBulbs"
   },
   {
      "groupName": "RedLights",
      "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/RedLights"
   },
   {
      "groupName": "RedLEDLights",
      "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/RedLEDLights"
   },
   {
      "groupName": "RedIncandescentLights",
      "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/RedIncandescentLights"
   },
   {
      "groupName": "ReplaceableObjects",
      "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/ReplaceableObjects"
   }
   ]
}
```

Use the optional filters to list those groups that have a given group as parent (**--parent-group**) or groups whose name begins with a given prefix (**--name-prefix-filter**). The **--recursive** parameter allows you to list all children groups, not just direct child groups of a thing group:

```bash
$ aws iot list-thing-groups --parent-group LightBulbs
```

In this case, the **ListThingGroups** command returns a list of the direct child groups of the thing group defined in your AWS account:

```json
{
   "childGroups":[
   {
      "groupName": "RedLights",
      "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/RedLights"
   }
   ]
}
```

Use the **--recursive** parameter with the **ListThingGroups** command to list all child groups of a thing group, not just direct children:

```bash
$ aws iot list-thing-groups --parent-group LightBulbs --recursive
```

The **ListThingGroups** command returns a list of all child groups of the thing group:

```json
{
   "childGroups":[
   {
      "groupName": "RedLights",
      "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/RedLights"
   },
   {
List groups for a thing

You can use the `ListThingGroupsForThing` command to list the direct groups that a thing belongs to:

```bash
$ aws iot list-thing-groups-for-thing --thing-name MyLightBulb
```

The `ListThingGroupsForThing` command returns a list of the direct thing groups that this thing belongs to:

```json
{
   "thingGroups": [
      {
         "groupName": "LightBulbs",
         "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/LightBulbs"
      },
      {
         "groupName": "RedLights",
         "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/RedLights"
      },
      {
         "groupName": "ReplaceableObjects",
         "groupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/ReplaceableObjects"
      }
   ]
}
```

Update a static thing group

You can use the `UpdateThingGroup` command to update the attributes of a static thing group:

```bash
$ aws iot update-thing-group --thing-group-name "LightBulbs" --thing-group-properties "thingGroupDescription":"this is a test group", attributePayload="{"attributes \"":{"Owner\\"":"150","modelNames\\"":"456\"}}"
```

The `UpdateThingGroup` command returns a response that contains the group's version number after the update:

```json
{
   "version": 4
}
```

Note
The number of attributes that a thing can have is limited.
Delete a thing group

To delete a thing group, use the `DeleteThingGroup` command:

```bash
$ aws iot delete-thing-group --thing-group-name "RedLights"
```

The `DeleteThingGroup` command does not produce any output.

**Important**

If you try to delete a thing group that has child thing groups, you receive an error:

```
A client error (InvalidRequestException) occurred when calling the DeleteThingGroup operation: Cannot delete thing group : RedLights when there are still child groups attached to it.
```

You must delete any child groups first before you delete the group.

You can delete a group that has child things, but any permissions granted to the things by membership in the group no longer apply. Before deleting a group that has a policy attached, check carefully that removing those permissions would not stop the things in the group from being able to function properly. Also, note that commands that show which groups a thing belongs to (for example, `ListGroupsForThing`) might continue to show the group while records in the cloud are being updated.

**Attach a policy to a static thing group**

You can use the `AttachPolicy` command to attach a policy to a static thing group and so, by extension, to all things in that group and things in any of its child groups:

```bash
$ aws iot attach-policy \
--target "arn:aws:iot:us-west-2:123456789012:thinggroup/LightBulbs" \
--policy-name "myLightBulbPolicy"
```

The `AttachPolicy` command does not produce any output.

**Important**

You can attach a maximum number of two policies to a group.

**Note**

We don't recommend using personally identifiable information in your policy names.

The `--target` parameter can be a thing group ARN (as above), a certificate ARN, or an Amazon Cognito Identity. For more information about policies, certificates and authentication, see [Authentication](p. 297).

For more information, see [AWS IoT Core policies](#).

**Detach a policy from a static thing group**

You can use the `DetachPolicy` command to detach a policy from a group and so, by extension, to all things in that group and things in any of its child groups:

```bash
```

The `DetachPolicy` command does not produce any output.
List the policies attached to a static thing group

You can use the `ListAttachedPolicies` command to list the policies attached to a static thing group:

```bash
```

The `--target` parameter can be a thing group ARN (as above), a certificate ARN, or an Amazon Cognito identity.

Add the optional `--recursive` parameter to include all policies attached to the group's parent groups.

The `ListAttachedPolicies` command returns a list of policies:

```json
{
   "policies": [
      "MyLightBulbPolicy"
   ]
}
```

List the groups for a policy

You can use the `ListTargetsForPolicy` command to list the targets, including any groups, that a policy is attached to:

```bash
$ aws iot list-targets-for-policy --policy-name "MyLightBulbPolicy"
```

Add the optional `--page-size` `number` parameter to specify the maximum number of results to be returned for each query, and the `--marker` `string` parameter on subsequent calls to retrieve the next set of results, if any.

The `ListTargetsForPolicy` command returns a list of targets and the token to use to retrieve more results:

```json
{
   "nextMarker": "string",
   "targets": [ "string" ... ]
}
```

Get effective policies for a thing

You can use the `GetEffectivePolicies` command to list the policies in effect for a thing, including the policies attached to any groups the thing belongs to (whether the group is a direct parent or indirect ancestor):

```bash
$ aws iot get-effective-policies \
   --thing-name "MyLightBulb" \
   --principal "arn:aws:iot:us-east-1:123456789012:cert/a0c01f5835079de0a7514643d68ef8414ab739a1ee94ee4162977b02b12842847"
```

Use the `--principal` parameter to specify the ARN of the certificate attached to the thing. If you are using Amazon Cognito identity authentication, use the `--cognito-identity-pool-id` parameter and, optionally, add the `--principal` parameter to specify an Amazon Cognito identity. If you specify only the `--cognito-identity-pool-id`, the policies associated with that identity pool's role for
unauthenticated users are returned. If you use both, the policies associated with that identity pool's role for authenticated users are returned.

The `--thing-name` parameter is optional and can be used instead of the `--principal` parameter. When used, the policies attached to any group the thing belongs to, and the policies attached to any parent groups of these groups (up to the root group in the hierarchy) are returned.

The `GetEffectivePolicies` command returns a list of policies:

```json
{
  "effectivePolicies": [
    {
      "policyArn": "string",
      "policyDocument": "string",
      "policyName": "string"
    }
  ]
}
```

**Test authorization for MQTT actions**

You can use the `TestAuthorization` command to test whether an MQTT action (Publish, Subscribe) is allowed for a thing:

```bash
aws iot test-authorization \  
  --principal "arn:aws:iot:us-east-1:123456789012:cert/a0c01f5835079de0a7514643d68ef8414ab739a1e94ee4162977b02b12842847" \  
  --auth-infos "{""actionType": "PUBLISH", "resources": [ "arn:aws:iot:us-east-1:123456789012:topic/my/topic"]}"
```

Use the `--principal` parameter to specify the ARN of the certificate attached to the thing. If using Amazon Cognito Identity authentication, specify a Cognito Identity as the `--principal` or use the `--cognito-identity-pool-id` parameter, or both. (If you specify only the `--cognito-identity-pool-id` then the policies associated with that identity pool's role for unauthenticated users are considered. If you use both, the policies associated with that identity pool's role for authenticated users are considered.

Specify one or more MQTT actions you want to test by listing sets of resources and action types following the `--auth-infos` parameter. The `actionType` field should contain "PUBLISH", "SUBSCRIBE", "RECEIVE", or "CONNECT". The `resources` field should contain a list of resource ARNs. See AWS IoT Core policies (p. 336) for more information.

You can test the effects of adding policies by specifying them with the `--policy-names-to-add` parameter. Or you can test the effects of removing policies by them with the `--policy-names-to-skip` parameter.

You can use the optional `--client-id` parameter to further refine your results.

The `TestAuthorization` command returns details on actions that were allowed or denied for each set of `--auth-infos` queries you specified:

```json
{
  "authResults": [
    {
      "allowed": {
        "policies": [
```

284
Dynamic thing groups

Dynamic thing groups update group membership through search queries. Using dynamic thing groups, you can change the way you interact with things depending on their connectivity, registry, shadow, or Device Defender violations data. Because dynamic thing groups are tied to your fleet index, you must enable fleet indexing to use them. You can preview the things in a dynamic thing group before you create the group with a fleet indexing search query. For more information, see Fleet indexing (p. 885) and Query syntax (p. 905).

**Note**
Dynamic thing group operations are metered under registry operations. For more information, see AWS IoT Core additional metering details.

You can specify a dynamic thing group as a target for a job. Only things that meet the criteria that define the dynamic thing group perform the job.

For example, suppose that you want to update the firmware on your devices, but, to minimize the chance that the update is interrupted, you only want to update firmware on devices with battery life greater than 80%. You can create a dynamic thing group that only includes devices with a reported battery life above 80%, and you can use that dynamic thing group as the target for your firmware update job. Only devices that meet your battery life criteria receive the firmware update. As devices reach the 80% battery life criteria, they are added to the dynamic thing group and receive the firmware update.

For more information about specifying thing groups as job targets, see CreateJob.

Dynamic thing groups differ from static thing groups in the following ways:
• Thing membership is not explicitly defined. To create a dynamic thing group, you must define a query string (p. 906) that defines group membership.
• Dynamic thing groups can't be part of a hierarchy.
• Dynamic thing groups can't have policies applied to them.
• You use a different set of commands to create, update, and delete dynamic thing groups. For all other operations, the same commands that you use to interact with static thing groups can be used to interact with dynamic thing groups.
• The number of dynamic groups that a single account can have is limited.

• You should not use personally identifiable information in your thing group name. The thing group name can appear in unencrypted communications and reports.

For more information about static thing groups, see Static thing groups (p. 276).

As an example, suppose we create a dynamic group that contains all rooms in a warehouse whose temperature is greater than 60 degrees Fahrenheit. When a room's temperature is 61 degrees or higher, it is added to the RoomTooWarm dynamic thing group. All rooms in the RoomTooWarm dynamic thing group have cooling fans turned on. When a room's temperature falls to 60 degrees or lower, it is removed from the dynamic thing group and its fan would be turned off.

Create a dynamic thing group

Use the CreateDynamicThingGroup command to create a dynamic thing group. To create a dynamic thing group for the room too warm scenario you would use the create-dynamic-thing-group CLI command:

```
$ aws iot create-dynamic-thing-group --thing-group-name "RoomTooWarm" --query-string "attributes.temperature>60"
```

Note
We don't recommend using personally identifiable information in your dynamic thing group names.

The CreateDynamicThingGroup command returns a response that contains the index name, query string, query version, thing group name, thing group ID, and the Amazon Resource Name (ARN) of your thing group:

```
{
  "indexName": "AWS_Things",
  "queryVersion": "2017-09-30",
  "thingGroupName": "RoomTooWarm",
  "thingGroupArn": "arn:aws:iot:us-west-2:123456789012:thinggroup/RoomTooWarm",
  "queryString": "attributes.temperature>60\n",
  "thingGroupId": "abcdefgh12345678ijklmnop12345678qrstuvwx"
}
```

Dynamic thing group creation is not instantaneous. The dynamic thing group backfill takes time to complete. When a dynamic thing group is created, the status of the group is set to BUILDING. When the backfill is complete, the status changes to ACTIVE. To check the status of your dynamic thing group, use the DescribeThingGroup command.

Describe a dynamic thing group

Use the DescribeThingGroup command to get information about a dynamic thing group:
Update a dynamic thing group

Use the `update-dynamic-thing-group` command to update the attributes of a dynamic thing group, including the group's search query. The following command updates the thing group description and the query string changing the membership criteria to temperature > 65:

```
$ aws iot update-dynamic-thing-group --thing-group-name "RoomTooWarm" --thing-group-properties "thingGroupDescription="This thing group contains rooms warmer than 65F."" --query-string "attributes.temperature>65"
```

The `update-dynamic-thing-group` command returns a response that contains the group's version number after the update:

```json
{
}
```
Dynamic thing group updates are not instantaneous. The dynamic thing group backfill takes time to complete. When a dynamic thing group is updated, the status of the group changes to REBUILDING while the group updates its membership. When the backfill is complete, the status changes to ACTIVE. To check the status of your dynamic thing group, use the DescribeThingGroup command.

**Delete a dynamic thing group**

Use the DeleteDynamicThingGroup command to delete a dynamic thing group:

```bash
$ aws iot delete-dynamic-thing-group --thing-group-name "RoomTooWarm"
```

The DeleteDynamicThingGroup command does not produce any output.

Commands that show which groups a thing belongs to (for example, ListGroupsForThing) might continue to show the group while records in the cloud are being updated.

**Limitations and conflicts**

Dynamic thing groups share these limitations with static thing groups:

- The number of attributes a thing group can have is limited.
- The number of groups to which a thing can belong is limited.
- Thing groups can't be renamed.
- Thing group names can't contain international characters, such as û, é, and ñ.

When using dynamic thing groups, keep the following in mind.

**The fleet indexing service must be enabled**

The fleet indexing service must be enabled and the fleet indexing backfill must be complete before you can create and use dynamic thing groups. Expect a delay after you enable the fleet indexing service. The backfill can take some time to complete. The more things that you have registered, the longer the backfill process takes. After you enable the fleet indexing service for dynamic thing groups, you cannot disable it until you delete all of your dynamic thing groups.

**Note**

If you have permissions to query the fleet index, you can access the data of things across the entire fleet.

**The number of dynamic thing groups is limited**

The number of dynamic groups is limited.

**Successful commands can log errors**

When creating or updating a dynamic thing group, it's possible that some things might be eligible to be in a dynamic thing group yet not be added to it. The command to create or update a dynamic thing group, however, still succeeds in those cases while logging an error and generating an AddThingToDynamicThingGroupsFailed metric (p. 450).

An error log entry in the CloudWatch log is created for each thing when an eligible thing can't be added to a dynamic thing group or a thing is removed from a dynamic thing group to add it to another group.
When a thing can't be added to a dynamic group, an **AddThingToDynamicThingGroupsFailed metric** (p. 450) is also created; however, a single metric can represent multiple log entries.

When a thing becomes eligible to be added to a dynamic thing group, the following is considered:

- **Is the thing already in as many groups as it can be?** (See **limits**)
  - **NO:** The thing is added to the dynamic thing group.
  - **YES:** Is the thing a member of any dynamic thing groups?
    - **NO:** The thing can't be added to the dynamic thing group, an error is logged, and an **AddThingToDynamicThingGroupsFailed metric** (p. 450) is generated.
    - **YES:** Is the dynamic thing group to join older than any dynamic thing group that the thing is already a member of?
      - **NO:** The thing can't be added to the dynamic thing group, an error is logged, and an **AddThingToDynamicThingGroupsFailed metric** (p. 450) is generated.
      - **YES:** Remove the thing from the most recent dynamic thing group it is a member of, log an error, and add the thing to the dynamic thing group. This generates an error and an **AddThingToDynamicThingGroupsFailed metric** (p. 450) for the dynamic thing group from which the thing was removed.

When a thing in a dynamic thing group no longer meets the search query, it is removed from the dynamic thing group. Likewise, when a thing is updated to meet a dynamic thing group's search query, it is then added to the group as previously described. These additions and removals are normal and don't produce error log entries.

**With overrideDynamicGroups enabled, static groups take priority over dynamic groups**

The number of groups to which a thing can belong is **limited**. When you update thing membership by using the **AddThingToThingGroup** or **UpdateThingGroupsForThing** commands, adding the **--overrideDynamicGroups** parameter gives static thing groups priority over dynamic thing groups.

When adding a thing to a static thing group, the following is considered:

- Does the thing already belong to the maximum number of groups?
  - **NO:** The thing is added to the static thing group.
  - **YES:** Is the thing in any dynamic groups?
    - **NO:** The thing can't be added to the thing group. The command raises an exception.
    - **YES:** Was **--overrideDynamicGroups** enabled?
      - **NO:** The thing can't be added to the thing group. The command raises an exception.
      - **YES:** The thing is removed from the most recently created dynamic thing group, an error is logged, and an **AddThingToDynamicThingGroupsFailed metric** (p. 450) is generated for the dynamic thing group from which the thing was removed. Then, the thing is added to the static thing group.

**Older dynamic thing groups take priority over newer ones**

The number of groups to which a thing can belong is **limited**. When a thing becomes eligible to be added to a dynamic thing group because of a create or update operation, and the thing is already in as many groups as it can be, it can be removed from another dynamic thing group to enable this addition. For more information about how this occurs, see **Successful commands can log errors** (p. 288) and **With overrideDynamicGroups enabled, static groups take priority over dynamic groups** (p. 289) for examples.
When a thing is removed from a dynamic thing group, an error is logged, and an event is raised.

You can't apply policies to dynamic thing groups

Attempting to apply a policy to a dynamic thing group generates an exception.

Dynamic thing group membership is eventually consistent

Only the final state of a thing is evaluated for the registry. Intermediary states can be skipped if states are updated rapidly. Avoid associating a rule or job, with a dynamic thing group whose membership depends on an intermediary state.
Tagging your AWS IoT resources

To help you manage and organize your thing groups, thing types, topic rules, jobs, scheduled audits and security profiles you can optionally assign your own metadata to each of these resources in the form of tags. This section describes tags and shows you how to create them.

To help you manage your costs related to things, you can create billing groups (p. 294) that contain things. You can then assign tags that contain your metadata to each of these billing groups. This section also discusses billing groups and the commands available to create and manage them.

Tag basics

You can use tags to categorize your AWS IoT resources in different ways (for example, by purpose, owner, or environment). This is useful when you have many resources of the same type — you can quickly identify a resource based on the tags you've assigned to it. Each tag consists of a key and optional value, both of which you define. For example, you can define a set of tags for your thing types that helps you track devices by type. We recommend that you create a set of tag keys that meets your needs for each kind of resource. Using a consistent set of tag keys makes it easier for you to manage your resources.

You can search for and filter resources based on the tags you add or apply. You can also use billing group tags to categorize and track your costs. You can also use tags to control access to your resources as described in Using tags with IAM policies (p. 292).

For ease of use, the Tag Editor in the AWS Management Console provides a central, unified way to create and manage your tags. For more information, see Working with Tag Editor in Working with the AWS Management Console.

You can also work with tags using the AWS CLI and the AWS IoT API. You can associate tags with thing groups, thing types, topic rules, jobs, security profiles, policies, billing groups, and the packages and versions associated with things when you create them by using the Tags field in the following commands:

- CreateBillingGroup
- CreateDestination
- CreateDeviceProfile
- CreateDynamicThingGroup
- CreateJob
- CreateOTAUpdate
- CreatePolicy
- CreateScheduledAudit
- CreateSecurityProfile
- CreateServiceProfile
- CreateStream
- CreateThingGroup
- CreateThingType
- CreateTopicRule
• **CreateWirelessGateway**
• **CreateWirelessDevice**

You can add, modify, or delete tags for existing resources that support tagging by using the following commands:

• **TagResource**
• **ListTagsForResource**
• **UntagResource**

You can edit tag keys and values, and you can remove tags from a resource at any time. You can set the value of a tag to an empty string, but you can't set the value of a tag to null. If you add a tag that has the same key as an existing tag on that resource, the new value overwrites the old value. If you delete a resource, any tags associated with the resource are also deleted.

**Tag restrictions and limitations**

The following basic restrictions apply to tags:

• Maximum number of tags per resource — 50
• Maximum key length — 127 Unicode characters in UTF-8
• Maximum value length — 255 Unicode characters in UTF-8
• Tag keys and values are case sensitive.
• Do not use the `aws:` prefix in your tag names or values. It's reserved for AWS use. You can't edit or delete tag names or values with this prefix. Tags with this prefix don't count against your tags per resource limit.
• If your tagging schema is used across multiple services and resources, remember that other services might have restrictions on allowed characters. Allowed characters include letters, spaces, and numbers representable in UTF-8, and the following special characters: + - = . _ : / @.

**Using tags with IAM policies**

You can apply tag-based resource-level permissions in the IAM policies you use for AWS IoT API actions. This gives you better control over what resources a user can create, modify, or use. You use the `Condition` element (also called the `Condition` block) with the following condition context keys and values in an IAM policy to control user access (permissions) based on a resource’s tags:

• Use `aws:ResourceTag/tag-key: tag-value` to allow or deny user actions on resources with specific tags.
• Use `aws:RequestTag/tag-key: tag-value` to require that a specific tag be used (or not used) when making an API request to create or modify a resource that allows tags.
• Use `aws:TagKeys: [tag-key, ...]` to require that a specific set of tag keys be used (or not used) when making an API request to create or modify a resource that allows tags.

**Note**

The condition context keys and values in an IAM policy apply only to those AWS IoT actions where an identifier for a resource capable of being tagged is a required parameter. For example, the use of `DescribeEndpoint` is not allowed or denied on the basis of condition context keys and values because no taggable resource (thing groups, thing types, topic rules, jobs, or security profile) is referenced in this request. For more information about AWS IoT resources that are...
taggable and condition keys they support, read Actions, resources, and condition keys for AWS IoT.

For more information about using tags, see Controlling Access Using Tags in the AWS Identity and Access Management User Guide. The IAM JSON Policy Reference section of that guide has detailed syntax, descriptions, and examples of the elements, variables, and evaluation logic of JSON policies in IAM.

The following example policy applies two tag-based restrictions for the ThingGroup actions. An IAM user restricted by this policy:

- Can't create a thing group the tag "env=prod" (in the example, see the line "aws:RequestTag/env" : "prod").
- Can't modify or access a thing group that has an existing tag "env=prod" (in the example, see the line "aws:ResourceTag/env" : "prod").

```json
{
  "Version": "2012-10-17",
  "Statement": [ 
    { 
      "Effect": "Deny",
      "Action": [ "iot:CreateThingGroup", "iot:DeleteThingGroup", "iot:DescribeThingGroup", "iot:UpdateThingGroup" ],
      "Resource": "*",
      "Condition": { 
        "StringEquals": { 
          "aws:RequestTag/env": "prod"
        }
      }
    },
    { 
      "Effect": "Deny",
      "Action": [ "iot:CreateThingGroup", "iot:DeleteThingGroup", "iot:DescribeThingGroup", "iot:UpdateThingGroup" ],
      "Resource": "*",
      "Condition": { 
        "StringEquals": { 
          "aws:ResourceTag/env": "prod"
        }
      }
    },
    { 
      "Effect": "Allow",
      "Action": [ "iot:CreateThingGroup", "iot:DeleteThingGroup", "iot:DescribeThingGroup", "iot:UpdateThingGroup" ],
      "Resource": "*"
    }
  ]
}
```

You can also specify multiple tag values for a given tag key by enclosing them in a list, like this:

```json
"StringEquals" : {
  "aws:ResourceTag/env" : ["dev", "test"]
}
```
Billing groups

AWS IoT doesn’t allow you to directly apply tags to individual things, but it does allow you to place things in billing groups and to apply tags to these. For AWS IoT, allocation of cost and usage data based on tags is limited to billing groups.

AWS IoT Core for LoRaWAN resources, such as wireless devices and gateways, can’t be added to billing groups. However, they can be associated with AWS IoT things, which can be added to billing groups.

The following commands are available:

• `AddThingToBillingGroup` adds a thing to a billing group.
• `CreateBillingGroup` creates a billing group.
• `DeleteBillingGroup` deletes the billing group.
• `DescribeBillingGroup` returns information about a billing group.
• `ListBillingGroups` lists the billing groups you have created.
• `ListThingsInBillingGroup` lists the things you have added to the given billing group.
• `RemoveThingFromBillingGroup` removes the given thing from the billing group.
• `UpdateBillingGroup` updates information about the billing group.
• `CreateThing` allows you to specify a billing group for the thing when you create it.
• `DescribeThing` returns the description of a thing including the billing group the thing belongs to, if any.

The AWS IoT Wireless API provides these actions to associate wireless devices and gateways with AWS IoT things.

• `AssociateWirelessDeviceWithThing`
• `AssociateWirelessGatewayWithThing`

Viewing cost allocation and usage data

You can use billing group tags to categorize and track your costs. When you apply tags to billing groups (and so to the things they include), AWS generates a cost allocation report as a comma-separated value (CSV) file with your usage and costs aggregated by your tags. You can apply tags that represent business categories (such as cost centers, application names, or owners) to organize your costs across multiple services. For more information about using tags for cost allocation, see Use Cost Allocation Tags in the AWS Billing and Cost Management User Guide.

Note
To accurately associate usage and cost data with those things you have placed in billing groups, each device or application must:

• Be registered as a thing in AWS IoT. For more information, see Managing devices with AWS IoT (p. 269).
• Connect to the AWS IoT message broker through MQTT using only the thing's name as the client ID. For more information, see the section called “Device communication protocols” (p. 85).
• Authenticate using a client certificate associated with the thing.

The following pricing dimensions are available for billing groups (based on the activity of things associated with the billing group):

• Connectivity (based on the thing name used as the client ID to connect).
• Messaging (based on messages inbound from, and outbound to, a thing; MQTT only).
• Shadow operations (based on the thing whose message triggered a shadow update).
• Rules triggered (based on the thing whose inbound message triggered the rule; does not apply to those rules triggered by MQTT lifecycle events).
• Thing index updates (based on the thing that was added to the index).
• Remote actions (based on the thing updated).
• Detect (p. 1031) reports (based on the thing whose activity is reported).

Cost and usage data based on tags (and reported for a billing group) doesn't reflect the following activities:

• Device registry operations (including updates to things, thing groups, and thing types). For more information, see Managing devices with AWS IoT (p. 269).)
• Thing group index updates (when adding a thing group).
• Index search queries.
• Device provisioning (p. 852).
• Audit (p. 966) reports.
Security in AWS IoT

Cloud security at AWS is the highest priority. As an AWS customer, you benefit from a data center and network architecture that is built to meet the requirements of the most security-sensitive organizations.

Security is a shared responsibility between AWS and you. The shared responsibility model describes this as security of the cloud and security in the cloud:

- **Security of the cloud** – AWS is responsible for protecting the infrastructure that runs AWS services in the AWS Cloud. AWS also provides you with services that you can use securely. Third-party auditors regularly test and verify the effectiveness of our security as part of the AWS compliance programs. To learn about the compliance programs that apply to AWS IoT, see AWS Services in Scope by Compliance Program.
- **Security in the cloud** – Your responsibility is determined by the AWS service that you use. You are also responsible for other factors including the sensitivity of your data, your company's requirements, and applicable laws and regulations.

This documentation helps you understand how to apply the shared responsibility model when using AWS IoT. The following topics show you how to configure AWS IoT to meet your security and compliance objectives. You also learn how to use other AWS services that help you to monitor and secure your AWS IoT resources.

**Topics**
- AWS IoT security (p. 296)
- Authentication (p. 297)
- Authorization (p. 334)
- Data protection in AWS IoT Core (p. 385)
- Identity and access management for AWS IoT (p. 390)
- Logging and Monitoring (p. 425)
- Compliance validation for AWS IoT Core (p. 426)
- Resilience in AWS IoT Core (p. 426)
- Using AWS IoT Core with interface VPC endpoints (p. 427)
- Infrastructure security in AWS IoT (p. 432)
- Security monitoring of production fleets or devices with AWS IoT Core (p. 433)
- Security best practices in AWS IoT Core (p. 433)
- AWS training and certification (p. 438)

**AWS IoT security**

Each connected device or client must have a credential to interact with AWS IoT. All traffic to and from AWS IoT is sent securely over Transport Layer Security (TLS). AWS cloud security mechanisms protect data as it moves between AWS IoT and other AWS services.
You are responsible for managing device credentials (X.509 certificates, AWS credentials, Amazon Cognito identities, federated identities, or custom authentication tokens) and policies in AWS IoT. For more information, see Key management in AWS IoT (p. 389). You are responsible for assigning unique identities to each device and managing the permissions for each device or group of devices.

Your devices connect to AWS IoT using X.509 certificates or Amazon Cognito identities over a secure TLS connection. During research and development, and for some applications that make API calls or use WebSockets, you can also authenticate using IAM users and groups or custom authentication tokens. For more information, see IAM users, groups, and roles (p. 321).

When using AWS IoT authentication, the message broker is responsible for authenticating your devices, securely ingesting device data, and granting or denying access permissions you specify for your devices using AWS IoT policies.

When using custom authentication, a custom authorizer is responsible for authenticating your devices and granting or denying access permissions you specify for your devices using AWS IoT or IAM policies.

The AWS IoT rules engine forwards device data to other devices or other AWS services according to rules you define. It uses AWS Identity and Access Management to securely transfer data to its final destination. For more information, see Identity and access management for AWS IoT (p. 390).

### Authentication

Authentication is a mechanism where you verify the identity of a client or a server. Server authentication is the process where devices or other clients ensure they are communicating with an actual AWS IoT endpoint. Client authentication is the process where devices or other clients authenticate themselves with AWS IoT.

### AWS training and certification

Take the following course to learn about authentication in AWS IoT: Deep Dive into AWS IoT Authentication and Authorization.

### X.509 Certificate overview

X.509 certificates are digital certificates that use the X.509 public key infrastructure standard to associate a public key with an identity contained in a certificate. X.509 certificates are issued by a trusted entity called a certification authority (CA). The CA maintains one or more special certificates called CA certificates that it uses to issue X.509 certificates. Only the certification authority has access to
CA certificates. X.509 certificate chains are used both for server authentication by clients and client authentication by the server.

**Server authentication**

When your device or other client attempts to connect to AWS IoT Core, the AWS IoT Core server will send an X.509 certificate that your device uses to authenticate the server. Authentication takes place at the TLS layer through validation of the X.509 certificate chain (p. 300). This is the same method used by your browser when you visit an HTTPS URL. If you want to use certificates from your own certificate authority, see **Manage your CA certificates** (p. 305).

When your devices or other clients establish a TLS connection to an AWS IoT Core endpoint, AWS IoT Core presents a certificate chain that the devices use to verify that they're communicating with AWS IoT Core and not another server impersonating AWS IoT Core. The chain that is presented depends on a combination of the type of endpoint the device is connecting to and the **cipher suite** (p. 386) that the client and AWS IoT Core negotiated during the TLS handshake.

**Endpoint types**

AWS IoT Core supports two different data endpoint types, `iot:Data` and `iot:Data-ATS`. `iot:Data` endpoints present a certificate signed by the **VeriSign Class 3 Public Primary G5 root CA certificate**. `iot:Data-ATS` endpoints present a server certificate signed by an **Amazon Trust Services** CA.

Certificates presented by ATS endpoints are cross signed by Starfield. Some TLS client implementations require validation of the root of trust and require that the Starfield CA certificates are installed in the client's trust stores.

**Warning**

Using a method of certificate pinning that hashes the whole certificate (including the issuer name, and so on) is not recommended because this will cause certificate verification to fail because the ATS certificates we provide are cross signed by Starfield and have a different issuer name.

Use `iot:Data-ATS` endpoints unless your device requires Symantec or Verisign CA certificates. Symantec and Verisign certificates have been deprecated and are no longer supported by most web browsers.

You can use the `describe-endpoint` command to create your ATS endpoint.

```
aws iot describe-endpoint --endpoint-type iot:Data-ATS
```

The `describe-endpoint` command returns an endpoint in the following format.

```
account-specific-prefix.iot.your-region.amazonaws.com
```

The first time `describe-endpoint` is called, an endpoint is created. All subsequent calls to `describe-endpoint` return the same endpoint.

For backward-compatibility, AWS IoT Core still supports Symantec endpoints. For more information, see **How AWS IoT Core is Helping Customers Navigate the Upcoming Distrust of Symantec Certificate Authorities**. Devices operating on ATS endpoints are fully interoperable with devices operating on Symantec endpoints in the same account and do not require any re-registration.

**Note**

To see your `iot:Data-ATS` endpoint in the AWS IoT Core console, choose **Settings**. The console displays only the `iot:Data-ATS` endpoint. By default, the `describe-endpoint` command displays the `iot:Data` endpoint for backward compatibility. To see the `iot:Data-ATS` endpoint, specify the `-endpointType` parameter, as in the previous example.
Creating an IotDataPlaneClient with the AWS SDK for Java

By default, the AWS SDK for Java - Version 2 creates an IotDataPlaneClient by using an iot:Data endpoint. To create a client that uses an iot:Data-ATS endpoint, you must do the following.

- Create an iot:Data-ATS endpoint by using the DescribeEndpoint API.
- Specify that endpoint when you create the IotDataPlaneClient.

The following example performs both of these operations.

```java
public void setup() throws Exception {
    IotClient client =
        IotClient.builder().credentialsProvider(CREDENTIALS_PROVIDER_CHAIN).region(Region.US_EAST_1).build();
    String endpoint = client.describeEndpoint(r -> r.endpointType("iot:Data-ATS")).endpointAddress();
    String endpointOverride = URI.create("https://" + endpoint);
    IotDataPlaneClient iot =
        IotDataPlaneClient.builder()
            .credentialsProvider(CREDENTIALS_PROVIDER_CHAIN)
            .endpointOverride(URI.create("https://" + endpoint))
            .region(Region.US_EAST_1)
            .build();
}
```

CA certificates for server authentication

Depending on which type of data endpoint you are using and which cipher suite you have negotiated, AWS IoT Core server authentication certificates are signed by one of the following root CA certificates:

VeriSign Endpoints (legacy)

- RSA 2048 bit key: VeriSign Class 3 Public Primary G5 root CA certificate

Amazon Trust Services Endpoints (preferred)

  - RSA 2048 bit key: Amazon Root CA 1.
  - RSA 4096 bit key: Amazon Root CA 2. Reserved for future use.
  - ECC 256 bit key: Amazon Root CA 3.
  - ECC 384 bit key: Amazon Root CA 4. Reserved for future use.

These certificates are all cross-signed by the Starfield Root CA Certificate. All new AWS IoT Core regions, beginning with the May 9, 2018 launch of AWS IoT Core in the Asia Pacific (Mumbai) Region, serve only ATS certificates.

Server authentication guidelines

There are many variables that can affect a device's ability to validate the AWS IoT Core server authentication certificate. For example, devices may be too memory constrained to hold all possible root CA certificates, or devices may implement a non-standard method of certificate validation. For these reasons we suggest following these guidelines:

- We recommend that you use your ATS endpoint and install all supported Amazon Root CA certificates.
- If you cannot store all of these certificates on your device and if your devices do not use ECC-based validation, you can omit the Amazon Root CA 3 and Amazon Root CA 4 ECC certificates. If your devices
do not implement RSA-based certificate validation, you can omit the Amazon Root CA 1 and Amazon Root CA 2 RSA certificates. You might need to right click these links and select Save link as... to save these certificates as files.

- If you are experiencing server certificate validation issues when connecting to your ATS endpoint, try adding the relevant cross-signed Amazon Root CA certificate to your trust store. You might need to right click these links and select Save link as... to save these certificates as files.
  - Cross-signed Amazon Root CA 1
  - Cross-signed Amazon Root CA 2 - Reserved for future use.
  - Cross-signed Amazon Root CA 3
  - Cross-signed Amazon Root CA 4 - Reserved for future use.

- If you are experiencing server certificate validation issues, your device may need to explicitly trust the root CA. Try adding the Starfield Root CA Certificate to your trust store.

- If you still experience issues after executing the steps above, please contact AWS Developer Support.

**Note**

CA certificates have an expiration date after which they cannot be used to validate a server’s certificate. CA certificates might have to be replaced before their expiration date. Make sure that you can update the root CA certificates on all of your devices or clients to help ensure ongoing connectivity and to keep up to date with security best practices.

**Note**

When connecting to AWS IoT Core in your device code, pass the certificate into the API you are using to connect. The API you use will vary by SDK. For more information, see the AWS IoT Core Device SDKs (p.1428).

### Client authentication

AWS IoT supports three types of identity principals for device or client authentication:

- X.509 client certificates (p. 300)
- IAM users, groups, and roles (p. 321)
- Amazon Cognito identities (p. 322)

These identities can be used with devices, mobile, web, or desktop applications. They can even be used by a user typing AWS IoT command line interface (CLI) commands. Typically, AWS IoT devices use X.509 certificates, while mobile applications use Amazon Cognito identities. Web and desktop applications use IAM or federated identities. AWS CLI commands use IAM. For more information about IAM identities, see Identity and access management for AWS IoT (p.390).

#### X.509 client certificates

X.509 certificates provide AWS IoT with the ability to authenticate client and device connections. Client certificates must be registered with AWS IoT before a client can communicate with AWS IoT. A client certificate can be registered in multiple AWS accounts in the same AWS Region to facilitate moving devices between your AWS accounts in the same region. See Using X.509 client certificates in multiple AWS accounts with multi-account registration (p.302) for more information.

We recommend that each device or client be given a unique certificate to enable fine-grained client management actions, including certificate revocation. Devices and clients must also support rotation and replacement of certificates to help ensure smooth operation as certificates expire.

For information about using X.509 certificates to support more than a few devices, see Device provisioning (p.852) to review the different certificate management and provisioning options that AWS IoT supports.
AWS IoT supports these types of X.509 client certificates:

- X.509 certificates generated by AWS IoT
- X.509 certificates signed by a CA registered with AWS IoT.
- X.509 certificates signed by a CA that is not registered with AWS IoT.

This section describes how to manage X.509 certificates in AWS IoT. You can use the AWS IoT console or AWS CLI to perform these certificate operations:

- Create AWS IoT client certificates (p. 303)
- Create your own client certificates (p. 304)
- Register a client certificate (p. 311)
- Activate or deactivate a client certificate (p. 315)
- Revoke a client certificate (p. 317)

For more information about the AWS CLI commands that perform these operations, see AWS IoT CLI Reference.

Using X.509 client certificates

X.509 certificates authenticate client and device connections to AWS IoT. X.509 certificates provide several benefits over other identification and authentication mechanisms. X.509 certificates enable asymmetric keys to be used with devices. For example, you could burn private keys into secure storage on a device so that sensitive cryptographic material never leaves the device. X.509 certificates provide stronger client authentication over other schemes, such as user name and password or bearer tokens, because the private key never leaves the device.

AWS IoT authenticates client certificates using the TLS protocol's client authentication mode. TLS support is available in many programming languages and operating systems and is commonly used for encrypting data. In TLS client authentication, AWS IoT requests an X.509 client certificate and validates the certificate's status and AWS account against a registry of certificates. It then challenges the client for proof of ownership of the private key that corresponds to the public key contained in the certificate. AWS IoT requires clients to send the Server Name Indication (SNI) extension to the Transport Layer Security (TLS) protocol. For more information on configuring the SNI extension, see Transport security in AWS IoT Core (p. 386).

To facilitate a secure and consistent client connection to AWS IoT core, a X.509 client certificate must posses the following:

- Registered in AWS IoT Core. For more information, see Register a client certificate (p. 311).
- Have a status state of ACTIVE. For more information, see Activate or deactivate a client certificate (p. 315).
- Not yet reached the certificate expiration date.

You can create client certificates that use the Amazon Root CA and you can use your own client certificates signed by another certificate authority (CA). For more information about using the AWS IoT console to create certificates that use the Amazon Root CA, see Create AWS IoT client certificates (p. 303). For more information about using your own X.509 certificates, see Create your own client certificates (p. 304).

The date and time when certificates signed by a CA certificate expire are set when the certificate is created. X.509 certificates generated by AWS IoT expire at midnight UTC on December 31, 2049 (2049-12-31T23:59:59Z).
AWS IoT Device Defender can perform audits on your AWS account and devices supporting common IoT security best practices. This includes managing the expiration dates of X.509 certificates signed by your CA or the Amazon Root CA. For more information on managing a certificate's expiration date, see [Device certificate expiring](p. 994) and [CA certificate expiring](p. 992).

On the official AWS IoT blog, a deeper dive into the management of device certificate rotation and security best practices is explored in [How to manage IoT device certificate rotation using AWS IoT](p. 992).

**Using X.509 client certificates in multiple AWS accounts with multi-account registration**

Multi-account registration makes it possible to move devices between your AWS accounts in the same Region or in different Regions. You can register, test, and configure a device in a pre-production account, and then register and use the same device and device certificate in a production account. You can also register the client certificate on the device or the device certificates without a CA that is registered with AWS IoT. For more information, see [Register a client certificate signed by an unregistered CA (CLI)](p. 313).

**Note**

Certificates used for multi-account registration are supported on the `iot:Data-ATS`, `iot:Data` (legacy), `iot:Jobs`, and `iot:CredentialProvider` endpoint types. For more information about AWS IoT device endpoints, see [AWS IoT device data and service endpoints](p. 82).

Devices that use multi-account registration must send the Server Name Indication (SNI) extension to the Transport Layer Security (TLS) protocol and provide the complete endpoint address in the `host_name` field, when they connect to AWS IoT. AWS IoT uses the endpoint address in `host_name` to route the connection to the correct AWS IoT account. Existing devices that don't send a valid endpoint address in `host_name` will continue to work, but they will not be able to use the features that require this information. For more information about the SNI extension and to learn how to identify the endpoint address for the `host_name` field, see [Transport security in AWS IoT Core](p. 386).

**To use multi-account registration**

1. You can register the device certificates with a CA. You can register the signing CA in SNI_ONLY mode and use that CA to register the same client certificate to multiple accounts. For more information, see [Register a CA certificate in SNI_ONLY mode (CLI) - Recommended](p. 306).
2. You can register the device certificates without a CA. See [Register a client certificate signed by an unregistered CA (CLI)](p. 313). Registering a CA is optional. You're not required to register the CA that signed the device certificates with AWS IoT.

**Certificate signing algorithms supported by AWS IoT**

AWS IoT supports the following certificate-signing algorithms:

- `SHA256WITHRSA`
- `SHA384WITHRSA`
- `SHA512WITHRSA`
- `SHA256WITHRSAANDMGF1 (RSASSA-PSS)`
- `SHA384WITHRSAANDMGF1 (RSASSA-PSS)`
- `SHA512WITHRSAANDMGF1 (RSASSA-PSS)`
- `DSA_WITH_SHA256`
- `ECDSA-WITH-SHA256`
- `ECDSA-WITH-SHA384`
• ECDSA-WITH-SHA512

For more information about certificate authentication and security, see Device certificate key quality (p. 970).

Note
The certificate signing request (CSR) must include a public key. The key can be either an RSA key with a length of at least 2,048 bits or an ECC key from NIST P-256, NIST P-384, or NIST P-521 curves. For more information, see CreateCertificateFromCsr in the AWS IoT API Reference Guide.

Create AWS IoT client certificates
AWS IoT provides client certificates that are signed by the Amazon Root certificate authority (CA).

This topic describes how to create a client certificate signed by the Amazon Root certificate authority and download the certificate files. After you create the client certificate files, you must install them on the client.

Note
Each X.509 client certificate provided by AWS IoT holds issuer and subject attributes that you set at the time of certificate creation. The certificate attributes are immutable only after the certificate is created.

You can use the AWS IoT console or the AWS CLI to create an AWS IoT certificate signed by the Amazon Root certificate authority.

Create an AWS IoT certificate (console)

To create an AWS IoT certificate using the AWS IoT console

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the navigation pane, choose Security, then choose Certificates, and then choose Create.
3. Choose One-click certificate creation (recommended) - Create certificate.
4. From the Certificate created page, download the client certificate files for the thing, public key, and private key to a secure location. These certificates generated by AWS IoT are only available for use with AWS IoT services.

If you also need the Amazon Root CA certificate file, this page also has the link to the page where you can download it.

5. A client certificate has now been created and registered with AWS IoT. You must activate the certificate before you use it in a client.

To activate the client certificate now, choose Activate. If you don't want to activate the certificate now, see Activate a client certificate (console) (p. 315) to learn how to activate the certificate later.

6. If you want to attach a policy to the certificate, choose Attach a policy.

If you don't want to attach a policy now, choose Done to finish. You can attach a policy later.

After you complete the procedure, install the certificate files on the client.

Create an AWS IoT certificate (CLI)

The AWS CLI provides the create-keys-and-certificate command to create client certificates signed by the Amazon Root certificate authority. This command, however, does not download the Amazon Root CA certificate file. You can download the Amazon Root CA certificate file from CA certificates for server authentication (p. 299).
This command creates private key, public key, and X.509 certificate files and registers and activates the certificate with AWS IoT.

```
aws iot create-keys-and-certificate \
  --set-as-active \
  --certificate-pem-outfile certificate_filename.pem \
  --public-key-outfile public_filename.key \
  --private-key-outfile private_filename.key
```

If you don't want to activate the certificate when you create and register it, this command creates private key, public key, and X.509 certificate files and registers the certificate, but it does not activate it. Activate a client certificate (CLI) (p. 316) describes how to activate the certificate later.

```
aws iot create-keys-and-certificate \
  --no-set-as-active \
  --certificate-pem-outfile certificate_filename.pem \
  --public-key-outfile public_filename.key \
  --private-key-outfile private_filename.key
```

Install the certificate files on the client.

Create your own client certificates

AWS IoT supports client certificates signed by any root or intermediate certificate authorities (CA). AWS IoT uses CA certificates to verify the ownership of certificates. To use device certificates signed by a CA that’s not Amazon’s CA, the CA’s certificate must be registered with AWS IoT so that we can verify the device certificate's ownership.

AWS IoT supports multiple ways for bringing your own certificates (BYOC):

- First, register the CA that’s used for signing the client certificates and then register individual client certificates. If you want to register the device or client to its client certificate when it first connects to AWS IoT (also known as Just-in-Time Provisioning), you must register the signing CA with AWS IoT and activate auto-registration.
- If you can’t register the signing CA, you can choose to register client certificates without CA. For devices registered without CA, you’ll need to present Server Name Indication (SNI) when you connect them to AWS IoT.

**Note**

To register client certificates using CA, you must register the signing CA with AWS IoT, not any other CAs in the hierarchy.

**Note**

A CA certificate can be registered in DEFAULT mode by only one account in a Region. A CA certificate can be registered in SNI_ONLY mode by multiple accounts in a Region.

For more information about using X.509 certificates to support more than a few devices, see Device provisioning (p. 852) to review the different certificate management and provisioning options that AWS IoT supports.

Topics

- Manage your CA certificates (p. 305)
- Create a client certificate using your CA certificate (p. 310)
Manage your CA certificates

This section describes common tasks for managing your own certificate authority (CA) certificates.

You can register your certificate authority (CA) with AWS IoT if you are using client certificates signed by a CA that AWS IoT doesn't recognize.

If you want clients to automatically register their client certificates with AWS IoT when they first connect, the CA that signed the client certificates must be registered with AWS IoT. Otherwise, you don’t need to register the CA certificate that signed the client certificates.

**Note**
A CA certificate can be registered in DEFAULT mode by only one account in a Region. A CA certificate can be registered in SNI_ONLY mode by multiple accounts in a Region.

Topics:
- Create a CA certificate (p. 305)
- Register your CA certificate (p. 305)
- Deactivate a CA certificate (p. 309)

Create a CA certificate

If you do not have a CA certificate, you can use OpenSSL v1.1.1i tools to create one.

**Note**
You can’t perform this procedure in the AWS IoT console.

To create a CA certificate using OpenSSL v1.1.1i tools

1. Generate a key pair.

```bash
openssl genrsa -out root_CA_key_filename.key 2048
```

2. Use the private key from the key pair to generate a CA certificate.

```bash
openssl req -x509 -new -nodes \ 
-key root_CA_key_filename.key \ 
-sha256 -days 1024 \ 
-out root_CA_cert_filename.pem
```

Register your CA certificate

These procedures describe how to register a certificate from a certificate authority (CA) that’s not Amazon's CA. AWS IoT Core uses CA certificates to verify the ownership of certificates. To use device certificates signed by a CA that's not Amazon's CA, you must register the CA certificate with AWS IoT Core so that it can verify the device certificate’s ownership.

Register a CA certificate (console)

**Note**
To register a CA certificate in the console, start in the console at Register CA certificate. You can register your CA in Multi-account mode and without the need to provide a verification certificate or access to the private key. A CA can be registered in Multi-account mode by multiple AWS accounts in the same AWS Region. You can register your CA in Single-account mode by providing a verification certificate and proof of ownership of CAs private key. A CA can be registered in Multi-account mode by one AWS account in one AWS Region.
Register a CA certificate (CLI)

You can register a CA certificate in DEFAULT mode or SNI_ONLY mode. A CA can be registered in DEFAULT mode by one AWS account in one AWS Region. A CA can be registered in SNI_ONLY mode by multiple AWS accounts in the same AWS Region. For more information about CA certificate mode, see `certificateMode`.

**Note**

We recommend that you register a CA in SNI_ONLY mode. You don't need to provide a verification certificate or access to the private key, and you can register the CA by multiple AWS accounts in the same AWS Region.

Register a CA certificate in SNI_ONLY mode (CLI) - Recommended

**Prerequisites**

Make sure you have the following available on your computer before you continue:

- The root CA's certificate file (referenced in the following example as `root_CA_cert_filename.pem`)
- `OpenSSL v1.1.1i` or later

To register a CA certificate in SNI_ONLY mode using the AWS CLI

1. Register the CA certificate with AWS IoT. Using the `register-ca-certificate` command, enter the CA certificate file name. For more information, see `register-ca-certificate` in the AWS CLI Command Reference.

```bash
aws iot register-ca-certificate \
   --ca-certificate file://root_CA_cert_filename.pem \
   --certificate-mode SNI_ONLY
```

If successful, this command returns the `certificateId`.

2. At this point, the CA certificate has been registered with AWS IoT but is inactive. The CA certificate must be active before you can register any client certificates that it has signed.

   This step activates the CA certificate.

   To activate the CA certificate, use the `update-certificate` command as follows. For more information, see `update-certificate` in the AWS CLI Command Reference.

```bash
aws iot update-ca-certificate \
   --certificate-id certificateId \
   --new-status ACTIVE
```

To see the status of the CA certificate, use the `describe-ca-certificate` command. For more information, see `describe-ca-certificate` in the AWS CLI Command Reference.

Register a CA certificate in DEFAULT mode (CLI)

**Prerequisites**

Make sure you have the following available on your computer before you continue:

- The root CA's certificate file (referenced in the following example as `root_CA_cert_filename.pem`)
- The root CA certificate's private key file (referenced in the following example as `root_CA_key_filename.key`
• OpenSSL v1.1.1i or later

To register a CA certificate in DEFAULT mode using the AWS CLI

1. To get a registration code from AWS IoT, use `get-registration-code`. Save the returned registrationCode to use as the Common Name of the private key verification certificate. For more information, see `get-registration-code` in the AWS CLI Command Reference.

   ```bash
   aws iot get-registration-code
   ```

2. Generate a key pair for the private key verification certificate:

   ```bash
   openssl genrsa -out verification_cert_key_filename.key 2048
   ```

3. Create a certificate signing request (CSR) for the private key verification certificate. Set the Common Name field of the certificate to the registrationCode returned by `get-registration-code`.

   ```bash
   openssl req -new \
   -key verification_cert_key_filename.key \
   -out verification_cert_csr_filename.csr
   
   You are prompted for some information, including the Common Name for the certificate.
   
   You are about to be asked to enter information that will be incorporated into your certificate request.
   What you are about to enter is what is called a Distinguished Name or a DN.
   There are quite a few fields but you can leave some blank
   For some fields there will be a default value,
   If you enter '.', the field will be left blank.
   
   Country Name (2 letter code) [AU]:
   State or Province Name (full name) []: 
   Locality Name (for example, city) []: 
   Organization Name (for example, company) []: 
   Organizational Unit Name (for example, section) []: 
   Common Name (e.g. server FQDN or YOUR name) []:your_registration_code 
   Email Address []: 
   
   Please enter the following 'extra' attributes to be sent with your certificate request
   A challenge password []: 
   An optional company name []:
   ```

4. Use the CSR to create a private key verification certificate:

   ```bash
   openssl x509 -req \
   -in verification_cert_csr_filename.csr \
   -CA root_CA_cert_filename.pem \
   -CAkey root_CA_key_filename.key \
   -CAcreateserial \
   -out verification_cert_filename.pem \
   -days 500 -sha256
   ```

5. Register the CA certificate with AWS IoT. Pass in the CA certificate file name and the private key verification certificate file name to the `register-ca-certificate` command, as follows. For more information, see `register-ca-certificate` in the AWS CLI Command Reference.

   ```bash
   aws iot register-ca-certificate \
   --ca-certificate file://root_CA_cert_filename.pem \
   ```
Client authentication

--verification-cert file://verification_cert_filename.pem

This command returns the certificateId, if successful.

6. At this point, the CA certificate has been registered with AWS IoT but is not active. The CA certificate must be active before you can register any client certificates it has signed.

This step activates the CA certificate.

To activate the CA certificate, use the update-certificate command as follows. For more information, see update-certificate in the AWS CLI Command Reference.

```
aws iot update-ca-certificate \
  --certificate-id certificateId \
  --new-status ACTIVE
```

To see the status of the CA certificate, use the describe-ca-certificate command. For more information, see describe-ca-certificate in the AWS CLI Command Reference.

Create a CA verification certificate to register the CA certificate in the console

**Note**

This procedure is only for use if you are registering a CA certificate from the AWS IoT console. If you did not come to this procedure from the AWS IoT console, start the CA certificate registration process in the console at Register CA certificate.

Make sure you have the following available on the same computer before you continue:

- The root CA's certificate file (referenced in the following example as root_CA_cert_filename.pem)
- The root CA certificate's private key file (referenced in the following example as root_CA_key_filename.key)
- OpenSSL v1.1.1i or later

To use the command line interface to create a CA verification certificate to register your CA certificate in the console

1. Replace verification_cert_key_filename.key with the name of the verification certificate key file that you want to create (for example, verification_cert.key). Then run this command to generate a key pair for the private key verification certificate:

```
openssl genrsa -out verification_cert_key_filename.key 2048
```

2. Replace verification_cert_key_filename.key with the name of the key file that you created in step 1.

Replace verification_cert_csr_filename.csr with the name of the certificate signing request (CSR) file that you want to create. For example, verification_cert.csr.

Run this command to create the CSR file.

```
openssl req -new \
  -key verification_cert_key_filename.key \
  -out verification_cert_csr_filename.csr
```

The command prompts you for additional information that's explained later.

3. In the AWS IoT console, in the Verification certificate container, copy the registration code.
4. The information that the openssl command prompts you for is shown in the following example. Except for the Common Name field, you can enter your own values or keep them blank.

In the Common Name field, paste the registration code that you copied in the previous step.

You are about to be asked to enter information that will be incorporated into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:
State or Province Name (full name) []:
Locality Name (for example, city) []:
Organization Name (for example, company) []:
Organizational Unit Name (for example, section) []:
Common Name (e.g. server FQDN or YOUR name) []: your_registration_code
Email Address []:

Please enter the following 'extra' attributes to be sent with your certificate request
A challenge password []:
An optional company name []:

After you finish, the command creates the CSR file.

5. Replace verification_cert_csr_filename.csr with the verification_cert_csr_filename.csr you used in the previous step.

Replace root_CA_cert_filename.pem with the file name of the CA certificate that you want to register.

Replace root_CA_key_filename.key with the file name of the CA certificate's private key file.

Replace verification_cert_filename.pem with the file name of the verification certificate that you want to create. For example, verification_cert.pem.

openssl x509 -req \\
   -in verification_cert_csr_filename.csr \\
   -CA root_CA_cert_filename.pem \\
   -CAkey root_CA_key_filename.key \\
   -CAcreateserial \\
   -out verification_cert_filename.pem \\
   -days 500 -sha256

6. After the OpenSSL command completes, you should have these files ready to use for when you return to the console.

   • Your CA certificate file (root_CA_cert_filename.pem used in the previous command)
   • The verification certificate that you created in the previous step (verification_cert_filename.pem used in the previous command)

Deactivate a CA certificate

When a certificate authority (CA) certificate is enabled for automatic client certificate registration, AWS IoT checks the CA certificate to make sure the CA is ACTIVE. If the CA certificate is INACTIVE, AWS IoT doesn't allow the client certificate to be registered.
By setting the CA certificate to INACTIVE, you prevent any new client certificates issued by the CA from being registered automatically.

**Note**
Any registered client certificates that were signed by the compromised CA certificate continue to work until you explicitly revoke each one of them.

**Deactivate a CA certificate (console)**

**To deactivate a CA certificate using the AWS IoT console**

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the left navigation pane, choose Secure, choose CAs.
3. In the list of certificate authorities, find the one that you want to deactivate, and choose the ellipsis icon to open the option menu.
4. On the option menu, choose Deactivate.

The certificate authority should show as Inactive in the list.

**Note**
The AWS IoT console does not provide a way to list the certificates that were signed by the CA you deactivated. For an AWS CLI option to list those certificates, see Deactivate a CA certificate (CLI) (p. 310).

**Deactivate a CA certificate (CLI)**

The AWS CLI provides the update-ca-certificate command to deactivate a CA certificate.

```bash
aws iot update-ca-certificate \
  --certificate-id certificateId \
  --new-status INACTIVE
```

Use the list-certificates-by-ca command to get a list of all registered client certificates that were signed by the specified CA. For each client certificate signed by the specified CA certificate, use the update-certificate command to revoke the client certificate to prevent it from being used.

Use the describe-ca-certificate command to see the status of the CA certificate.

**Create a client certificate using your CA certificate**

You can use your own certificate authority (CA) to create client certificates. The client certificate must be registered with AWS IoT before use. For information about the registration options for your client certificates, see Register a client certificate (p. 311).

**Create a client certificate (CLI)**

**Note**
You can't perform this procedure in the AWS IoT console.

**To create a client certificate using the AWS CLI**

1. Generate a key pair.

   ```bash
   openssl genrsa -out device_cert_key_filename.key 2048
   ```

2. Create a CSR for the client certificate.

   ```bash
   openssl req -new \
   ```
You are prompted for some information, as shown here:

You are about to be asked to enter information that will be incorporated into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:
State or Province Name (full name) []:
Locality Name (for example, city) []:
Organization Name (for example, company) []:
Organizational Unit Name (for example, section) []:
Common Name (e.g. server FQDN or YOUR name) []:
Email Address []:

Please enter the following 'extra' attributes to be sent with your certificate request
A challenge password []:
An optional company name []:

3. Create a client certificate from the CSR.

```bash
openssl x509 -req \
  -in device_cert_csr_filename.csr \
  -CA root_CA_cert_filename.pem \
  -CAkey root_CA_key_filename.key \
  -CAcreateserial \
  -out device_cert_filename.pem \
  -days 500 -sha256
```

At this point, the client certificate has been created, but it has not yet been registered with AWS IoT. For information about how and when to register the client certificate, see Register a client certificate (p. 311).

**Register a client certificate**

Client certificates must be registered with AWS IoT to enable communications between the client and AWS IoT. You can register each client certificate manually, or you can configure the client certificates to register automatically when the client connects to AWS IoT for the first time.

If you want your clients and devices to register their client certificates when they first connect, you must Register your CA certificate (p. 305) used to sign the client certificate with AWS IoT in the Regions in which you want to use it. The Amazon Root CA is automatically registered with AWS IoT.

Client certificates can be shared by AWS accounts and Regions. The procedures in these topics must be performed in each account and Region in which you want to use the client certificate. The registration of a client certificate in one account or Region is not automatically recognized by another.

**Note**

Clients that use the Transport Layer Security (TLS) protocol to connect to AWS IoT must support the Server Name Indication (SNI) extension to TLS. For more information, see Transport security in AWS IoT Core (p. 386).

**Topics**

- Register a client certificate manually (p. 312)
Register a client certificate when the client connects to AWS IoT just-in-time registration (JITR) (p. 314)

Register a client certificate manually

You can register a client certificate manually by using the AWS IoT console and AWS CLI.

The registration procedure to use depends on whether the certificate will be shared by AWS accounts and Regions. The registration of a client certificate in one account or Region is not automatically recognized by another.

The procedures in this topic must be performed in each account and Region in which you want to use the client certificate. Client certificates can be shared by AWS accounts and Regions, but only if the client certificate is signed by a certificate authority (CA) that is NOT registered with AWS IoT.

Register a client certificate signed by a registered CA (console)

**Note**
Before you perform this procedure, make sure that you have the client certificate's .pem file and that the client certificate was signed by a CA that you have registered with AWS IoT (p. 305).

To register an existing certificate with AWS IoT using the console

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the navigation pane, under the Manage section, choose Security, and then choose Certificates.
3. On the Certificates page in the Certificates dialog box, choose Add certificate, and then choose Register certificates.
4. On the Register certificate page in the Certificates to upload dialog box, do the following:
   - Choose CA is registered with AWS IoT.
   - From Choose a CA certificate, select your Certification authority.
     - Choose Register a new CA to register a new Certification authority that's not registered with AWS IoT.
     - Leave Choose a CA certificate blank if Amazon Root certificate authority is your certification authority.
   - Select up to 10 certificates to upload and register with AWS IoT.
   - Use the certificate files you created in Create AWS IoT client certificates (p. 303) and Create a client certificate using your CA certificate (p. 310).
   - Choose Activate or Deactivate. If you choose Deactivate, Activate or deactivate a client certificate (p. 315) explains how to activate your certificate after certificate registration.
   - Choose Register.

On the Certificates page in the Certificates dialog box, your registered certificates will now appear.

Register a client certificate signed by an unregistered CA (console)

**Note**
Before you perform this procedure, make sure that you have the client certificate's .pem file.

To register an existing certificate with AWS IoT using the console

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the left navigation pane, choose Secure, choose Certificates, and then choose Create.
3. On Create a certificate, locate the Use my certificate entry, and choose Get started.
4. On Select a CA, choose Next.
5. On Register existing device certificates, choose Select certificates, and select up to 10 certificate files to register.
6. After closing the file dialog box, select whether you want to activate or revoke the client certificates when you register them.

If you don't activate a certificate when it is registered, Activate a client certificate (console) (p. 315) describes how to activate it later.

If a certificate is revoked when it is registered, it can't be activated later.

After you choose the certificate files to register, and select the actions to take after registration, select Register certificates.

The client certificates that are registered successfully appear in the list of certificates.

Register a client certificate signed by a registered CA (CLI)

Note
Before you perform this procedure, make sure that you have the certificate authority (CA) .pem and the client certificate's .pem file. The client certificate must be signed by a certificate authority (CA) that you have registered with AWS IoT (p. 305).

Use the register-certificate command to register, but not activate, a client certificate.

```bash
aws iot register-certificate
   --certificate-pem file://device_cert_filename.pem
   --ca-certificate-pem file://ca_cert_filename.pem
```

The client certificate is registered with AWS IoT, but it is not active yet. See Activate a client certificate (CLI) (p. 316) for information on how to activate it later.

You can also activate the client certificate when you register it by using this command.

```bash
aws iot register-certificate
   --set-as-active
   --certificate-pem file://device_cert_filename.pem
   --ca-certificate-pem file://ca_cert_filename.pem
```

For more information about activating the certificate so that it can be used to connect to AWS IoT, see Activate or deactivate a client certificate (p. 315)

Register a client certificate signed by an unregistered CA (CLI)

Note
Before you perform this procedure, make sure that you have the certificate's .pem file.

Use the register-certificate-without-ca command to register, but not activate, a client certificate.

```bash
aws iot register-certificate-without-ca
   --certificate-pem file://device_cert_filename.pem
```

The client certificate is registered with AWS IoT, but it is not active yet. See Activate a client certificate (CLI) (p. 316) for information on how to activate it later.

You can also activate the client certificate when you register it by using this command.
aws iot register-certificate-without-ca \
--status ACTIVE \
--certificate-pem file://device_cert_filename.pem

For more information about activating the certificate so that it can be used to connect to AWS IoT, see Activate or deactivate a client certificate (p. 315).

Register a client certificate when the client connects to AWS IoT just-in-time registration (JITR)

You can configure a CA certificate to enable client certificates it has signed to register with AWS IoT automatically the first time the client connects to AWS IoT.

To register client certificates when a client connects to AWS IoT for the first time, you must enable the CA certificate for automatic registration and configure the first connection by the client to provide the required certificates.

Configure a CA certificate to support automatic registration (console)

To configure a CA certificate to support automatic client certificate registration using the AWS IoT console

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the left navigation pane, choose Secure, choose CAs.
3. In the list of certificate authorities, find the one for which you want to enable automatic registration, and open the option menu by using the ellipsis icon.
4. On the option menu, choose Enable auto-registration.

Note
The auto-registration status is not shown in the list of certificate authorities. To see the auto-registration status of a certificate authority, you must open the Details page of the certificate authority.

Configure a CA certificate to support automatic registration (CLI)

If you have already registered your CA certificate with AWS IoT, use the update-ca-certificate command to set autoRegistrationStatus of the CA certificate to ENABLE.

aws iot update-ca-certificate \
--certificate-id caCertificateId \
--new-auto-registration-status ENABLE

If you want to enable autoRegistrationStatus when you register the CA certificate, use the register-ca-certificate command.

aws iot register-ca-certificate \
--allow-auto-registration \
--ca-certificate file://root_CA_cert_filename.pem \
--verification-cert file://verification_cert_filename.pem

Use the describe-ca-certificate command to see the status of the CA certificate.

Configure the first connection by a client for automatic registration

When a client attempts to connect to AWS IoT for the first time, the client certificate signed by your CA certificate must be present on the client during the Transport Layer Security (TLS) handshake.
When the client connects to AWS IoT, use the client certificate you created in Create AWS IoT client certificates or Create your own client certificates. AWS IoT recognizes the CA certificate as a registered CA certificate, registers the client certificate, and sets its status to PENDING_ACTIVATION. This means that the client certificate was automatically registered and is awaiting activation. The client certificate's state must be ACTIVE before it can be used to connect to AWS IoT. See Activate or deactivate a client certificate (p. 315) for information on activating a client certificate.

**Note**

You can provision devices using AWS IoT Core just-in-time registration (JITR) feature without having to send the entire trust chain on devices' first connection to AWS IoT Core. Presenting the CA certificate is optional but the device is required to send the Server Name Indication (SNI) extension when they connect.

When AWS IoT automatically registers a certificate or when a client presents a certificate in the PENDING_ACTIVATION status, AWS IoT publishes a message to the following MQTT topic:

$aws/events/certificates/registered/caCertificateId

Where `caCertificateId` is the ID of the CA certificate that issued the client certificate.

The message published to this topic has the following structure:

```json
{
  "certificateId": "certificateId",
  "caCertificateId": "caCertificateId",
  "timestamp": timestamp,
  "certificateStatus": "PENDING_ACTIVATION",
  "awsAccountId": "awsAccountId",
  "certificateRegistrationTimestamp": "certificateRegistrationTimestamp"
}
```

You can create a rule that listens on this topic and performs some actions. We recommend that you create a Lambda rule that verifies the client certificate is not on a certificate revocation list (CRL), activates the certificate, and creates and attaches a policy to the certificate. The policy determines which resources the client can access. For more information about how to create a Lambda rule that listens on the $aws/events/certificates/registered/caCertificateId topic and performs these actions, see just-in-time registration of Client Certificates on AWS IoT.

If any error or exception occurs during the auto-registration of the client certificates, AWS IoT sends events or messages to your logs in CloudWatch Logs. For more information about setting up the logs for your account, see the Amazon CloudWatch documentation.

**Activate or deactivate a client certificate**

AWS IoT verifies that a client certificate is active when it authenticates a connection.

You can create and register client certificates without activating them so they can't be used until you want to use them. You can also deactivate active client certificates to disable them temporarily. Finally, you can revoke client certificates to prevent them from any future use.

**Activate a client certificate (console)**

**To activate a client certificate using the AWS IoT console**

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the left navigation pane, choose Secure, choose Certificates.
3. In the list of certificates, locate the certificate that you want to activate, and open the option menu by using the ellipsis icon.
4. In the option menu, choose **Activate**.

The certificate should show as **Active** in the list of certificates.

**Deactivate a client certificate (console)**

**To deactivate a client certificate using the AWS IoT console**

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the left navigation pane, choose **Secure**, choose **Certificates**.
3. In the list of certificates, locate the certificate that you want to deactivate, and open the option menu by using the ellipsis icon.
4. In the option menu, choose **Deactivate**.

The certificate should show as **Inactive** in the list of certificates.

**Activate a client certificate (CLI)**

The AWS CLI provides the `update-certificate` command to activate a certificate.

```sh
aws iot update-certificate \
  --certificate-id certificateId \
  --new-status ACTIVE
```

If the command was successful, the certificate's status will be **ACTIVE**. Run `describe-certificate` to see the certificate's status.

```sh
aws iot describe-certificate \
  --certificate-id certificateId
```

**Deactivate a client certificate (CLI)**

The AWS CLI provides the `update-certificate` command to deactivate a certificate.

```sh
aws iot update-certificate \
  --certificate-id certificateId \
  --new-status INACTIVE
```

If the command was successful, the certificate's status will be **INACTIVE**. Run `describe-certificate` to see the certificate's status.

```sh
aws iot describe-certificate \
  --certificate-id certificateId
```

**Attach a thing or policy to a client certificate**

When you create and register a certificate separate from an AWS IoT thing, it will not have any policies that authorize any AWS IoT operations, nor will it be associated with any AWS IoT thing object. This section describes how to add these relationships to a registered certificate.

**Important**

To complete these procedures, you must have already created the thing or policy that you want to attach to the certificate.
The certificate authenticates a device with AWS IoT so that it can connect. Attaching the certificate to a thing resource establishes the relationship between the device (by way of the certificate) and the thing resource. To authorize the device to perform AWS IoT actions, such as to allow the device to connect and publish messages, an appropriate policy must be attached to the device's certificate.

**Attach a thing to a client certificate (console)**

You will need the name of the thing object to complete this procedure.

**To attach a thing object to a registered certificate**

1. Sign in to the AWS Management Console and open the [AWS IoT console](https://aws.amazon.com/iot/).
2. In the left navigation pane, choose Secure, choose Certificates.
3. In the list of certificates, locate the certificate to which you want to attach a policy, open the certificate's option menu by choosing the ellipsis icon, and choose Attach thing.
4. In the pop-up, locate the name of the thing you want to attach to the certificate, choose its check box, and choose Attach.

The thing object should now appear in the list of things on the certificate's details page.

**Attach a policy to a client certificate (console)**

You will need the name of the policy object to complete this procedure.

**To attach a policy object to a registered certificate**

1. Sign in to the AWS Management Console and open the [AWS IoT console](https://aws.amazon.com/iot/).
2. In the left navigation pane, choose Secure, choose Certificates.
3. In the list of certificates, locate the certificate to which you want to attach a policy, open the certificate's option menu by choosing the ellipsis icon, and choose Attach policy.
4. In the pop-up, locate the name of the policy you want to attach to the certificate, choose its check box, and choose Attach.

The policy object should now appear in the list of policies on the certificate's details page.

**Attach a thing to a client certificate (CLI)**

The AWS CLI provides the `attach-thing-principal` command to attach a thing object to a certificate.

```
aws iot attach-thing-principal \
   --principal certificateArn \
   --thing-name thingName
```

**Attach a policy to a client certificate (CLI)**

The AWS CLI provides the `attach-policy` command to attach a policy object to a certificate.

```
aws iot attach-policy \
   --target certificateArn \
   --policy-name policyName
```

**Revoke a client certificate**

If you detect suspicious activity on a registered client certificate, you can revoke it so that it can't be used again.
Note
Once a certificate is revoked, its status can't be changed. That is, the certificate status can't be changed to Active or any other status.

Revoke a client certificate (console)

To revoke a client certificate using the AWS IoT console
1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the left navigation pane, choose Secure, choose Certificates.
3. In the list of certificates, locate the certificate that you want to revoke, and open the option menu by using the ellipsis icon.
4. In the option menu, choose Revoke.

If the certificate was successfully revoked, it will show as Revoked in the list of certificates.

Revoke a client certificate (CLI)
The AWS CLI provides the update-certificate command to revoke a certificate.

```
aws iot update-certificate \
   --certificate-id certificateId \
   --new-status REVOKED
```

If the command was successful, the certificate's status will be REVOKED. Run describe-certificate to see the certificate's status.

```
aws iot describe-certificate \
   --certificate-id certificateId
```

Transfer a certificate to another account

X.509 certificates that belong to one AWS account can be transferred to another AWS account.

To transfer an X.509 certificate from one AWS account to another
1. the section called “Begin a certificate transfer” (p. 318)
   The certificate must be deactivated and detached from all policies and things before initiating the transfer.
2. the section called "Accept or reject a certificate transfer" (p. 320)
   The receiving account must explicitly accept or reject the transferred certificate. After the receiving account accepts the certificate, the certificate must be activated before use.
3. the section called “Cancel a certificate transfer” (p. 321)
   The originating account can cancel a transfer, if the certificate has not been accepted.

Begin a certificate transfer

You can begin to transfer a certificate to another AWS account by using the AWS IoT console or the AWS CLI.

Begin a certificate transfer (console)

To complete this procedure, you'll need the ID of the certificate that you want to transfer.
Do this procedure from the account with the certificate to transfer.

**To begin to transfer a certificate to another AWS account**

1. Sign in to the AWS Management Console and open the [AWS IoT console](https://aws.amazon.com/iot-console/).
2. In the left navigation pane, choose Secure, choose Certificates.
   
   Choose the certificate with an Active or Inactive status that you want to transfer and open its details page.
3. On the certificate's Details page, in the Actions menu, if the Deactivate option is available, choose the Deactivate option to deactivate the certificate.
4. On the certificate's Details page, in the left menu, choose Policies.
5. On the certificate's Policies page, if there are any policies attached to the certificate, detach each one by opening the policy's options menu and choosing Detach.
   
   The certificate must not have any attached policies before you continue.
7. On the certificate's Things page, if there are any things attached to the certificate, detach each one by opening the thing's options menu and choosing Detach.
   
   The certificate must not have any attached things before you continue.
8. On the certificate's Things page, in the left menu, choose Details.
9. On the certificate's Details page, in the Actions menu, choose Start transfer to open the Start transfer dialog box.
10. In the Start transfer dialog box, enter the AWS account number of the account to receive the certificate and an optional short message.
11. Choose Start transfer to transfer the certificate.

The console should display a message that indicates the success or failure of the transfer. If the transfer was started, the certificate's status is updated to Transferred.

**Begin a certificate transfer (CLI)**

To complete this procedure, you'll need the certificateId and the certificateArn of the certificate that you want to transfer.

Do this procedure from the account with the certificate to transfer.

**To begin to transfer a certificate to another AWS account**

1. Use the `update-certificate` command to deactivate the certificate.

   ```shell
   aws iot update-certificate --certificate-id certificateId --new-status INACTIVE
   ```
2. Detach all policies.
   
   1. Use the `list-attached-policies` command to list the policies attached to the certificate.

   ```shell
   aws iot list-attached-policies --target certificateArn
   ```
   2. For each attached policy, use the `detach-policy` command to detach the policy.

   ```shell
   aws iot detach-policy --target certificateArn --policy-name policy-name
   ```
3. Detach all things.
   1. Use the `list-principal-things` command to list the things attached to the certificate.
      
      ```
      aws iot list-principal-things --principal certificateArn
      ```
   2. For each attached thing, use the `detach-thing-principal` command to detach the thing.
      
      ```
      aws iot detach-thing-principal --principal certificateArn --thing-name thing-name
      ```
   4. Use the `transfer-certificate` command to start the certificate transfer.
      
      ```
      aws iot transfer-certificate --certificate-id certificateId --target-aws-account account-id
      ```

Accept or reject a certificate transfer

You can accept or reject a certificate transferred to your AWS account from another AWS account by using the AWS IoT console or the AWS CLI.

Accept or reject a certificate transfer (console)

To complete this procedure, you'll need the ID of the certificate that was transferred to your account.

Do this procedure from the account receiving the certificate that was transferred.

**To accept or reject a certificate that was transferred to your AWS account**

1. Sign in to the AWS Management Console and open the AWS IoT console.
   2. In the left navigation pane, choose Secure, choose Certificates.
      
      Choose the certificate with a status of Pending transfer that you want to accept or reject and open its details page.
   3. On the certificate's Details page, in the Actions menu,
      
      - To accept the certificate, choose Accept transfer.
      - To not accept the certificate, choose Reject transfer.

Accept or reject a certificate transfer (CLI)

To complete this procedure, you'll need the `certificateId` of the certificate transfer that you want to accept or reject.

Do this procedure from the account receiving the certificate that was transferred.

**To accept or reject a certificate that was transferred to your AWS account**

1. Use the `accept-certificate-transfer` command to accept the certificate.
   
   ```
   aws iot accept-certificate-transfer --certificate-id certificateId
   ```
   2. Use the `reject-certificate-transfer` command to reject the certificate.
      
      ```
      aws iot reject-certificate-transfer --certificate-id certificateId
      ```
Cancel a certificate transfer

You can cancel a certificate transfer before it has been accepted by using the AWS IoT console or the AWS CLI.

Cancel a certificate transfer (console)

To complete this procedure, you'll need the ID of the certificate transfer that you want to cancel.

Do this procedure from the account that initiated the certificate transfer.

**To cancel a certificate transfer**

1. Sign in to the AWS Management Console and open the AWS IoT console.
2. In the left navigation pane, choose Secure, choose Certificates.
   - Choose the certificate with Transferred status whose transfer you want to cancel and open its options menu.
3. On the certificate's options menu, choose the Revoke transfer option to cancel the certificate transfer.

   **Important**
   Be careful not to mistake the Revoke transfer option with the Revoke option. The Revoke transfer option cancels the certificate transfer, while the Revoke option makes the certificate irreversibly unusable by AWS IoT.

Cancel a certificate transfer (CLI)

To complete this procedure, you'll need the certificateId of the certificate transfer that you want to cancel.

Do this procedure from the account that initiated the certificate transfer.

Use the cancel-certificate-transfer command to cancel the certificate transfer.

```bash
aws iot cancel-certificate-transfer --certificate-id certificateId
```

IAM users, groups, and roles

IAM users, groups, and roles are the standard mechanisms for managing identity and authentication in AWS. You can use them to connect to AWS IoT HTTP interfaces using the AWS SDK and AWS CLI.

IAM roles also allow AWS IoT to access other AWS resources in your account on your behalf. For example, if you want to have a device publish its state to a DynamoDB table, IAM roles allow AWS IoT to interact with Amazon DynamoDB. For more information, see IAM Roles.

For message broker connections over HTTP, AWS IoT authenticates users, groups, and roles using the Signature Version 4 signing process. For information, see Signing AWS API Requests.

When using AWS Signature Version 4 with AWS IoT, clients must support the following in their TLS implementation:

- TLS 1.2
- SHA-256 RSA certificate signature validation
- One of the cipher suites from the TLS cipher suite support section
Custom authentication and authorization

AWS IoT Core lets you define custom authorizers so that you can manage your own client authentication and authorization. This is useful when you need to use authentication mechanisms other than the ones that AWS IoT Core natively supports. (For more information about the natively supported mechanisms, see the section called “Client authentication” (p. 300)).

For example, if you are migrating existing devices in the field to AWS IoT Core and these devices use a custom bearer token or MQTT user name and password to authenticate, you can migrate them to AWS IoT Core without having to provision new identities for them. You can use custom authentication...
with any of the communication protocols that AWS IoT Core supports. For more information about the protocols that AWS IoT Core supports, see the section called “Device communication protocols” (p. 85).

Topics

• Understanding the custom authentication workflow (p. 323)
• Creating and managing custom authorizers (p. 324)
• Connecting to AWS IoT Core by using custom authentication (p. 329)
• Troubleshooting your authorizers (p. 331)

Understanding the custom authentication workflow

Custom authentication enables you to define how to authenticate and authorize clients by using authorizer resources. Each authorizer contains a reference to a customer-managed Lambda function, an optional public key for validating device credentials, and additional configuration information. The following diagram illustrates the authorization workflow for custom authentication in AWS IoT Core.

AWS IoT Core custom authentication and authorization workflow

The following list explains each step in the custom authentication and authorization workflow.

1. A device connects to a customer’s AWS IoT Core data endpoint by using one of the supported the section called “Device communication protocols” (p. 85). The device passes credentials in either the request’s header fields or query parameters (for the HTTP Publish or MQTT over WebSockets protocols) or in the user name and password field of the MQTT CONNECT message (for the MQTT and MQTT over WebSockets protocols).

2. AWS IoT Core checks for one of two conditions:
   • The incoming request specifies an authorizer.
   • The AWS IoT Core data endpoint receiving the request has a default authorizer configured for it.

If AWS IoT Core finds an authorizer in either of these ways, AWS IoT Core triggers the Lambda function associated with the authorizer.
3. (Optional) If you’ve enabled token signing, AWS IoT Core validates the request signature by using the public key stored in the authorizer before triggering the Lambda function. If validation fails, AWS IoT Core stops the request without invoking the Lambda function.

4. The Lambda function receives the credentials and connection metadata in the request and makes an authentication decision.

5. The Lambda function returns the results of the authentication decision and an AWS IoT Core policy document that specifies what actions are allowed in the connection. The Lambda function also returns information that specifies how often AWS IoT Core revalidates the credentials in the request by invoking the Lambda function.

6. AWS IoT Core evaluates activity on the connection against the policy it has received from the Lambda function.

**Scaling considerations**

Because a Lambda function handles authentication and authorization for your authorizer, the function is subject to Lambda pricing and service limits, such as concurrent execution rate. For more information about Lambda pricing, see [Lambda Pricing](#). You can manage the load on your Lambda function by adjusting the `refreshAfterInSeconds` and `disconnectAfterInSeconds` parameters in your Lambda function response. For more information about the contents of your Lambda function response, see the section called "Defining your Lambda function" (p. 325).

**Note**

If you leave signing enabled, you can prevent excessive triggering of your Lambda by unrecognized clients. Consider this before you disable signing in your authorizer.

**Note**

The Lambda function timeout limit for custom authorizer is 5 seconds.

**Creating and managing custom authorizers**

AWS IoT Core implements custom authentication and authorization schemes by using [authorizer resources](#). Each authorizer consists of the following components:

- **Name**: A unique user-defined string that identifies the authorizer.
- **Lambda function ARN**: The Amazon Resource Name (ARN) of the Lambda function that implements the authorization and authentication logic.
- **Token key name**: The key name used to extract the token from the HTTP headers, query parameters, or MQTT CONNECT user name in order to perform signature validation. This value is required if signing is enabled in your authorizer.
- **Signing disabled flag (optional)**: A Boolean value that specifies whether to disable the signing requirement on credentials. This is useful for scenarios where signing the credentials doesn’t make sense, such as authentication schemes that use MQTT user name and password. The default value is `false`, so signing is enabled by default.
- **Token signing public key**: The public key that AWS IoT Core uses to validate the token signature. Its minimum length is 2,048 bits. This value is required if signing is enabled in your authorizer.

Lambda charges you for the number of times your Lambda function runs and for the amount of time it takes for the code in your function to execute. For more information about Lambda pricing, see [Lambda Pricing](#). For more information about creating Lambda functions, see the [Lambda Developer Guide](#).

**Note**

If you leave signing enabled, you can prevent excessive triggering of your Lambda by unrecognized clients. Consider this before you disable signing in your authorizer.

**Note**

The Lambda function timeout limit for custom authorizer is 5 seconds.
Defining your Lambda function

When AWS IoT Core invokes your authorizer, it triggers the associated Lambda associated with the
authorizer with an event that contains the following JSON object. The example JSON object contains all
of the possible fields. Any fields that aren't relevant to the connection request aren't included.

```
{
    "token": "aToken",
    "signatureVerified": Boolean, // Indicates whether the device gateway has validated the
    signature.
    "protocols": ["tls", "http", "mqtt"], // Indicates which protocols to expect for the
    request.
    "protocolData": {
        "tls": {
            "servername": "servername" // The server name indication (SNI) host_name
        },
        "http": {
            "headers": {
                "#{name}": "#{value}"
            },
            "queryString": "?#{name}=#{value}"
        },
        "mqtt": {
            "username": "myUserName",
            "password": "myPassword", // A base64-encoded string.
            "clientId": "myClientId" // Included in the event only when the device sends
            the value.
        }
    },
    "connectionMetadata": {
        "id": UUID // The connection ID. You can use this for logging.
    }
}
```

The Lambda function should use this information to authenticate the incoming connection and decide
what actions are permitted in the connection. The function should send a response that contains the
following values.

- `isAuthenticated`: A Boolean value that indicates whether the request is authenticated.
- `principalId`: An alphanumeric string that acts as an identifier for the token sent by the custom
  authorization request. The value must be an alphanumeric string with at least one, and no more than
  128, characters and match this regular expression (regex) pattern: ([a-zA-Z0-9])\{1,128\}. Special
  characters that are not alphanumeric are not allowed for use with the `principalId` in AWS IoT Core.
  Refer to the documentation for other AWS services if non-alphanumeric special characters are allowed
  for the `principalId`.
- `policyDocuments`: A list of JSON-formatted AWS IoT Core policy documents For more information
  about creating AWS IoT Core policies, see the section called “AWS IoT Core policies” (p. 336). The
  maximum number of policy documents is 10 policy documents. Each policy document can contain a
  maximum of 2,048 characters.
- `disconnectAfterInSeconds`: An integer that specifies the maximum duration (in seconds) of the
  connection to the AWS IoT Core gateway. The minimum value is 300 seconds, and the maximum value
  is 86,400 seconds.
- `refreshAfterInSeconds`: An integer that specifies the interval between policy refreshes. When this
  interval passes, AWS IoT Core invokes the Lambda function to allow for policy refreshes. The minimum
  value is 300 seconds, and the maximum value is 86,400 seconds.

The following JSON object contains an example of a response that your Lambda function can send.
Custom authentication and authorization

The policyDocument value must contain a valid AWS IoT Core policy document. For more information about AWS IoT Core policies, see the section called “AWS IoT Core policies” (p. 336). In MQTT over TLS and MQTT over WebSockets connections, AWS IoT Core caches this policy for the interval specified in the value of the refreshAfterInSeconds field. In the case of HTTP connections the Lambda function is called for every authorization request unless your device is using HTTP persistent connections (also called HTTP keep-alive or HTTP connection reuse) you can choose to enable caching when configuring the authorizer. During this interval, AWS IoT Core authorizes actions in an established connection against this cached policy without triggering your Lambda function again. If failures occur during custom authentication, AWS IoT Core terminates the connection. AWS IoT Core also terminates the connection if it has been open for longer than the value specified in the disconnectAfterInSeconds parameter.

The following JavaScript contains a sample Node.js Lambda function that looks for a password in the MQTT Connect message with a value of test and returns a policy that grants permission to connect to AWS IoT Core with a client named myClientName and publish to a topic that contains the same client name. If it doesn't find the expected password, it returns a policy that denies those two actions.

```javascript
// A simple Lambda function for an authorizer. It demonstrates how to parse an MQTT password and generate a response.
exports.handler = function(event, context, callback) {
    var uname = event.protocolData.mqtt.username;
    var pwd = event.protocolData.mqtt.password;
    var buff = new Buffer(pwd, 'base64');
    var passwd = buff.toString('ascii');
    switch (passwd) {
    case 'test':
        callback(null, generateAuthResponse(passwd, 'Allow'));
        break;
    default:
        callback(null, generateAuthResponse(passwd, 'Deny'));
    }
};

// Helper function to generate the authorization response.
var generateAuthResponse = function(token, effect) {
    var authResponse = {};
    authResponse.isAuthenticated = true;
    authResponse.principalId = 'TEST123';
    var policyDocument = {};
    policyDocument.Version = '2012-10-17';
```
public class Authorizer implements AuthorizerInterface {
    private final AWSSDKAuthorizer...
aws iot create-authorizer
--authorizer-name MyAuthorizer
[--token-key-name MyAuthorizerToken //The key used to extract the token from headers.
--token-signing-public-keys FirstKey="-----BEGIN PUBLIC KEY-----
[...insert your public key here...]
-----END PUBLIC KEY-----"
[--status ACTIVE]
[--tags <value>]
[--signing-disabled | --no-signing-disabled]

You can use the signing-disabled parameter to opt out of signature validation for each invocation of your authorizer. We strongly recommend that you do not disable signing unless you have to. Signature validation protects you against excessive invocations of your Lambda function from unknown devices. You can't update the signing-disabled status of an authorizer after you create it. To change this behavior, you must create another custom authorizer with a different value for the signing-disabled parameter.

Values for the tokenKeyName and tokenSigningPublicKeys parameters are optional if you have disabled signing. They are required values if signing is enabled.

After you create your Lambda function and the custom authorizer, you must explicitly grant the AWS IoT Core service permission to invoke the function on your behalf. You can do this with the following command.

aws lambda add-permission --function-name <lambda_function_name> --principal iot.amazonaws.com --source-arn <authorizer_arn> --statement-id Id-123 --action "lambda:InvokeFunction"

Testing your authorizers

You can use the TestInvokeAuthorizer API to test the invocation and return values of your authorizer. This API enables you to specify protocol metadata and test the signature validation in your authorizer.

The following tabs show how to use the AWS CLI to test your authorizer.

Unix-like

```bash
aws iot test-invoke-authorizer --authorizer-name NAME_OF_AUTHORIZER \
--token TOKEN_VALUE --token-signature TOKEN_SIGNATURE
```

Windows CMD

```cmd
aws iot test-invoke-authorizer --authorizer-name NAME_OF_AUTHORIZER ^
--token TOKEN_VALUE --token-signature TOKEN_SIGNATURE
```

Windows PowerShell

```powershell
aws iot test-invoke-authorizer --authorizer-name NAME_OF_AUTHORIZER `\
--token TOKEN_VALUE --token-signature TOKEN_SIGNATURE
```

The value of the token-signature parameter is the signed token. To learn how to obtain this value, see the section called “Signing the token” (p. 331).
If your authorizer takes a user name and password, you can pass this information by using the --mqtt-context parameter. The following tabs show how to use the TestInvokeAuthorizer API to send a JSON object that contains a user name, password, and client name to your custom authorizer.

Unix-like

```
aws iot test-invoke-authorizer --authorizer-name NAME_OF_AUTHORIZER
   --mqtt-context '{"username": "USER_NAME", "password": "dGVzdA==", "clientId": "CLIENT_NAME"}';
```

Windows CMD

```
aws iot test-invoke-authorizer --authorizer-name NAME_OF_AUTHORIZER
   --mqtt-context '{"username": "USER_NAME", "password": "dGVzdA==", "clientId": "CLIENT_NAME"}';
```

Windows PowerShell

```
aws iot test-invoke-authorizer --authorizer-name NAME_OF_AUTHORIZER
   --mqtt-context '{"username": "USER_NAME", "password": "dGVzdA==", "clientId": "CLIENT_NAME"}';
```

The password must be base64-encoded. The following example shows how to encode a password in a Unix-like environment.

```
echo -n PASSWORD | base64
```

**Managing custom authorizers**

You can manage your authorizers by using the following APIs.

- **ListAuthorizers**: Show all authorizers in your account.
- **DescribeAuthorizer**: Displays properties of the specified authorizer. These values include creation date, last modified date, and other attributes.
- **SetDefaultAuthorizer**: Specifies the default authorizer for your AWS IoT Core data endpoints. AWS IoT Core uses this authorizer if a device doesn't pass AWS IoT Core credentials and doesn't specify an authorizer. For more information about using AWS IoT Core credentials, see the section called “Client authentication” (p. 300).
- **UpdateAuthorizer**: Changes the status, token key name, or public keys for the specified authorizer.
- **DeleteAuthorizer**: Deletes the specified authorizer.

**Note**

You can't update an authorizer's signing requirement. This means that you can't disable signing in an existing authorizer that requires it. You also can't require signing in an existing authorizer that doesn't require it.

**Connecting to AWS IoT Core by using custom authentication**

Devices can connect to AWS IoT Core by using custom authentication with any protocol that AWS IoT Core supports for device messaging. For more information about supported communication protocols, see the section called “Device communication protocols” (p. 85). The connection data that you pass to
your authorizer Lambda function depends on the protocol you use. For more information about creating
your authorizer Lambda function, see the section called “Defining your Lambda function” (p. 325). The
following sections explain how to connect to authenticate by using each supported protocol.

HTTPS

Devices sending data to AWS IoT Core by using the HTTP Publish API can pass credentials either
through request headers or query parameters in their HTTP POST requests. Devices can specify an
authorizer to invoke by using the x-amz-customauthorizer-name header or query parameter. If
you have token signing enabled in your authorizer, you must pass the token-key-name and x-amz-
customauthorizer-signature in either request headers or query parameters. Note that the token-
signature value must be URL-encoded when using JavaScript from within the browser.

**Note**

The customer authorizer for the HTTPS protocol only supports publish operations. For
more information about the HTTPS protocol, see the section called “Device communication
protocols” (p. 85).

The following example requests show how you pass these parameters in both request headers and query
parameters.

```
//Passing credentials via headers
POST /topics/topic?qos=qos HTTP/1.1
Host: your-endpoint
x-amz-customauthorizer-signature: token-signature
token-key-name: token-value
x-amz-customauthorizer-name: authorizer-name

//Passing credentials via query parameters
POST /topics/topic?qos=qos&x-amz-customauthorizer-signature=token-signature&token-key-
name=token-value HTTP/1.1
```

MQTT

Devices connecting to AWS IoT Core by using an MQTT connection can pass credentials through the
username and password fields of MQTT messages. The username value can also optionally contain
a query string that passes additional values (including a token, signature, and authorizer name) to your
authorizer. You can use this query string if you want to use a token-based authentication scheme instead
of username and password values.

**Note**

Data in the password field is base64-encoded by AWS IoT Core. Your Lambda function must
decode it.

The following example contains a username string that contains extra parameters that specify a token
and signature.

```
username?x-amz-customauthorizer-name=authorizer-name&x-amz-customauthorizer-
signature=token-signature&token-key-name=token-value
```

In order to invoke an authorizer, devices connecting to AWS IoT Core by using MQTT and custom
authentication must connect on port 443. They also must pass the Application Layer Protocol
Negotiation (ALPN) TLS extension with a value of mqtt and the Server Name Indication (SNI) extension
with the host name of their AWS IoT Core data endpoint. To avoid potential errors, the value for x-amz-
customauthorizer-signature should be URL encoded. We also highly recommend that the values of
x-amz-customauthorizer-name and token-key-name be URL encoded. For more information about
these values, see the section called “Device communication protocols” (p. 85). The V2 AWS IoT Device
SDKs, Mobile SDKs, and AWS IoT Device Client (p. 1428) can configure both of these extensions.
MQTT over WebSockets

Devices connecting to AWS IoT Core by using MQTT over WebSockets can pass credentials in one of the two following ways.

- Through request headers or query parameters in the HTTP UPGRADE request to establish the WebSockets connection.
- Through the username and password fields in the MQTT CONNECT message.

If you pass credentials through the MQTT connect message, the ALPN and SNI TLS extensions are required. For more information about these extensions, see the section called "MQTT" (p. 330). The following example demonstrates how to pass credentials through the HTTP Upgrade request.

```plaintext
GET /mqtt HTTP/1.1
Host: your-endpoint
Upgrade: WebSocket
Connection: Upgrade
x-amz-customauthorizer-signature: token-signature
token-key-name: token-value
sec-WebSocket-Key: any random base64 value
sec-websocket-protocol: mqtt
sec-WebSocket-Version: websocket version
```

Signing the token

You must sign the token with the private key of the public-private key pair that you used in the create-authorizer call. The following examples show how to create the token signature by using a UNIX-like command and JavaScript. They use the SHA-256 hash algorithm to encode the signature.

Command line

```plaintext
echo -n TOKEN_VALUE | openssl dgst -sha256 -sign PEM encoded RSA private key | openssl base64
```

JavaScript

```javascript
const crypto = require('crypto')
const key = "PEM encoded RSA private key"
const k = crypto.createPrivateKey(key)
let sign = crypto.createSign ('SHA256')
sign.write(t)
sign.end()
const s = sign.sign(k, 'base64')
```

Troubleshooting your authorizers

This topic walks through common issues that can cause problems in custom authentication workflows and steps for resolving them. To troubleshoot issues most effectively, enable CloudWatch logs for AWS IoT Core and set the log level to DEBUG. You can enable CloudWatch logs in the AWS IoT Core console (https://console.aws.amazon.com/iot/). For more information about enabling and configuring logs for AWS IoT Core, see the section called "Configure AWS IoT logging" (p. 439).
Note
If you leave the log level at DEBUG for long periods of time, CloudWatch might store large amounts of logging data. This can increase your CloudWatch charges. Consider using resource-based logging to increase the verbosity for only devices in a particular thing group. For more information about resource-based logging, see the section called “Configure AWS IoT logging” (p. 439). Also, when you're done troubleshooting, reduce the log level to a less verbose level.

Before you start troubleshooting, review the section called “Understanding the custom authentication workflow” (p. 323) for a high-level view of the custom authentication process. This helps you understand where to look for the source of a problem.

This topic discusses the following two areas for you to investigate.

- Issues related to your authorizer's Lambda function.
- Issues related to your device.

Check for issues in your authorizer's Lambda function

Perform the following steps to make sure that your devices' connection attempts are invoking your Lambda function.

1. Verify which Lambda function is associated with your authorizer.

   You can do this by calling the DescribeAuthorizer API or by clicking on the desired authorizer in the Secure section of the AWS IoT Core console.

2. Check the invocation metrics for the Lambda function. Perform the following steps to do this.

   a. Open the AWS Lambda console (https://console.aws.amazon.com/lambda/) and select the function that is associated with your authorizer.
   
   b. Choose the Monitor tab and view metrics for the time frame that is relevant to your problem.

3. If you see no invocations, verify that AWS IoT Core has permission to invoke your Lambda function. If you see invocations, skip to the next step. Perform the following steps to verify that your Lambda function has the required permissions.

   a. Choose the Permissions tab for your function in the AWS Lambda console.
   
   b. Find the Resource-based Policy section at the bottom of the page. If your Lambda function has the required permissions, the policy looks like the following example.

```
{
  "Version": "2012-10-17",
  "Id": "default",
  "Statement": [
    {
      "Sid": "Id123",
      "Effect": "Allow",
      "Principal": {
        "Service": "iot.amazonaws.com"
      },
      "Action": "lambda:InvokeFunction",
      "Condition": {
        "ArnLike": {
          "AWS:SourceArn": "arn:aws:iot:us-east-1:111111111111:authorizer/AuthorizerName"
        },
        "StringEquals": {
          "AWS:SourceAccount": "111111111111"
        }
    }
  ]
}
```
c. This policy grants the InvokeFunction permission on your function to the AWS IoT Core principal. If you don't see it, you'll have to add it by using the AddPermission API. The following example shows you how to do this by using the AWS CLI.

```bash
aws lambda add-permission --function-name FunctionName --principal iot.amazonaws.com --source-arn AuthorizerArn --statement-id Id-123 --action "lambda:InvokeFunction"
```

4. If you see invocations, verify that there are no errors. An error might indicate that the Lambda function isn't properly handling the connection event that AWS IoT Core sends to it.

   For information about handling the event in your Lambda function, see the section called "Defining your Lambda function" (p. 325). You can use the test feature in the AWS Lambda console (https://console.aws.amazon.com/lambda/) to hard-code test values in the function to make sure that the function is handling events correctly.

5. If you see invocations with no errors, but your devices are not able to connect (or publish, subscribe, and receive messages), the issue might be that the policy that your Lambda function returns doesn't give permissions for the actions that your devices are trying to take. Perform the following steps to determine whether anything is wrong with the policy that the function returns.

   a. Use an Amazon CloudWatch Logs Insights query to scan logs over a short period of time to check for failures. The following example query sorts events by timestamp and looks for failures.

   ```bash
display clientId, eventType, status, @timestamp | sort @timestamp desc | filter status = "Failure"
```

   b. Update your Lambda function to log the data that it's returning to AWS IoT Core and the event that triggers the function. You can use these logs to inspect the policy that the function creates.

6. If you see invocations with no errors, but your devices are not able to connect (or publish, subscribe, and receive messages), another reason can be that your Lambda function exceeds the timeout limit. The Lambda function timeout limit for custom authorizer is 5 seconds. You can check the function duration in CloudWatch logs or metrics.

**Investigating device issues**

If you find no issues with invoking your Lambda function or with the policy that the function returns, look for problems with devices' connection attempts. Malformed connection requests can cause AWS IoT Core not to trigger your authorizer. Connection problems can occur at both the TLS and application layers.

**Possible TLS layer issues:**

- Customers must pass either a hostname header (HTTP, MQTT over WebSockets) or the Server Name Indication TLS extension (HTTP, MQTT over WebSockets, MQTT) in all custom authentication requests. In both cases, the value passed must match one of your account's AWS IoT Core data endpoints. These are the endpoints that are returned when you perform the following CLI commands.
  - `aws iot describe-endpoint --endpoint-type iot:Data-ATS`
  - `aws iot describe-endpoint --endpoint-type iot:Data` (for legacy VeriSign endpoints)
- Devices that use custom authentication for MQTT connections must also pass the Application Layer Protocol Negotiation (ALPN) TLS extension with a value of mqtt.
Custom authentication is currently available only on port 443.

**Possible application layer issues:**

- If signing is enabled (the signingDisabled field is false in your authorizer), look for the following signature issues.
  - Make sure that you're passing the token signature in either the x-amz-customauthorizer-signatureheader or in a query string parameter.
  - Make sure that the service isn't signing a value other than the token.
  - Make sure that you pass the token in the header or query parameter that you specified in the token-key-name field in your authorizer.
  - Make sure that the authorizer name you pass in the x-amz-customauthorizer-name header or query string parameter is valid or that you have a default authorizer defined for your account.

## Authorization

Authorization is the process of granting permissions to an authenticated identity. You grant permissions in AWS IoT Core using AWS IoT Core and IAM policies. This topic covers AWS IoT Core policies. For more information about IAM policies, see Identity and access management for AWS IoT (p. 390) and How AWS IoT works with IAM (p. 394).

AWS IoT Core policies determine what an authenticated identity can do. An authenticated identity is used by devices, mobile applications, web applications, and desktop applications. An authenticated identity can even be a user typing AWS IoT Core CLI commands. An identity can execute AWS IoT Core operations only if it has a policy that grants it permission for those operations.

Both AWS IoT Core policies and IAM policies are used with AWS IoT Core to control the operations an identity (also called a principal) can perform. The policy type you use depends on the type of identity you are using to authenticate with AWS IoT Core.

AWS IoT Core operations are divided into two groups:

- Control plane API allows you to perform administrative tasks like creating or updating certificates, things, rules, and so on.
- Data plane API allows you to send data to and receive data from AWS IoT Core.

The type of policy you use depends on whether you are using control plane or data plane API.

The following table shows the identity types, the protocols they use, and the policy types that can be used for authorization.

### AWS IoT Core data plane API and policy types

<table>
<thead>
<tr>
<th>Protocol and authentication mechanism</th>
<th>SDK</th>
<th>Identity type</th>
<th>Policy type</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQTT over TLS/TCP, TLS mutual authentication (port 8883 or 443)†</td>
<td>AWS IoT Device SDK</td>
<td>X.509 certificates</td>
<td>AWS IoT Core policy</td>
</tr>
</tbody>
</table>
## Authorization

AWS IoT Core policies are attached to X.509 certificates, Amazon Cognito identities, or thing groups. IAM policies are attached to an IAM user, group, or role. If you use the AWS IoT console or the AWS IoT Core CLI to attach the policy (to a certificate, Amazon Cognito Identity, or thing group), you use an AWS IoT Core policy. Otherwise, you use an IAM policy. AWS IoT Core policies attached to a thing group applies to any thing within that thing group. For the AWS IoT Core policy to take effect, the `clientId` and the thing name must match.

Policy-based authorization is a powerful tool. It gives you complete control over what a device, user, or application can do in AWS IoT Core. For example, consider a device connecting to AWS IoT Core with a

<table>
<thead>
<tr>
<th>Protocol and authentication mechanism</th>
<th>SDK</th>
<th>Identity type</th>
<th>Policy type</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQTT over HTTPS/WebSocket, AWS SigV4 authentication (port 443)</td>
<td>AWS Mobile SDK</td>
<td>Authenticated Amazon Cognito identity</td>
<td>IAM and AWS IoT Core policies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unauthenticated Amazon Cognito identity</td>
<td>IAM policy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IAM, or federated identity</td>
<td>IAM policy</td>
</tr>
<tr>
<td>HTTPS, AWS Signature Version 4 authentication (port 443)</td>
<td>AWS CLI</td>
<td>Amazon Cognito, IAM, or federated identity</td>
<td>IAM policy</td>
</tr>
<tr>
<td>HTTPS, TLS mutual authentication (port 8443)</td>
<td>No SDK support</td>
<td>X.509 certificates</td>
<td>AWS IoT Core policy</td>
</tr>
<tr>
<td>HTTPS over custom authentication (Port 443)</td>
<td>AWS IoT Device SDK</td>
<td>Custom authorizer</td>
<td>Custom authorizer policy</td>
</tr>
</tbody>
</table>

### AWS IoT Core control plane API and policy types

<table>
<thead>
<tr>
<th>Protocol and authentication mechanism</th>
<th>SDK</th>
<th>Identity type</th>
<th>Policy type</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTPS AWS Signature Version 4 authentication (port 443)</td>
<td>AWS CLI</td>
<td>Amazon Cognito identity</td>
<td>IAM policy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IAM, or federated identity</td>
<td>IAM policy</td>
</tr>
</tbody>
</table>
AWS IoT Core Developer Guide
AWS training and certification

certificate. You can allow the device to access all MQTT topics, or you can restrict its access to a single
topic. In another example, consider a user typing CLI commands at the command line. By using a policy,
you can allow or deny access to any command or AWS IoT Core resource for the user. You can also control
an application's access to AWS IoT Core resources.

Changes made to a policy can take a few minutes to become effective because of how AWS IoT caches
the policy documents. That is, it may take a few minutes to access a resource that has recently been
granted access, and a resource may be accessible for several minutes after its access has been revoked.

AWS training and certification

For information about authorization in AWS IoT Core, take the Deep Dive into AWS IoT Core
Authentication and Authorization course on the AWS Training and Certification website.

AWS IoT Core policies

AWS IoT Core policies are JSON documents. They follow the same conventions as IAM policies. AWS
IoT Core supports named policies so many identities can reference the same policy document. Named
policies are versioned so they can be easily rolled back.

AWS IoT Core policies allow you to control access to the AWS IoT Core data plane. The AWS IoT Core data
plane consists of operations that allow you to connect to the AWS IoT Core message broker, send and
receive MQTT messages, and get or update a thing's Device Shadow.

An AWS IoT Core policy is a JSON document that contains one or more policy statements. Each
statement contains:

- **Effect**, which specifies whether the action is allowed or denied.
- **Action**, which specifies the action the policy is allowing or denying.
- **Resource**, which specifies the resource or resources on which the action is allowed or denied.

Changes made to a policy can take anywhere between 6 and 8 minutes to become effective because of
how AWS IoT caches the policy documents. That is, it may take a few minutes to access a resource that
has recently been granted access, and a resource may be accessible for several minutes after its access
has been revoked.

AWS IoT Core policies can be attached to X.509 certificates, Amazon Cognito identities, and thing
groups. The policies attached to a thing group apply to any thing within that group. For the policy to
take effect, the clientId and the thing name must match. AWS IoT Core policies follow the same policy
evaluation logic as IAM policies. By default, all policies are implicitly denied. An explicit allow in any
identity-based or resource-based policy overrides the default behavior. An explicit deny in any policy
overrides any allows. For more information, see Policy evaluation logic in the AWS Identity and Access
Management User Guide.

Topics
- AWS IoT Core policy actions (p. 337)
- AWS IoT Core action resources (p. 339)
- AWS IoT Core policy variables (p. 340)
- Cross-service confused deputy prevention (p. 346)
- AWS IoT Core policy examples (p. 347)
- Authorization with Amazon Cognito identities (p. 376)
AWS IoT Core policy actions

The following policy actions are defined by AWS IoT Core:

MQTT Policy Actions

**iot:Connect**

Represents the permission to connect to the AWS IoT Core message broker. The `iot:Connect` permission is checked every time a CONNECT request is sent to the broker. The message broker doesn't allow two clients with the same client ID to stay connected at the same time. After the second client connects, the broker closes the existing connection. Use the `iot:Connect` permission to ensure only authorized clients using a specific client ID can connect.

**iot:GetRetainedMessage**

Represents the permission to get the contents of a single retained message. Retained messages are the messages that were published with the RETAIN flag set and stored by AWS IoT Core. For permission to get a list of all the account's retained messages, see [iot:ListRetainedMessages](p. 337).

**iot:ListRetainedMessages**

Represents the permission to retrieve summary information about the account's retained messages, but not the contents of the messages. Retained messages are the messages that were published with the RETAIN flag set and stored by AWS IoT Core. The resource ARN specified for this action must be `*`. For permission to get the contents of a single retained message, see [iot:GetRetainedMessage](p. 337).

**iot:Publish**

Represents the permission to publish an MQTT topic. This permission is checked every time a PUBLISH request is sent to the broker. You can use this to allow clients to publish to specific topic patterns.

*Note*

To grant `iot:Publish` permission, you must also grant `iot:Connect` permission.

**iot:Receive**

Represents the permission to receive a message from AWS IoT Core. The `iot:Receive` permission is confirmed every time a message is delivered to a client. Because this permission is checked on every delivery, you can use it to revoke permissions to clients that are currently subscribed to a topic.

**iot:RetainPublish**

Represents the permission to publish an MQTT message with the RETAIN flag set.

*Note*

To grant `iot:RetainPublish` permission, you must also grant `iot:Publish` permission.

**iot:Subscribe**

Represents the permission to subscribe to a topic filter. This permission is checked every time a SUBSCRIBE request is sent to the broker. Use it to allow clients to subscribe to topics that match specific topic patterns.

*Note*

To grant `iot:Subscribe` permission, you must also grant `iot:Connect` permission.
Device Shadow Policy Actions

`iot:DeleteThingShadow`

Represents the permission to delete a thing's Device Shadow. The `iot:DeleteThingShadow` permission is checked every time a request is made to delete a thing's Device Shadow contents.

`iot:GetThingShadow`

Represents the permission to retrieve a thing's Device Shadow. The `iot:GetThingShadow` permission is checked every time a request is made to retrieve a thing's Device Shadow contents.

`iot:ListNamedShadowsForThing`

Represents the permission to list a thing's named Shadows. The `iot:ListNamedShadowsForThing` permission is checked every time a request is made to list a thing's named Shadows.

`iot:UpdateThingShadow`

Represents the permission to update a device's shadow. The `iot:UpdateThingShadow` permission is checked every time a request is made to update a thing's Device Shadow contents.

**Note**
The job execution policy actions apply only for the HTTP TLS endpoint. If you use the MQTT endpoint, you must use MQTT policy actions defined in this topic.

For an example of a job execution policy that demonstrates this, see the section called "Basic job policy example" (p. 375) that works with the MQTT protocol.

Job Executions AWS IoT Core Policy Actions

`iot:DescribeJobExecution`

Represents the permission to retrieve a job execution for a given thing. The `iot:DescribeJobExecution` permission is checked every time a request is made to get a job execution.

`iot:GetPendingJobExecutions`

Represents the permission to retrieve the list of jobs that are not in a terminal status for a thing. The `iot:GetPendingJobExecutions` permission is checked every time a request is made to retrieve the list.

`iot:UpdateJobExecution`

Represents the permission to update a job execution. The `iot:UpdateJobExecution` permission is checked every time a request is made to update the state of a job execution.

`iot:StartNextPendingJobExecution`

Represents the permission to get and start the next pending job execution for a thing. (That is, to update a job execution with status QUEUED to IN_PROGRESS.) The `iot:StartNextPendingJobExecution` permission is checked every time a request is made to start the next pending job execution.

AWS IoT Core Credential Provider Policy Action

`iot:AssumeRoleWithCertificate`

Represents the permission to call AWS IoT Core credential provider to assume an IAM role with certificate-based authentication. The `iot:AssumeRoleWithCertificate` permission is checked every time a request is made to AWS IoT Core credential provider to assume a role.
### AWS IoT Core action resources

To specify a resource for an AWS IoT Core policy action, you must use the ARN of the resource. All resource ARNs are of the following form:

```
```

The following table shows the resource to specify for each action type:

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource type</th>
<th>Resource name</th>
<th>ARN example</th>
</tr>
</thead>
<tbody>
<tr>
<td>iot:Connect</td>
<td>client</td>
<td>The client's client ID</td>
<td>arn:aws:iot:us-east-1:123456789012:client/myClientId</td>
</tr>
</tbody>
</table>
| iot:DeleteThingShadow| thing         | The thing's name, and the shadow's name, if applicable | arn:aws:iot:us-east-1:123456789012:thing/thingOne  
|                      |               |                                        | arn:aws:iot:us-east-1:123456789012:thing/thingOne/shadowOne               |
| iot:DescribeJobExecution| thing         | The thing's name                       | arn:aws:iot:us-east-1:123456789012:thing/thingOne                         |
| iot:GetPendingJobExecutions| thing         | The thing's name                       | arn:aws:iot:us-east-1:123456789012:thing/thingOne                         |
| iot:GetRetainedMessage| topic         | A retained message topic              | arn:aws:iot:us-east-1:123456789012:topic/myTopicName                     |
| iot:GetThingShadow   | thing         | The thing's name, and the shadow's name, if applicable | arn:aws:iot:us-east-1:123456789012:thing/thingOne  
<p>|                      |               |                                        | arn:aws:iot:us-east-1:123456789012:thing/thingOne/shadowOne               |
| iot:ListNamedShadowsForThing| All          | All                                    | *                                                                            |
| iot:ListRetainedMessages| All          | All                                    | *                                                                            |
| iot:Publish          | topic         | A topic string                         | arn:aws:iot:us-east-1:123456789012:topic/myTopicName                     |
| iot:Receive          | topic         | A topic string                         | arn:aws:iot:us-east-1:123456789012:topic/myTopicName                     |
| iot:RetainPublish    | topic         | A topic to publish with the RETAIN flag set | arn:aws:iot:us-east-1:123456789012:topic/myTopicName                     |</p>
<table>
<thead>
<tr>
<th>Action</th>
<th>Resource type</th>
<th>Resource name</th>
<th>ARN example</th>
</tr>
</thead>
<tbody>
<tr>
<td>iot:StartNextPendingExecution</td>
<td>thing</td>
<td>The thing's name</td>
<td>arn:aws:iot:us-east-1:123456789012:thing/thingOne</td>
</tr>
<tr>
<td>iot:Subscribe</td>
<td>topicfilter</td>
<td>A topic filter string</td>
<td>arn:aws:iot:us-east-1:123456789012:topicfilter/myTopicFilter</td>
</tr>
<tr>
<td>iot:UpdateJobExecution</td>
<td>thing</td>
<td>The thing's name</td>
<td>arn:aws:iot:us-east-1:123456789012:thing/thingOne</td>
</tr>
<tr>
<td>iot:AssumeRoleWithCertificate</td>
<td>rolealias</td>
<td>A role alias that points to a role ARN</td>
<td>arn:aws:iot:us-east-1:123456789012:rolealias/CredentialProviderRole_alias</td>
</tr>
</tbody>
</table>

**AWS IoT Core policy variables**

AWS IoT Core defines policy variables that can be used in AWS IoT Core policies in the Resource or Condition block. When a policy is evaluated, the policy variables are replaced by actual values. For example, if a device is connected to the AWS IoT Core message broker with a client ID of 100-234-3456, the `iot:ClientId` policy variable is replaced in the policy document by 100-234-3456.

AWS IoT Core policies can use wildcard characters and follow a similar convention to IAM policies. Inserting an * (asterik) in the string can be treated as a wildcard, matching any characters. For example, you can use * to describe multiple MQTT topic names in the Resource attribute of a policy. The characters + and # are treated as literal strings in a policy. For an example policy that shows how to use wildcards, see *Using wildcard characters in MQTT and AWS IoT Core policies* (p. 354).

You can also use predefined policy variables with fixed values to represent characters that otherwise have special meaning. These special characters include $(*)$, $(?)$, and $(\$)$. For more information about policy variables and the special characters, see *IAM Policy elements: Variables and tags* and *Creating a condition with multiple keys or values*.

**Topics**
- *Basic AWS IoT Core policy variables* (p. 340)
- *Thing policy variables* (p. 342)
- *X.509 Certificate AWS IoT Core policy variables* (p. 343)

**Basic AWS IoT Core policy variables**

AWS IoT Core defines the following basic policy variables:

- `iot:ClientId`: The client ID used to connect to the AWS IoT Core message broker.
- `aws:SourceIp`: The IP address of the client connected to the AWS IoT Core message broker.
The following AWS IoT Core policy shows a policy that uses policy variables. `aws:SourceIp` can be used in the Condition element of your policy to allow principals to make API requests only within a specific address range. For examples, see Authorizing users and cloud services to use AWS IoT Jobs (p. 795).

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": ["iot:Connect"],
         "Resource": ["arn:aws:iot:us-east-1:123456789012:client/clientid1"]
      },
      {
         "Effect": "Allow",
         "Action": ["iothub:Publish"],
         "Resource": ["arn:aws:iot:us-east-1:123456789012:topic/my/topic/${iot:ClientId}"],
         "Condition": {
            "IpAddress": {
               "aws:SourceIp": "123.45.167.89"
            }
         }
      }
   ]
}
```

In these examples, `${iot:ClientId}` is replaced by the ID of the client connected to the AWS IoT Core message broker when the policy is evaluated. When you use policy variables like `${iot:ClientId}`, you can inadvertently open access to unintended topics. For example, if you use a policy that uses `${iot:ClientId}` to specify a topic filter:

```json
{
   "Effect": "Allow",
   "Action": ["iot:Subscribe"],
   "Resource": ["arn:aws:iot:us-east-1:123456789012:topicfilter/my/${iot:ClientId}/topic"]
}
```

A client can connect using + as the client ID. This would allow the user to subscribe to any topic that matches the topic filter `my/+/topic`. To protect against such security gaps, use the `iot:Connect` policy action to control which client IDs can connect. For example, this policy allows only those clients whose client ID is `clientid1` to connect:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": ["iot:Connect"],
         "Resource": ["arn:aws:iot:us-east-1:123456789012:client/clientid1"]
      }
   ]
}
```
AWS IoT Core Developer Guide
AWS IoT Core policies

Note
Using the policy variable `${iot:ClientId}` with Connect is not recommended. There is no check on the value ofClientId, so an attacher with a different client's ID can pass the validation but cause disconnection. Because any ClientId is allowed, setting a random client ID can bypass thing group policies.

Thing policy variables

Thing policy variables allow you to write AWS IoT Core policies that grant or deny permissions based on thing properties like thing names, thing types, and thing attribute values. You can use thing policy variables to apply the same policy to control many AWS IoT Core devices. For more information about device provisioning, see Device Provisioning. The thing name is obtained from the client ID in the MQTT Connect message sent when a thing connects to AWS IoT Core.

Keep the following in mind when using thing policy variables in AWS IoT Core policies.

- Use the AttachThingPrincipal API to attach certificates or principals (authenticated Amazon Cognito identities) to a thing.
- When you're replacing thing names with thing policy variables, the value of clientId in the MQTT connect message or the TLS connection must exactly match the thing name.

The following thing policy variables are available:

- `iot:Connection.Thing.ThingName`
  This resolves to the name of the thing in the AWS IoT Core registry for which the policy is being evaluated. AWS IoT Core uses the certificate the device presents when it authenticates to determine which thing to use to verify the connection. This policy variable is only available when a device connects over MQTT or MQTT over the WebSocket protocol.

- `iot:Connection.Thing.ThingTypeName`
  This resolves to the thing type associated with the thing for which the policy is being evaluated. The client ID of the MQTT/WebSocket connection must be the same as the thing name. This policy variable is available only when connecting over MQTT or MQTT over the WebSocket protocol.

- `iot:Connection.Thing.Attributes[attributeName]`
  This resolves to the value of the specified attribute associated with the thing for which the policy is being evaluated. A thing can have up to 50 attributes. Each attribute is available as a policy variable: `iot:Connection.Thing.Attributes[attributeName]` where `attributeName` is the name of the attribute. The client ID of the MQTT/WebSocket connection must be the same as the thing name. This policy variable is only available when connecting over MQTT or MQTT over the WebSocket protocol.

- `iot:Connection.Thing.IsAttached`
  `iot:Connection.Thing.IsAttached: ["true"]` enforces that only the devices that are both registered in AWS IoT and attached to principal can access the permissions inside the policy. You can use this variable to prevent a device from connecting to AWS IoT Core if it presents a certificate that is not attached to an IoT thing in the AWS IoT Core registry. This variable has values true or false indicating that the connecting thing is attached to the certificate or Amazon Cognito identity in the registry using AttachThingPrincipal API. Thing name is taken as client Id.
X.509 Certificate AWS IoT Core policy variables

X.509 certificate policy variables allow you to write AWS IoT Core policies that grant permissions based on X.509 certificate attributes. The following sections describe how you can use these certificate policy variables.

CertificateId

In the RegisterCertificate API, the certificateId appears in the response body. To get information about your certificate, you can use the certificateId in DescribeCertificate.

Issuer attributes

The following AWS IoT Core policy variables allow you to allow or deny permissions based on certificate attributes set by the certificate issuer.

- iot:Certificate.Issuer.DistinguishedNameQualifier
- iot:Certificate.Issuer.Organization
- iot:Certificate.Issuer.OrganizationalUnit
- iot:Certificate.Issuer.State
- iot:Certificate.Issuer.CommonName
- iot:Certificate.Issuer.SerialNumber
- iot:Certificate.Issuer.Title
- iot:Certificate.Issuer.Surname
- iot:Certificate.Issuer.GivenName
- iot:Certificate.Issuer.Initials
- iot:Certificate.Issuer.Pseudonym
- iot:Certificate.Issuer.GenerationQualifier

Subject attributes

The following AWS IoT Core policy variables allow you to grant or deny permissions based on certificate subject attributes set by the certificate issuer.

- iot:Certificate.Subject.DistinguishedNameQualifier
- iot:Certificate.Subject.Country
- iot:Certificate.Subject.Organization
- iot:Certificate.Subject.OrganizationalUnit
- iot:Certificate.Subject.State
- iot:Certificate.Subject.CommonName
- iot:Certificate.Subject.SerialNumber
- iot:Certificate.Subject.Title
- iot:Certificate.Subject.Surname
- iot:Certificate.Subject.GivenName
- iot:Certificate.Subject.Initials
- iot:Certificate.Subject.Pseudonym
- iot:Certificate.Subject.GenerationQualifier
X.509 certificates allow these attributes to contain one or more values. By default, the policy variables for each multi-value attribute return the first value. For example, the Certificate.Subject.Country attribute might contain a list of country names, but when evaluated in a policy, iot:Certificate.Subject.Country is replaced by the first country name. You can request a specific attribute value other than the first value by using a one-based index. For example, iot:Certificate.Subject.Country.1 is replaced by the second country name in the Certificate.Subject.Country attribute. If you specify an index value that does not exist (for example, if you ask for a third value when there are only two values assigned to the attribute), no substitution is made and authorization fails. You can use the .List suffix on the policy variable name to specify all values of the attribute.

Registered devices (2)

For devices registered as things in the AWS IoT Core registry, the following policy allows clients with a thing name registered in the AWS IoT Core registry to connect, but restricts the right to publish to a thing name specific topic to those clients with certificates whose Certificate.Subject.Organization attribute is set to "Example Corp" or "AnyCompany". This restriction is accomplished by using a "Condition" field that specifies a condition that must be met to allow the preceding action. In this case the condition is that the Certificate.Subject.Organization attribute associated with the certificate must include one of the values listed:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Connect"
            ],
            "Resource": [
                "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish"
            ],
            "Condition": {
                "ForAllValues:StringEquals": {
                    "iot:Certificate.Subject.Organization.List": [
                        "Example Corp",
                        "AnyCompany"
                    ]
                }
            }
        }
    ]
}
```

Unregistered devices (2)

For devices not registered as things in the AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with client IDs client1, client2, and client3, but restricts the right to publish to a client-id specific topic to those clients with certificates whose Certificate.Subject.Organization attribute is set to "Example Corp" or
"AnyCompany". This restriction is accomplished by using a "Condition" field that specifies a condition that must be met to allow the preceding action. In this case the condition is that the Certificate.Subject.Organization attribute associated with the certificate must include one of the values listed:

```json
{
   "Version":"2012-10-17",
   "Statement":[
      {
         "Effect":"Allow",
         "Action":[
            "iot:Connect"
         ],
         "Resource":[
            "arn:aws:iot:us-east-1:123456789012:client/client1",
            "arn:aws:iot:us-east-1:123456789012:client/client2",
            "arn:aws:iot:us-east-1:123456789012:client/client3"
        ]
      },
      {
         "Effect":"Allow",
         "Action":[
            "iot:Publish"
         ],
         "Resource":[
            "arn:aws:iot:us-east-1:123456789012:topic/my/topic/${iot:ClientId}"
        ],
         "Condition":{
            "ForAllValues:StringEquals":{
               "iot:Certificate.Subject.Organization.List":[
                  "Example Corp",
                  "AnyCompany"
               ]
            }
         }
      }
   ]
}
```

Issuer alternate name attributes

The following AWS IoT Core policy variables allow you to grant or deny permissions based on issuer alternate name attributes set by the certificate issuer.

- `iot:Certificate.Issuer.AlternativeName.RFC822Name`
- `iot:Certificate.Issuer.AlternativeName.DNSName`
- `iot:Certificate.Issuer.AlternativeName.DirectoryName`
- `iot:Certificate.Issuer.AlternativeName.IPAddress`

Subject alternate name attributes

The following AWS IoT Core policy variables allow you to grant or deny permissions based on subject alternate name attributes set by the certificate issuer.

- `iot:Certificate.Subject.AlternativeName.RFC822Name`
- `iot:Certificate.Subject.AlternativeName.DNSName`
- `iot:Certificate.Subject.AlternativeName.DirectoryName`
• `iot:Certificate.Subject.AlternativeName.UniformResourceIdentifier`
• `iot:Certificate.Subject.AlternativeName.IPAddress`

Other attributes

You can use `iot:Certificate.SerialNumber` to allow or deny access to AWS IoT Core resources based on the serial number of a certificate. The `iot:Certificate.AvailableKeys` policy variable contains the name of all certificate policy variables that contain values.

X.509 Certificate policy variable limitations

The following limitations apply to X.509 certificate policy variables:

Wildcards

If wildcard characters are present in certificate attributes, the policy variable is not replaced by the certificate attribute value, leaving the `${policy-variable}` text in the policy document. This might cause authorization failure. The following wildcard characters can be used: `*`, `?`, and `#`.

Array fields

Certificate attributes that contain arrays are limited to five items. Additional items are ignored.

String length

All string values are limited to 1024 characters. If a certificate attribute contains a string longer than 1024 characters, the policy variable is not replaced by the certificate attribute value, leaving the `${policy-variable}` in the policy document. This might cause authorization failure.

Special Characters

Any special character, such as `,`, `\`, `+`, `=`, `<`, `>`, and `;` must be prefixed with a backslash (`\`) when used in a policy variable. For example, Amazon Web Services O=Amazon.com Inc. L=Seattle ST=Washington C=US becomes Amazon Web Service O\=Amazon.com Inc. L\=Seattle ST\=Washington C\=US.

Cross-service confused deputy prevention

The *confused deputy problem* is a security issue where an entity that doesn't have permission to perform an action can coerce a more-privileged entity to perform the action. In AWS, cross-service impersonation can result in the confused deputy problem. Cross-service impersonation can occur when one service (the calling service) calls another service (the called service). The calling service can be manipulated to use its permissions to act on another customer's resources in a way it shouldn't otherwise have permission to access. To prevent this, AWS provides tools that help you protect your data for all services with service principals that have been given access to resources in your account.

To limit the permissions that AWS IoT gives another service to the resource, we recommend using the `aws:SourceArn` and `aws:SourceAccount` global condition context keys in resource policies. If you use both global condition context keys, the `aws:SourceAccount` value and the account in the `aws:SourceArn` value must use the same account ID when used in the same policy statement.

The most effective way to protect against the confused deputy problem is to use the `aws:SourceArn` global condition context key with the full Amazon Resource Name (ARN) of the resource. For AWS IoT, your `aws:SourceArn` must comply with the format: `arn:aws:iot:`. Make sure that the `region` matches your AWS IoT Region and the `account-id` matches your customer account ID.

The following example shows how to prevent the confused deputy problem by using the `aws:SourceArn` and `aws:SourceAccount` global condition context keys in the AWS IoT role trust policy.
AWS IoT Core policies

The example policies in this section illustrate the policy documents used to complete common tasks in AWS IoT Core. You can use them as examples to start from when creating the policies for your solutions.

The examples in this section use these policy elements:

- the section called “AWS IoT Core policy actions” (p. 337)
- the section called “AWS IoT Core action resources” (p. 339)
- the section called “Identity-based policy examples” (p. 410)
- the section called “Basic AWS IoT Core policy variables” (p. 340)
- the section called “X.509 Certificate AWS IoT Core policy variables” (p. 343)

Policy examples in this section:

- Connect policy examples (p. 347)
- Publish/Subscribe policy examples (p. 353)
- Connect and publish policy examples (p. 367)
- Retained message policy examples (p. 368)
- Certificate policy examples (p. 370)
- Thing policy examples (p. 374)
- Basic job policy example (p. 375)

Connect policy examples

The following policy denies permission to client IDs client1 and client2 to connect to AWS IoT Core, while allowing devices to connect using a client ID. The client ID matches the name of a thing that's registered in the AWS IoT Core registry and attached to the principal that's used for connection:

**Note**

For registered devices, we recommend that you use thing policy variables (p. 342) for Connect actions and attach the thing to the principal that's used for the connection.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "iot.amazonaws.com"
            },
            "Action": "sts:AssumeRole",
            "Condition": {
                "StringEquals": {
                    "aws:SourceAccount": "123456789012"
                },
                "ArnLike": {
                    "aws:SourceArn": "arn:aws:iot:us-east-1:123456789012:*"
                }
            }
        }
    ]
}
```
The following policy grants permission to connect to AWS IoT Core with client ID client1. This policy example is for unregistered devices.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"],
      "Resource": ["arn:aws:iot:us-east-1:123456789012:client/client1"
    }
  ]
}
```

MQTT persistent sessions policy examples

`connectAttributes` allow you to specify what attributes you want to use in your connect message in your IAM policies such as `PersistentConnect` and `LastWill`. For more information, see Using `connectAttributes` (p. 97).

The following policy allows connect with `PersistentConnect` feature:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"],
      "Resource": ["arn:aws:iot:us-east-1:123456789012:client/client1"
    }
  ]
}
```
The following policy disallows PersistentConnect, other features are allowed:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"],
      "Condition": {
        "ForAllValues:StringNotEquals": {
          "iot:ConnectAttributes": ["PersistentConnect"]
        }
      }
    }
  ]
}
```

The above policy can also be expressed using StringEquals, any other feature including new feature is allowed:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"],
    },
    {
      "Effect": "Deny",
      "Action": ["iot:Connect"],
      "Resource": "*",
      "Condition": {
        "ForAnyValue:StringEquals": {
          "iot:ConnectAttributes": ["PersistentConnect"]
        }
      }
    }
  ]
}
```
The following policy allows connect by both PersistentConnect and LastWill, any other new feature is not allowed:

```json
{
    "Version": "2012-10-17",
    "Statement": [
    {
        "Effect": "Allow",
        "Action": ["iot:Connect"],
        "Condition": {
            "ForAllValues:StringEquals": {
                "iot:ConnectAttributes": ["PersistentConnect",
                                        "LastWill"
            ]
        }
    }
    ]
}
```

The following policy allows clean connect by clients with or without LastWill, no other features will be allowed:

```json
{
    "Version": "2012-10-17",
    "Statement": [
    {
        "Effect": "Allow",
        "Action": ["iot:Connect"],
        "Condition": {
            "ForAllValues:StringEquals": {
                "iot:ConnectAttributes": ["LastWill"
            ]
        }
    }
    ]
}
```

The following policy only allows connect using default features:

```json
{
    "Version": "2012-10-17",
    "Statement": [
    {
        "Effect": "Allow",
        "Action": ["iot:Connect"],
        "Condition": {
            "ForAllValues[StringEquals]: {"iot:ConnectAttributes": []
            }
        }
    }
    ]
}
```
The following policy allows connect only with `PersistentConnect`, any new feature is allowed as long as the connection uses `PersistentConnect`:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
      "Condition": {
        "ForAnyValue:StringEquals": {
          "iot:ConnectAttributes": [
            "PersistentConnect"
          ]
        }
      }
    }
  ]
}
```

The following policy states the connect must have both `PersistentConnect` and `LastWill` usage, no new feature is allowed:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
      "Condition": {
        "ForAllValues:StringEquals": {
          "iot:ConnectAttributes": [
            "PersistentConnect",
            "LastWill"
          ]
        }
      }
    },
    {
      "Effect": "Deny",
      "Action": [
        "iot:Connect"
      ],
      "Resource": "*",
      "Condition": {
        "ForAllValues:StringEquals": {
          "iot:ConnectAttributes": [
            "PersistentConnect"
          ]
        }
      }
    }
  ]
}
```
The following policy must not have `PersistentConnect` but can have `LastWill`, any other new feature is not allowed:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Deny",
         "Action": [
            "iot:Connect"
         ],
         "Resource": "*",
         "Condition": {
            "ForAllValues:StringEquals": {
               "iot:ConnectAttributes": [
                  "LastWill"
               ]
            }
         }
      },
      {
         "Effect": "Deny",
         "Action": [
            "iot:Connect"
         ],
         "Resource": "*",
         "Condition": {
            "ForAllValues:StringEquals": {
               "iot:ConnectAttributes": []
            }
         }
      },
      {
         "Effect": "Allow",
         "Action": [
            "iot:Connect"
         ],
         "Condition": {
            "ForAllValues:StringEquals": {
               "iot:ConnectAttributes": [
                  "LastWill"
               ]
            }
         }
      }
   ]
}
```
The following policy allows connect only by clients that have a LastWill topic "my/lastwill/topicName", any feature is allowed as long as it uses the LastWill topic:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": ["iot:Connect"],
         "Condition": {
            "ArnEquals": {
               "iot:LastWillTopic": "arn:aws:iotsm:us-east-1:123456789012:topic/my/lastwill/topicName"
            }
         }
      }
   ]
}
```

The following policy only allows clean connect using a specific LastWillTopic, any feature is allowed as long as it uses the LastWillTopic:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": ["iot:Connect"],
         "Condition": {
            "ArnEquals": {
               "iot:LastWillTopic": "arn:aws:iotsm:us-east-1:123456789012:topic/my/lastwill/topicName"
            }
         }
      },
      {
         "Effect": "Deny",
         "Action": ["iot:Connect"],
         "Resource": "*",
         "Condition": {
            "ForAnyValue: StringEquals": {
               "iot:ConnectAttributes": ["PersistentConnect"
            }
         }
      }
   ]
}
```

**Publish/Subscribe policy examples**

The policy you use depends on how you're connecting to AWS IoT Core. You can connect to AWS IoT Core by using an MQTT client, HTTP, or WebSocket. When you connect with an MQTT client, you're
authenticating with an X.509 certificate. When you connect over HTTP or the WebSocket protocol, you're authenticating with Signature Version 4 and Amazon Cognito.

**Note**
For registered devices, we recommend that you use thing policy variables (p. 342) for Connect actions and attach the thing to the principal that's used for the connection.

**In this section:**
- Using wildcard characters in MQTT and AWS IoT Core policies (p. 354)
- Policies to publish, subscribe and receive messages to/from specific topics (p. 355)
- Policies to publish, subscribe and receive messages to/from topics with a specific prefix (p. 356)
- Policies to publish, subscribe and receive messages to/from topics specific to each device (p. 358)
- Policies to publish, subscribe and receive messages to/from topics with thing attribute in topic name (p. 360)
- Policies to deny publishing messages to subtopics of a topic name (p. 361)
- Policies to deny receiving messages from subtopics of a topic name (p. 363)
- Policies to subscribe to topics using MQTT wildcard characters (p. 364)
- Policies for HTTP and WebSocket clients (p. 366)

**Using wildcard characters in MQTT and AWS IoT Core policies**

MQTT and AWS IoT Core policies have different wildcard characters and you should choose them after careful consideration. In MQTT, the wildcard characters # and + are used in MQTT topic filters to subscribe to multiple topic names. AWS IoT Core policies use * and ? as wildcard characters and follow the conventions of IAM policies. In a policy document, the * represents any combination of characters and a question mark ? represents any single character. In policy documents, the MQTT wildcard characters, + and # are treated as those characters with no special meaning. To describe multiple topic names and topic filters in the resource attribute of a policy, use the * and ? wildcard characters in place of the MQTT wildcard characters.

When choosing wildcard characters to use in a policy document, consider that the * character is not confined to a single topic level as the + character is in an MQTT topic filter. To help constrain a wildcard specification to a single MQTT topic filter level, consider using multiple ? characters. For more information about using wildcard characters in a policy resource and more examples of what they match, see Using wildcards in resource ARNs.

The table below shows the different wildcard characters used in MQTT and AWS IoT Core policies for MQTT clients.

<table>
<thead>
<tr>
<th>Wildcard character</th>
<th>Is MQTT wildcard character</th>
<th>Example in MQTT</th>
<th>Is AWS IoT Core policy wildcard character</th>
<th>Example in AWS IoT Core policies for MQTT clients</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>Yes</td>
<td>some/#</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>+</td>
<td>Yes</td>
<td>some/+/topic</td>
<td>No</td>
<td>N/A</td>
</tr>
<tr>
<td>*</td>
<td>No</td>
<td>N/A</td>
<td>Yes</td>
<td>topicfilter/some/<em>/topic topicfilter/some/sensor/</em>/topic</td>
</tr>
</tbody>
</table>
Wildcard character | Is MQTT wildcard character | Example in MQTT | Is AWS IoT Core policy wildcard character | Example in AWS IoT Core policies for MQTT clients
---|---|---|---|---
? | No | N/A | Yes | topic/some/?????/topic
topicfilter/some/sensor???/topic

**Policies to publish, subscribe and receive messages to/from specific topics**

The following shows examples for registered and unregistered devices to publish, subscribe and receive messages to/from the topic named "some_specific_topic". The examples also highlight that Publish and Receive use "topic" as the resource, and Subscribe uses "topicfilter" as the resource.

**Registered devices**

For devices registered in AWS IoT Core's Registry, the following policy allows devices to connect with clientId that matches the name of a thing in AWS IoT Core's Registry. It also provides Publish, Subscribe and Receive permissions for the topic named "some_specific_topic".

```json
{
"Version": "2012-10-17",
"Statement": [
{
"Effect": "Allow",
"Action": ["iot:Connect"],
"Condition": {
"Bool": {
"iot:Connection.Thing.IsAttached": "true"
}
}
},
{
"Effect": "Allow",
"Action": ["iot:Publish"],
"Resource": ["arn:aws:iot:us-east-1:123456789012:topic/some_specific_topic"
]
},
{
"Effect": "Allow",
"Action": ["iot:Subscribe"],
"Resource": ["arn:aws:iot:us-east-1:123456789012:topicfilter/some_specific_topic"
]
},
{
"Effect": "Allow",
"Action": ["iot:Receive"
]}
}
Unregistered devices

For devices not registered in AWS IoT Core's Registry, the following policy allows devices to connect using either clientId1, clientId2 or clientId3. It also provides Publish, Subscribe and Receive permissions for the topic named "some_specific_topic".

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:client/clientId1",
        "arn:aws:iot:us-east-1:123456789012:client/clientId2",
        "arn:aws:iot:us-east-1:123456789012:client/clientId3"
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topic/some_specific_topic"
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Subscribe"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topicfilter/some_specific_topic"
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Receive"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topic/some_specific_topic"
      ]
    }
  ]
}
```

Policies to publish, subscribe and receive messages to/from topics with a specific prefix

The following shows examples for registered and unregistered devices to publish, subscribe and receive messages to/from topics prefixed with "topic_prefix".
Note
Note the use of the wildcard character * in this example. Although the wildcard character * is useful to provide permissions for multiple topic names in a single statement, it can lead to unintended consequences by providing more privileges to devices than required. So we recommend that you only use the wildcard character * after careful consideration.

Registered devices
For devices registered in AWS IoT Core’s Registry, the following policy allows devices to connect with clientId that matches the name of a thing in AWS IoT Core’s Registry. It also provides Publish, Subscribe and Receive permissions for topics prefixed with "topic_prefix".

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish",
        "iot:Receive"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topic/topic_prefix*"
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Subscribe"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topicfilter/topic_prefix*"
      ]
    }
  ]
}
```

Unregistered devices
For devices not registered in AWS IoT Core’s Registry, the following policy allows devices to connect using either clientId1, clientId2 or clientId3. It also provides Publish, Subscribe and Receive permissions for topics prefixed with "topic_prefix".

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"],
      "Condition": {
        "Bool": {
          "iot:Connection.Thing.IsAttached": "true"
        }
      }
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish",
        "iot:Receive"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topic/topic_prefix*"
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Subscribe"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topicfilter/topic_prefix*"
      ]
    }
  ]
}
```
Policies to publish, subscribe and receive messages to/from topics specific to each device

The following shows examples for registered and unregistered devices to publish, subscribe and receive messages to/from topics that are specific to the given device.

Registered devices

For devices registered in AWS IoT Core's Registry, the following policy allows devices to connect with clientId that matches the name of a thing in AWS IoT Core's Registry. It provides permission to publish to the thing-specific topic (sensor/device/$\{\text{iota:Connection.\text{Thing.\text{ThingName}}}\}) and also subscribe to and receive from the thing-specific topic (command/device/$\{\text{iota:Connection.\text{Thing.\text{ThingName}}}\}). If the thing name in Registry is "thing1", then the device will be allowed to publish to the topic "sensor/device/thing1", and also subscribe to and receive from the topic "command/device/thing1".

```
"Version": "2012-10-17",
"Statement": [
  {
    "Effect": "Allow",
    "Action": [
      "iot:Connect"
    ],
    "Resource": [
      "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"
    ],
    "Condition": {
      "Bool": {
        "iot:Connection.Thing.IsAttached": "true"
      }
    }
  }
]
```
Unregistered devices

For devices not registered in AWS IoT Core's Registry, the following policy allows devices to connect using either clientId1, clientId2 or clientId3. It provides permission to publish to the client-specific topic (sensor/device/${iot:ClientId}), and also subscribe to and receive from the client-specific topic (command/device/${iot:ClientId}). If the device connects with clientId as clientId1, then it will be permitted to publish to the topic "sensor/device/clientId1", and subscribe to and receive from the topic device/clientId1/command.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "iot:Connect"
         ],
         "Resource": [
            "arn:aws:iot:us-east-1:123456789012:client/clientId1",
            "arn:aws:iot:us-east-1:123456789012:client/clientId2",
            "arn:aws:iot:us-east-1:123456789012:client/clientId3"
         ]
      },
      {
         "Effect": "Allow",
         "Action": [
            "iot:Publish"
         ],
         "Resource": [
            "arn:aws:iot:us-east-1:123456789012:topic/sensor/device/${iot:Connection.Thing.ThingName}"
         ]
      }
   ]
}
```
Policies to publish, subscribe and receive messages to/from topics with thing attribute in topic name

The following shows an example for registered devices to publish, subscribe and receive messages to/from topics whose names include thing attributes.

**Note**

Thing attributes only exist for devices registered in AWS IoT Core's Registry. There is no corresponding example for unregistered devices.

Registered devices

For devices registered in AWS IoT Core's Registry, the following policy allows devices to connect with clientId that matches the name of a thing in AWS IoT Core's Registry. It provides permission to publish to the topic (sensor/${iot:Connection.Thing.Attributes[version]}), and subscribe to and receive from the topic (command/${iot:Connection.Thing.Attributes[location]}) where the topic name includes thing attributes. If the thing name in Registry has version=v1 and location=Seattle, the device will be allowed to publish to the topic "sensor/v1", and subscribe to and receive from the topic "command/Seattle".

```json

```
Unregistered devices

Because thing attributes only exist for devices registered in AWS IoT Core's Registry, there is no corresponding example for unregistered things.

Policies to deny publishing messages to subtopics of a topic name

The following shows examples for registered and unregistered devices to publish messages to all topics except certain subtopics.

Registered devices

For devices registered in AWS IoT Core's Registry, the following policy allows devices to connect with clientid that matches the name of a thing in AWS IoT Core's Registry. It provides permission to publish to all topics prefixed with "department/" but not to the "department/admins" subtopic.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Publish"],
      "Resource": [
      ]
    },
    {
      "Effect": "Allow",
      "Action": ["iot:Subscribe"],
      "Resource": [
      ]
    },
    {
      "Effect": "Allow",
      "Action": ["iot:Receive"],
      "Resource": [
      ]
    }
  ]
}
```
Unregistered devices

For devices not registered in AWS IoT Core's Registry, the following policy allows devices to connect using either clientId1, clientId2 or clientId3. It provides permission to publish to all topics prefixed with "department/" but not to the "department/admins" subtopic.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Connect"],
            "Resource": [
                "arn:aws:iot:us-east-1:123456789012:client/clientId1",
                "arn:aws:iot:us-east-1:123456789012:client/clientId2",
                "arn:aws:iot:us-east-1:123456789012:client/clientId3"
            ]
        },
        {
            "Effect": "Allow",
            "Action": ["iot:Publish"],
            "Resource": [
                "arn:aws:iot:us-east-1:123456789012:topic/department/"*
            ]
        },
        {
            "Effect": "Deny",
            "Action": ["iot:Publish"],
            "Resource": [
                "arn:aws:iot:us-east-1:123456789012:topic/department/admins"
            ]
        }
    ]
}
```
Policies to deny receiving messages from subtopics of a topic name

The following shows examples for registered and unregistered devices to subscribe to and receive messages from topics with specific prefixes except certain subtopics.

Registered devices

For devices registered in AWS IoT Core's Registry, the following policy allows devices to connect with clientId that matches the name of a thing in AWS IoT Core's Registry. The policy allows devices to subscribe to any topic prefixed with "topic_prefix". By using NotResource in the statement for iot:Receive, we allow the device to receive messages from all topics that the device has subscribed to, except the topics prefixed with "topic_prefix/restricted". For example, with this policy, devices can subscribe to "topic_prefix/topic1" and even "topic_prefix/restricted", however, they will only receive messages from the topic "topic_prefix/topic1" and no messages from the topic "topic_prefix/restricted".

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Connect"],
            "Condition": {
                "Bool": {
                    "iot:Connection.Thing.IsAttached": "true"
                }
            }
        },
        {
            "Effect": "Allow",
            "Action": "iot:Subscribe",
            "Resource": "arn:aws:iot:us-east-1:123456789012:topicfilter/topic_prefix/*"
        },
        {
            "Effect": "Allow",
            "Action": "iot:Receive",
        }
    ]
}
```

Unregistered devices

For devices not registered in AWS IoT Core's Registry, the following policy allows devices to connect using either clientId1, clientId2 or clientId3. The policy allows devices to subscribe to any topic prefixed with "topic_prefix". By using NotResource in the statement for iot:Receive, we allow the device to receive messages from all topics that the device has subscribed to, except topics prefixed with "topic_prefix/restricted". For example, with this policy, devices can subscribe to "topic_prefix/topic1" and even "topic_prefix/restricted", however, they will only receive messages from the topic "topic_prefix/topic1" and no messages from the topic "topic_prefix/restricted".

```json
{
    "Version": "2012-10-17",
}
```
"Statement": [
  {
    "Effect": "Allow",
    "Action": [
      "iot:Connect"
    ],
    "Resource": [
      "arn:aws:iot:us-east-1:123456789012:client/clientId1",
      "arn:aws:iot:us-east-1:123456789012:client/clientId2",
      "arn:aws:iot:us-east-1:123456789012:client/clientId3"
    ],
    "Condition": {
      "Bool": {
        "iot:Connection.Thing.IsAttached": "true"
      }
    }
  },
  {
    "Effect": "Allow",
    "Action": "iot:Subscribe",
    "Resource": "arn:aws:iot:us-east-1:123456789012:topicfilter/topic_prefix/"n",
  },
  {
    "Effect": "Allow",
    "Action": "iot:Receive",
  }
]

Policies to subscribe to topics using MQTT wildcard characters

MQTT wildcard characters + and # are treated as literal strings, but they are not treated as wildcards when used in AWS IoT Core policies. In MQTT, + and # are treated as wildcards only when subscribing to a topic filter but as a literal string in all other contexts. We recommend that you only use these MQTT wildcards as part of AWS IoT Core policies after careful consideration.

The following shows examples for registered and unregistered things using MQTT wildcards in AWS IoT Core policies. These wildcards are treated as literal strings.

Registered devices

For devices registered in AWS IoT Core's Registry, the following policy allows devices to connect with clientId that matches the name of a thing in AWS IoT Core's Registry. The policy allows devices to subscribe to the topics "department/+/employees" and "location/#". Note that since + and # are treated as literal strings in AWS IoT Core policies, devices can subscribe to the topic "department/+/employees" but not to the topic "department/engineering/employees". Similarly, devices can subscribe to the topic "location/#" but not to the topic "location/Seattle". However, once the device subscribes to the topic "department/+/employees", the policy will allow them to receive messages from the topic "department/engineering/employees". Similarly, once the device subscribes to the topic "location/#", they will receive messages from the topic "location/Seattle" as well.

"Version": "2012-10-17",
"Statement": [
  {
    "Effect": "Allow",
    "Action": ["iot:Subscribe"
    ],
  },
  {
    "Effect": "Allow",
    "Action": "iot:Receive",
  }
]
Unregistered devices

For devices not registered in AWS IoT Core's Registry, the following policy allows devices to connect using either clientId1, clientId2 or clientId3. The policy allows devices to subscribe to the topics of "department/+/employees" and "location/#". Note that since + and # are treated as literal strings in AWS IoT Core policies, devices can subscribe to the topic "department/+/employees" but not to the topic "department/engineering/employees". Similarly, devices can subscribe to the topic "location/#" but not "location/Seattle". However, once the device subscribes to the topic "department/+/employees", the policy will allow them to receive messages from the topic "department/engineering/employees". Similarly, once the device subscribes to the topic "location/#", they will receive messages from the topic "location/Seattle" as well.
Policies for HTTP and WebSockets clients

When you connect over HTTP or the WebSocket protocol, you're authenticating with Signature Version 4 and Amazon Cognito. Amazon Cognito identities can be authenticated or unauthenticated. Authenticated identities belong to users who are authenticated by any supported identity provider. Unauthenticated identities typically belong to guest users who do not authenticate with an identity provider. Amazon Cognito provides a unique identifier and AWS credentials to support unauthenticated identities. For more information, see the section called "Authorization with Amazon Cognito identities" (p. 376).

For the following operations, AWS IoT Core uses AWS IoT Core policies attached to Amazon Cognito identities (through the AttachPolicy API) to scope down the permissions attached to the Amazon Cognito Identity pool with authenticated identities.

- `iot:Connect`
- `iot:Publish`
- `iot:Subscribe`
- `iot:Receive`
- `iot:GetThingShadow`
- `iot:UpdateThingShadow`
- `iot:DeleteThingShadow`

That means an Amazon Cognito Identity needs permission from the IAM role policy attached to the pool and the AWS IoT Core policy attached to the Amazon Cognito Identity through the AWS IoT Core AttachPolicy API.

Authenticated and unauthenticated users are different identity types. If you don't attach an AWS IoT policy to the Amazon Cognito Identity, an authenticated user fails authorization in AWS IoT and doesn't have access to AWS IoT resources and actions.

**Note**

For other AWS IoT Core operations or for unauthenticated identities, AWS IoT Core does not scope down the permissions attached to the Amazon Cognito identity pool role. For both authenticated and unauthenticated identities, this is the most permissive policy that we recommend you attach to the Amazon Cognito pool role.

HTTP

To allow unauthenticated Amazon Cognito identities to publish messages over HTTP on a topic specific to the Amazon Cognito Identity, attach the following IAM policy to the Amazon Cognito Identity pool role:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish",
      ],
    }
  ]
}
```
To allow authenticated users, attach the preceding policy to the Amazon Cognito Identity pool role and to the Amazon Cognito Identity using the AWS IoT Core AttachPolicy API.

**Note**
When authorizing Amazon Cognito identities, AWS IoT Core considers both policies and grants the least privileges specified. An action is allowed only if both policies allow the requested action. If either policy disallows an action, that action is unauthorized.

**MQTT**

To allow unauthenticated Amazon Cognito identities to publish MQTT messages over WebSocket on a topic specific to the Amazon Cognito Identity in your account, attach the following IAM policy to the Amazon Cognito Identity pool role:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Publish"],
        },
        {
            "Effect": "Allow",
            "Action": ["iot:Connect"],
        }
    ]
}
```

To allow authenticated users, attach the preceding policy to the Amazon Cognito Identity pool role and to the Amazon Cognito Identity using the AWS IoT Core AttachPolicy API.

**Note**
When authorizing Amazon Cognito identities, AWS IoT Core considers both and grants the least privileges specified. An action is allowed only if both policies allow the requested action. If either policy disallows an action, that action is unauthorized.

**Connect and publish policy examples**

For devices registered as things in the AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with a client ID that matches the thing name and restricts the device to publishing on a client-ID or thing name-specific MQTT topic. For a connection to be successful, the thing name must be registered in the AWS IoT Core registry and be authenticated using an identity or principal attached to the thing:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Publish"],
        }
    ]
}
```
For devices not registered as things in the AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with client ID `client1` and restricts the device to publishing on a `clientID-specific MQTT topic`:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Publish"],
      "Resource": ["arn:aws:iot:us-east-1:123456789012:topic/${iot:ClientId}"
    },
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"],
      "Resource": ["arn:aws:iot:us-east-1:123456789012:client/client1"
    }
  ]
}
```

Retained message policy examples

Using retained messages (p. 92) requires specific policies. Retained messages are MQTT messages published with the RETAIN flag set and stored by AWS IoT Core. This section presents examples of policies that allow common uses of retained messages.

In this section:

- Policy to connect and publish retained messages (p. 368)
- Policy to connect and publish retained Will messages (p. 369)
- Policy to list and get retained messages (p. 369)

Policy to connect and publish retained messages

For a device to publish retained messages, the device must be able to connect, publish (any MQTT message), and publish MQTT retained messages. The following policy grants these permissions for the topic: `device/sample/configuration` to client `device1`. For another example that grants permission to connect, see the section called “Connect and publish policy examples” (p. 367).

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"
        ],
      "Resource": ["arn:aws:iot:us-east-1:123456789012:client/device1"
    }
  ]
}
```
Clients can configure a message that AWS IoT Core will publish when the client disconnects unexpectedly. MQTT calls such a message a *Will message*. A client must have an additional condition added to its connect permission to include them.

The following policy document grants all clients permission to connect and publish a Will message, identified by its topic, `will`, that AWS IoT Core will also retain.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [ "iot:Connect"
      ],
      "Resource": [ "arn:aws:iot:us-east-1:123456789012:client/device1"
      ],
      "Condition": {
        "ForAllValues:StringEquals": {
          "iot:ConnectAttributes": [
            "LastWill"
          ]
        }
      }
    },
    {
      "Effect": "Allow",
      "Action": [ "iot:Publish", "iot:RetainPublish"
      ],
      "Resource": [ "arn:aws:iot:us-east-1:123456789012:topic/will"
      ]
    }
  ]
}
```

## Policy to list and get retained messages

Services and applications can access retained messages without the need to support an MQTT client by calling `ListRetainedMessages` and `GetRetainedMessage`. The services and applications that call these actions must be authorized by using a policy such as the following example.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [ "iot:GetRetainedMessage"
      ],
    }
  ]
}
```
Certificate policy examples

For devices registered in AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with a client ID that matches a thing name, and to publish to a topic whose name is equal to the certificateId of the certificate the device used to authenticate itself:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish"
            ],
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Connect"
            ],
        }
    ]
}
```

For devices not registered in the AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with client IDs, client1, client2, and client3 and to publish to a topic whose name is equal to the certificateId of the certificate the device used to authenticate itself:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish"
            ],
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish"
            ],
        }
    ]
}
```
For devices registered in AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with a client ID that matches the thing name, and to publish to a topic whose name is equal to the subject's CommonName field of the certificate the device used to authenticate itself:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish"
      ],
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
    }
  ]
}
```

**Note**

In this example, the certificate's subject common name is used as the topic identifier, with the assumption that the subject common name is unique for each registered certificate. If the certificates are shared across multiple devices, the subject common name is the same for all the devices that share this certificate, thereby allowing publish privileges to the same topic from multiple devices (not recommended).

For devices not registered in AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with client IDs, `client1`, `client2`, and `client3` and to publish to a topic whose name is equal to the subject's CommonName field of the certificate the device used to authenticate itself:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish"
      ],
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
    }
  ]
}
```
In this example, the certificate's subject common name is used as the topic identifier, with the assumption that the subject common name is unique for each registered certificate. If the certificates are shared across multiple devices, the subject common name is the same for all the devices that share this certificate, thereby allowing publish privileges to the same topic from multiple devices (not recommended).

For devices registered in the AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with a client ID that matches the thing name, and to publish to a topic whose name is prefixed with admin/ when the certificate used to authenticate the device has its Subject.CommonName.2 field set to Administrator:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Connect"
            ],
            "Resource": [
                "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish"
            ],
            "Resource": [
                "arn:aws:iot:us-east-1:123456789012:topic/admin/*"
            ],
            "Condition": {
                "StringEquals": {
                    "iot:Certificate.Subject.CommonName.2": "Administrator"
                }
            }
        }
    ]
}
```

For devices not registered in AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with client IDs client1, client2, and client3 and to publish to a topic whose name is prefixed with admin/ when the certificate used to authenticate the device has its Subject.CommonName.2 field set to Administrator:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Connect"
            ],
            "Resource": [
                "arn:aws:iot:us-east-1:123456789012:client/client1",
                "arn:aws:iot:us-east-1:123456789012:client/client2",
                "arn:aws:iot:us-east-1:123456789012:client/client3"
            ]
        }
    ]
}
```
For devices registered in AWS IoT Core registry, the following policy allows a device to use its thing name to publish on a specific topic that consists of `admin/` followed by the `ThingName` when the certificate used to authenticate the device has any one of its `Subject.CommonName` fields set to `Administrator`:

```
{  
  "Version": "2012-10-17", 
  "Statement": [  
    {  
      "Effect": "Allow", 
      "Action": [  
        "iot:Connect"  
      ], 
    },  
    {  
      "Effect": "Allow", 
      "Action": [  
        "iot:Publish" 
      ], 
      "Condition": {  
        "ForAnyValue:StringEquals": {  
          "iot:Certificate.Subject.CommonName.List": "Administrator"  
        }  
      }  
    }  
  ]
}
```

For devices not registered in AWS IoT Core registry, the following policy grants permission to connect to AWS IoT Core with client IDs `client1`, `client2`, and `client3` and to publish to the topic `admin` when the certificate used to authenticate the device has any one of its `Subject.CommonName` fields set to `Administrator`:

```
{  
  "Version": "2012-10-17", 
  "Statement": [  
    {  
      "Effect": "Allow", 
      "Action": [  
        "iot:Connect"  
      ], 
      "Resource": ["arn:aws:iot:us-east-1:123456789012:client/client1",  
        "arn:aws:iot:us-east-1:123456789012:client/client2",  
        "arn:aws:iot:us-east-1:123456789012:client/client3"  
      ],
    },  
    {  
      "Effect": "Allow", 
      "Action": [  
        "iot:Publish" 
      ], 
      "Resource": ["arn:aws:iot:us-east-1:123456789012:topic/admin/*"],
      "Condition": {  
        "StringEquals": {  
          "iot:Certificate.Subject.CommonName.2": "Administrator"  
        }  
      }  
    }  
  ]
}
```
"iot:Connect"
],
"Resource": [
    "arn:aws:iot:us-east-1:123456789012:client/client1",
    "arn:aws:iot:us-east-1:123456789012:client/client2",
    "arn:aws:iot:us-east-1:123456789012:client/client3"
]
},
{
    "Effect": "Allow",
    "Action": [
        "iot:Publish"
    ],
    "Resource": ["arn:aws:iot:us-east-1:123456789012:topic/admin"],
    "Condition": {
        "ForAnyValue:StringEquals": {
            "iot:Certificate.Subject.CommonName.List": "Administrator"
        }
    }
}]
}
]

**Thing policy examples**

The following policy allows a device to connect if the certificate used to authenticate with AWS IoT Core is attached to the thing for which the policy is being evaluated:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Connect"],
            "Resource": ["*"]
        },
        {
            "Effect": "Allow",
            "Action": ["iot:Publish"],
            "Resource": ["arn:aws:iot:us-east-1:123456789012:topic/admin"],
            "Condition": {
                "StringEquals": {
                    "iot:Connection.Thing.IsAttached": ["true"]
                }
            }
        }
    ]
}
```

The following policy allows a device to publish if the certificate is attached to a thing with a particular thing type and if the thing has an attribute of attributeName with value attributeValue. For more information about thing policy variables, see [Thing policy variables](p. 342).

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Publish"],
            "Condition": {
                "StringEquals": {
                    "iot:Connection.Thing.TypeName": "Thing_Type_Name"
                },
                "Bool": {
                    "iot:Connection.Thing.Attributes[attributeName]": "attributeValue"
                }
            }
        }
    ]
}
```
The following policy allows a device to publish to a topic that starts with an attribute of the thing. If the device certificate is not associated with the thing, this variable won't be resolved and will result in an access denied error. For more information about thing policy variables, see Thing policy variables (p. 342).

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish"
      ],
    }
  ]
}
```

**Basic job policy example**

This sample shows the policy statements required for a job target that's a single device to receive a job request and communicate job execution status with AWS IoT.

Replace `us-west-2:57EXAMPLE833` with your AWS Region, a colon character (:), and your 12-digit AWS account number, and then replace `uniqueThingName` with the name of the thing resource that represents the device in AWS IoT.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
      "Resource": "arn:aws:iot:us-west-2:57EXAMPLE833:client/uniqueThingName"
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish"
      ],
      "Resource": [
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
```
Authorization with Amazon Cognito identities

There are two types of Amazon Cognito identities: unauthenticated and authenticated. If your app supports unauthenticated Amazon Cognito identities, no authentication is performed, so you don't know who the user is.

**Unauthenticated Identities:** For unauthenticated Amazon Cognito identities, you grant permissions by attaching an IAM role to an unauthenticated identity pool. We recommend that you only grant access to those resources you want available to unknown users.

**Important**
For unauthenticated Amazon Cognito users connecting to AWS IoT Core, we recommend that you give access to very limited resources in IAM policies.

**Authenticated Identities:** For authenticated Amazon Cognito identities, you need to specify permissions in two places:

- Attach an IAM policy to the authenticated Amazon Cognito Identity pool and

- Attach an AWS IoT Core policy to the Amazon Cognito Identity (authenticated user).

**Policy examples for unauthenticated and authenticated Amazon Cognito users connecting to AWS IoT Core**

The following example shows permissions in both the IAM policy and the IoT policy of an Amazon Cognito identity. The authenticated user wants to publish to a device specific topic (e.g. device/DEVICE_ID/status).
The following example shows the permissions in an IAM policy of an Amazon Cognito unauthenticated role. The unauthenticated user wants to publish to non-device specific topics that do not require authentication.

GitHub examples

The following example web applications on GitHub show how to incorporate policy attachment to authenticated users into the user signup and authentication process.

- MQTT publish/subscribe React web application using AWS Amplify and the AWS IoT Device SDK for JavaScript
- MQTT publish/subscribe React web application using AWS Amplify, the AWS IoT Device SDK for JavaScript, and a Lambda function
Amplify is a set of tools and services that helps you build web and mobile applications that integrate with AWS services. For more information about Amplify, see Amplify Framework Documentation.

Both examples perform the following steps.

1. When a user signs up for an account, the application creates an Amazon Cognito user pool and identity.

2. When a user authenticates, the application creates and attaches a policy to the identity. This gives the user publish and subscribe permissions.

3. The user can use the application to publish and subscribe to MQTT topics.

The first example uses the AttachPolicy API operation directly inside the authentication operation. The following example demonstrates how to implement this API call inside a React web application that uses Amplify and the AWS IoT Device SDK for JavaScript.

```javascript
function attachPolicy(id, policyName) {
  var Iot = new AWS.Iot({region: AWSConfiguration.region, apiVersion: AWSConfiguration.apiVersion, endpoint: AWSConfiguration.endpoint});
  var params = {policyName: policyName, target: id};

  console.log("Attach IoT Policy: " + policyName + " with cognito identity id: " + id);
  Iot.attachPolicy(params, function(err, data) {
    if (err) {
      if (err.code !== 'ResourceAlreadyExistsException') {
        console.log(err);
      }
    } else {
      console.log("Successfully attached policy with the identity", data);
    }
  });
}
```

This code appears in the AuthDisplay.js file.

The second example implements the AttachPolicy API operation in a Lambda function. The following example shows how the Lambda uses this API call.

```javascript
iot.attachPolicy(params, function(err, data) {
  if (err) {
    if (err.code !== 'ResourceAlreadyExistsException') {
      console.log(err);
      res.json({error: err, url: req.url, body: req.body});
    }
  } else {
    console.log(data);
    res.json({success: 'Create and attach policy call succeed!', url: req.url, body: req.body});
  }
});
```

This code appears inside the iot.GetPolicy function in the app.js file.
Authorizing direct calls to AWS services using AWS IoT Core credential provider

Devices can use X.509 certificates to connect to AWS IoT Core using TLS mutual authentication protocols. Other AWS services do not support certificate-based authentication, but they can be called using AWS credentials in AWS Signature Version 4 format. The Signature Version 4 algorithm normally requires the caller to have an access key ID and a secret access key. AWS IoT Core has a credentials provider that allows you to use the built-in X.509 certificate as the unique device identity to authenticate AWS requests. This eliminates the need to store an access key ID and a secret access key on your device.

The credentials provider authenticates a caller using an X.509 certificate and issues a temporary, limited-privilege security token. The token can be used to sign and authenticate any AWS request. This way of authenticating your AWS requests requires you to create and configure an AWS Identity and Access Management (IAM) role and attach appropriate IAM policies to the role so that the credentials provider can assume the role on your behalf. For more information about AWS IoT Core and IAM, see Identity and access management for AWS IoT (p. 390).

AWS IoT requires devices to send the Server Name Indication (SNI) extension to the Transport Layer Security (TLS) protocol and provide the complete endpoint address in the host_name field. The host_name field must contain the endpoint you are calling, and it must be:

- The endpointAddress returned by aws iot describe-endpoint --endpoint-type iot:CredentialProvider.

Connections attempted by devices without the correct host_name value will fail.

The following diagram illustrates the credentials provider workflow.
1. The AWS IoT Core device makes an HTTPS request to the credentials provider for a security token. The request includes the device X.509 certificate for authentication.

2. The credentials provider forwards the request to the AWS IoT Core authentication and authorization module to validate the certificate and verify that the device has permission to request the security token.

3. If the certificate is valid and has permission to request a security token, the AWS IoT Core authentication and authorization module returns success. Otherwise, it sends an exception to the device.

4. After successfully validating the certificate, the credentials provider invokes the AWS Security Token Service (AWS STS) to assume the IAM role that you created for it.

5. AWS STS returns a temporary, limited-privilege security token to the credentials provider.

6. The credentials provider returns the security token to the device.

7. The device uses the security token to sign an AWS request with AWS Signature Version 4.

8. The requested service invokes IAM to validate the signature and authorize the request against access policies attached to the IAM role that you created for the credentials provider.

9. If IAM validates the signature successfully and authorizes the request, the request is successful. Otherwise, IAM sends an exception.

The following section describes how to use a certificate to get a security token. It is written with the assumption that you have already registered a device and created and activated your own certificate for it.
How to use a certificate to get a security token

1. Configure the IAM role that the credentials provider assumes on behalf of your device. Attach the following trust policy to the role.

   ```json
   {
     "Version": "2012-10-17",
     "Statement": {
       "Effect": "Allow",
       "Principal": {"Service": "credentials.iot.amazonaws.com"},
       "Action": "sts:AssumeRole"
     }
   }
   ```

   For each AWS service that you want to call, attach an access policy to the role. The credentials provider supports the following policy variables:

   - credentials-iot:ThingName
   - credentials-iot:ThingTypeName
   - credentials-iot:AwsCertificateId

   When the device provides the thing name in its request to an AWS service, the credentials provider adds credentials-iot:ThingName and credentials-iot:ThingTypeName as context variables to the security token. The credentials provider provides credentials-iot:AwsCertificateId as a context variable even if the device doesn't provide the thing name in the request. You pass the thing name as the value of the x-amzn-iot-thingname HTTP request header.

   These three variables work for IAM policies only, not AWS IoT Core policies.

2. Make sure that the user who performs the next step (creating a role alias) has permission to pass the newly created role to AWS IoT Core. The following policy gives both iam:GetRole and iam:PassRole permissions to an AWS user. The iam:GetRole permission allows the user to get information about the role that you've just created. The iam:PassRole permission allows the user to pass the role to another AWS service.

   ```json
   {
     "Version": "2012-10-17",
     "Statement": {
       "Effect": "Allow",
       "Action": ["iam:GetRole", "iam:PassRole"],
       "Resource": "arn:aws:iam::your AWS account id:role/your role name"
     }
   }
   ```

3. Create an AWS IoT Core role alias. The device that is going to make direct calls to AWS services must know which role ARN to use when connecting to AWS IoT Core. Hard-coding the role ARN is not a good solution because it requires you to update the device whenever the role ARN changes. A better solution is to use the CreateRoleAlias API to create a role alias that points to the role ARN. If the role ARN changes, you simply update the role alias. No change is required on the device. This API takes the following parameters:
roleAlias

Required. An arbitrary string that identifies the role alias. It serves as the primary key in the role alias data model. It contains 1-128 characters and must include only alphanumeric characters and the =, @, and - symbols. Uppercase and lowercase alphabetic characters are allowed.

documentation

roleArn

Required. The ARN of the role to which the role alias refers.

credentialDurationSeconds

Optional. How long (in seconds) the credential is valid. The minimum value is 900 seconds (15 minutes). The maximum value is 43,200 seconds (12 hours). The default value is 3,600 seconds (1 hour).

**Note**
The AWS IoT Core Credential Provider can issue a credential with a maximum lifetime of 43,200 seconds (12 hours). Having the credential be valid for up to 12 hours can help reduce the number of calls to the credential provider by caching the credential longer. The credentialDurationSeconds value must not be less than or equal to the maximum session duration of the IAM role that the role alias references.

For more information about this API, see CreateRoleAlias.

4. Attach a policy to the device certificate. The policy attached to the device certificate must grant the device permission to assume the role. You do this by granting permission for the iot:AssumeRoleWithCertificate action to the role alias, as in the following example.

```json
{
  "Version":"2012-10-17",
  "Statement":[
    {
      "Effect":"Allow",
      "Action":"iot:AssumeRoleWithCertificate",
      "Resource":"arn:aws:iot:your region:your_aws_account_id:rolealias/your role alias"
    }
  ]
}
```

5. Make an HTTPS request to the credentials provider to get a security token. Supply the following information:

- **Certificate**: Because this is an HTTP request over TLS mutual authentication, you must provide the certificate and the private key to your client while making the request. Use the same certificate and private key you used when you registered your certificate with AWS IoT Core.

  To make sure your device is communicating with AWS IoT Core (and not a service impersonating it), see Server Authentication, follow the links to download the appropriate CA certificates, and then copy them to your device.

- **RoleAlias**: The name of the role alias that you created for the credentials provider.

- **ThingName**: The thing name that you created when you registered your AWS IoT Core thing. This is passed as the value of the x-amzn-iot-thingname HTTP header. This value is required only if you are using thing attributes as policy variables in AWS IoT Core or IAM policies.

  **Note**
The ThingName that you provide in x-amzn-iot-thingname must match the name of the AWS IoT Thing resource assigned to a cert. If it doesn't match, a 403 error is returned.
Cross account access with IAM

AWS IoT Core allows you to enable a principal to publish or subscribe to a topic that is defined in an AWS account not owned by the principal. You configure cross account access by creating an IAM policy and IAM role and then attaching the policy to the role.

First, create a customer managed IAM policy as described in Creating IAM Policies, just like you would for other users and certificates in your AWS account.

For devices registered in AWS IoT Core registry, the following policy grants permission to devices connect to AWS IoT Core using a client ID that matches the device's thing name and to publish to the my/topic/thing-name where thing-name is the device's thing name:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [ "iot:Connect"
    }
  ]
}
```
For devices not registered in AWS IoT Core registry, the following policy grants permission to a device to use the thing name `client1` registered in your account's (123456789012) AWS IoT Core registry to connect to AWS IoT Core and to publish to a client ID-specific topic whose name is prefixed with `my/topic/`:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [ "iot:Connect" ],
      "Resource": [ "arn:aws:iot:us-east-1:123456789012:client/client1" ]
    },
    {
      "Effect": "Allow",
      "Action": [ "iot:Publish" ],
    }
  ]
}
```

Next, follow the steps in [Creating a role to delegate permissions to an IAM user](#). Enter the account ID of the AWS account with which you want to share access. Then, in the final step, attach the policy you just created to the role. If, at a later time, you need to modify the AWS account ID to which you are granting access, you can use the following trust policy format to do so:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Principal": { "AWS": "arn:aws:iam:us-east-1:1234567890123456:user/MyUser" },
      "Action": "sts:AssumeRole"
    }]
}
```
Data protection in AWS IoT Core

The AWS shared responsibility model applies to data protection in AWS IoT Core. As described in this model, AWS is responsible for protecting the global infrastructure that runs all of the AWS Cloud. You are responsible for maintaining control over your content that is hosted on this infrastructure. This content includes the security configuration and management tasks for the AWS services that you use. For more information about data privacy, see the Data Privacy FAQ. For information about data protection in Europe, see the AWS Shared Responsibility Model and GDPR blog post on the AWS Security Blog.

For data protection purposes, we recommend that you protect AWS account credentials and set up individual users with AWS IAM Identity Center or AWS Identity and Access Management (IAM). That way, each user is given only the permissions necessary to fulfill their job duties. We also recommend that you secure your data in the following ways:

- Use multi-factor authentication (MFA) with each account.
- Use SSL/TLS to communicate with AWS resources. We require TLS 1.2 and recommend TLS 1.3.
- Set up API and user activity logging with AWS CloudTrail.
- Use AWS encryption solutions, along with all default security controls within AWS services.
- Use advanced managed security services such as Amazon Macie, which assists in discovering and securing sensitive data that is stored in Amazon S3.
- If you require FIPS 140-2 validated cryptographic modules when accessing AWS through a command line interface or an API, use a FIPS endpoint. For more information about the available FIPS endpoints, see Federal Information Processing Standard (FIPS) 140-2.

We strongly recommend that you never put confidential or sensitive information, such as your customers’ email addresses, into tags or free-form text fields such as a Name field. This includes when you work with AWS IoT or other AWS services using the console, API, AWS CLI, or AWS SDKs. Any data that you enter into tags or free-form text fields used for names may be used for billing or diagnostic logs. If you provide a URL to an external server, we strongly recommend that you do not include credentials information in the URL to validate your request to that server.

For more information about data protection, see the AWS Shared Responsibility Model and GDPR blog post on the AWS Security Blog.

AWS IoT devices gather data, perform some manipulation on that data, and then send that data to another web service. You might choose to store some data on your device for a short period of time. You're responsible for providing any data protection on that data at rest. When your device sends data to AWS IoT, it does so over a TLS connection as discussed later in this section. AWS IoT devices can send data to any AWS service. For more information about each service’s data security, see the documentation for that service. AWS IoT can be configured to write logs to CloudWatch Logs and log AWS IoT API calls to AWS CloudTrail. For more information about data security for these services, see Authentication and Access Control for Amazon CloudWatch and Encrypting CloudTrail Log Files with AWS KMS-Managed Keys.

Data encryption in AWS IoT

By default, all AWS IoT data in transit and at rest is encrypted. Data in transit is encrypted using TLS (p. 386), and data at rest is encrypted using AWS owned keys. AWS IoT does not currently support customer-managed AWS KMS keys (KMS keys) from AWS Key Management Service (AWS KMS); however, Device Advisor and AWS IoT Wireless use only an AWS owned key to encrypt customer data.
Transport security in AWS IoT Core

TLS (Transport Layer Security) is a cryptographic protocol that is designed for secure communication over a computer network. The AWS IoT Core Device Gateway requires customers to encrypt all communication while in-transit by using TLS for connections from devices to the Gateway. TLS is used to achieve confidentiality of the application protocols (MQTT, HTTP, and WebSocket) supported by AWS IoT Core. TLS support is available in a number of programming languages and operating systems. Data within AWS is encrypted by the specific AWS service. For more information about data encryption on other AWS services, see the security documentation for that service.

Contents

• TLS protocols (p. 386)
• Security policies (p. 386)
• Important notes for transport security in AWS IoT Core (p. 388)
• Transport security for LoRaWAN wireless devices (p. 389)

TLS protocols

AWS IoT Core supports the following versions of the TLS protocol:

• TLS 1.3
• TLS 1.2

With AWS IoT Core, you can configure the TLS settings (for TLS 1.2 and TLS 1.3) in domain configurations. For more information, see ??? (p. 128).

Security policies

A security policy is a combination of TLS protocols and their ciphers that determine which protocols and ciphers are supported during TLS negotiations between a client and a server. You can configure your devices to use predefined security policies based on your needs. Note that AWS IoT Core doesn't support custom security policies.

You can choose one of the predefined security policies for your devices when connecting them to AWS IoT Core. The names of the most recent predefined security policies in AWS IoT Core include version information based on the year and month that they were released. The default predefined security policy is IoTSecurityPolicy_TLS13_1_2_2022_10. To specify a security policy, you can use the AWS IoT console or the AWS CLI. For more information, see ??? (p. 128).

The following table describes the most recent predefined security policies that AWS IoT Core supports. The IoTSecurityPolicy_ has been removed from policy names in the heading row so that they fit.

<table>
<thead>
<tr>
<th>Security policy</th>
<th>TLS13_1_3</th>
<th>TLS13_1_2</th>
<th>TLS12_1_2</th>
<th>TLS12_1_0_2016_01*</th>
<th>TLS12_1_0_2015_01*</th>
</tr>
</thead>
<tbody>
<tr>
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<td>443/8443/8883</td>
<td>8443/8883</td>
<td>8443</td>
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</tr>
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<td>✓</td>
</tr>
<tr>
<td>TLS 1.2</td>
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<td>✓</td>
<td>✓</td>
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<td>✓</td>
</tr>
<tr>
<td>TLS 1.3</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>TLS Ciphers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Security policy</td>
<td>TLS13_1_3</td>
<td>TLS13_1_2</td>
<td>TLS12_1_2</td>
<td>TLS12_1_0_2016_01*</td>
<td>TLS12_1_0_2015_01*</td>
</tr>
<tr>
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<td>-----------</td>
<td>-------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>TLS_AES_128_GCM_SHA256</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLS_AES_256_GCM_SHA384</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLS_CHACHA20_ROLY1305_SHA256</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECDHE-RSA-AES128-GCM-SHA256</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-RSA-AES128-SHA</td>
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<td></td>
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<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-RSA-AES256-GCM-SHA384</td>
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<td>✓</td>
</tr>
<tr>
<td>ECDHE-RSA-AES256-SHA384</td>
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</tr>
<tr>
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<td></td>
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<td>✓</td>
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</tr>
<tr>
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<td>✓</td>
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</tr>
<tr>
<td>AES128-SHA256</td>
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<td>✓</td>
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<td>✓</td>
</tr>
<tr>
<td>AES128-SHA</td>
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<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>AES256-GCM-SHA384</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>AES256-SHA256</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>AES256-SHA</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
### Transport security in AWS IoT Core

**Security policy** | **TLS13_1_3** | **TLS13_1_2** | **TLS12_1_2** | **TLS12_1_0_2016_01** | **TLS12_1_0_2015_01** |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DHE-RSA-AES256-SHA</td>
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<td></td>
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<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-ECDSA-AES128-GCM-SHA256</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-ECDSA-AES128-SHA</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-ECDSA-AES128-SHA</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-ECDSA-AES256-GCM-SHA384</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-ECDSA-AES256-SHA384</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ECDHE-ECDSA-AES256-SHA</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Note**

TLS12_1_0_2016_01 is only available in the following AWS Regions: ap-east-1, ap-northeast-2, ap-south-1, ap-southeast-2, ca-central-1, cn-north-1, cn-northwest-1, eu-north-1, eu-west-2, eu-west-3, me-south-1, sa-east-1, us-east-2, us-gov-west-1, us-gov-west-2, us-west-1.

TLS12_1_0_2015_01 is only available in the following AWS Regions: ap-northeast-1, ap-southeast-1, eu-central-1, eu-west-1, us-east-1, us-west-2.

### Important notes for transport security in AWS IoT Core

For devices that connect to AWS IoT Core using **MQTT**, TLS encrypts the connection between the devices and the broker, and AWS IoT Core uses TLS client authentication to identify devices. For more information, see [Client authentication](#). For devices that connect to AWS IoT Core using **HTTP**, TLS encrypts the connection between the devices and the broker, and authentication is delegated to AWS Signature Version 4. For more information, see [Signing requests with Signature Version 4](#) in the AWS General Reference.
When you connect devices to AWS IoT Core, sending the **Server Name Indication (SNI) extension** is not required but highly recommended. To use features such as **multi-account registration**, **custom domains**, and **VPC endpoints**, you must use the SNI extension and provide the complete endpoint address in the `host_name` field. The `host_name` field must contain the endpoint you are calling. That endpoint must be one of the following:

- The `endpointAddress` returned by `aws iot describe-endpoint --endpoint-type iot:Data-ATS`
- The `domainName` returned by `aws iot describe-domain-configuration --domain-configuration-name "domain_configuration_name"`

Connections attempted by devices with the incorrect or invalid `host_name` value will fail. AWS IoT Core will log failures to CloudWatch for the authentication type of **Custom Authentication**.

AWS IoT Core doesn't support the **SessionTicket TLS extension**.

**Transport security for LoRaWAN wireless devices**

LoRaWAN devices follow the security practices described in *LoRaWAN ™ SECURITY: A White Paper Prepared for the LoRa Alliance™ by Gemalto, Actility, and Semtech*.

For more information about transport security with LoRaWAN devices, see **Data security with AWS IoT Core for LoRaWAN (p. 1339)**.

**Data encryption in AWS IoT**

Data protection refers to protecting data while in-transit (as it travels to and from AWS IoT) and at rest (while it is stored on devices or by other AWS services). All data sent to AWS IoT is sent over an TLS connection using MQTT, HTTPS, and WebSocket protocols, making it secure by default while in transit. AWS IoT devices collect data and then send it to other AWS services for further processing. For more information about data encryption on other AWS services, see the security documentation for that service.

FreeRTOS provides a PKCS#11 library that abstracts key storage, accessing cryptographic objects and managing sessions. It is your responsibility to use this library to encrypt data at rest on your devices. For more information, see **FreeRTOS Public Key Cryptography Standard (PKCS) #11 Library**.

**Device Advisor**

**Encryption in transit**

Data sent to and from Device Advisor is encrypted in transit. All data sent to and from the service when using the Device Advisor APIs is encrypted using Signature Version 4. For more information about how AWS API requests are signed, see **Signing AWS API requests**. All data sent from your test devices to your Device Advisor test endpoint is sent over a TLS connection so it is secure by default in transit.

**Key management in AWS IoT**

All connections to AWS IoT are done using TLS, so no client-side encryption keys are necessary for the initial TLS connection.

Devices must authenticate using an X.509 certificate or an Amazon Cognito Identity. You can have AWS IoT generate a certificate for you, in which case it will generate a public/private key pair. If you are using the AWS IoT console you will be prompted to download the certificate and keys. If you are using the `create-keys-and-certificate` CLI command, the certificate and keys are returned by the CLI command. You are responsible for copying the certificate and private key onto your device and keeping it safe.
AWS IoT does not currently support customer-managed AWS KMS keys (KMS keys) from AWS Key Management Service (AWS KMS); however, Device Advisor and AWS IoT Wireless use only an AWS owned key to encrypt customer data.

Device Advisor

All data sent to Device Advisor when using the AWS APIs is encrypted at rest. Device Advisor encrypts all of your data at rest using KMS keys stored and managed in AWS Key Management Service. Device Advisor encrypts your data using AWS owned keys. For more information about AWS owned keys, see AWS owned keys.

Identity and access management for AWS IoT

AWS Identity and Access Management (IAM) is an AWS service that helps an administrator securely control access to AWS resources. IAM administrators control who can be authenticated (signed in) and authorized (have permissions) to use AWS IoT resources. IAM is an AWS service that you can use with no additional charge.

Topics
- Audience (p. 390)
- Authenticating with IAM identities (p. 390)
- Managing access using policies (p. 392)
- How AWS IoT works with IAM (p. 394)
- AWS IoT identity-based policy examples (p. 410)
- AWS managed policies for AWS IoT (p. 413)
- Troubleshooting AWS IoT identity and access (p. 423)

Audience

How you use AWS Identity and Access Management (IAM) differs, depending on the work that you do in AWS IoT.

Service user – If you use the AWS IoT service to do your job, then your administrator provides you with the credentials and permissions that you need. As you use more AWS IoT features to do your work, you might need additional permissions. Understanding how access is managed can help you request the right permissions from your administrator. If you cannot access a feature in AWS IoT, see Troubleshooting AWS IoT identity and access (p. 423).

Service administrator – If you’re in charge of AWS IoT resources at your company, you probably have full access to AWS IoT. It’s your job to determine which AWS IoT features and resources your service users should access. You must then submit requests to your IAM administrator to change the permissions of your service users. Review the information on this page to understand the basic concepts of IAM. To learn more about how your company can use IAM with AWS IoT, see How AWS IoT works with IAM (p. 394).

IAM administrator – If you’re an IAM administrator, you might want to learn details about how you can write policies to manage access to AWS IoT. To view example AWS IoT identity-based policies that you can use in IAM, see AWS IoT identity-based policy examples (p. 410).

Authenticating with IAM identities

In AWS IoT identities can be device (X.509) certificates, Amazon Cognito identities, or IAM users or groups. This topic discusses IAM identities only. For more information about the other identities that AWS IoT supports, see Client authentication (p. 300).
Authentication is how you sign in to AWS using your identity credentials. You must be authenticated (signed in to AWS) as the AWS account root user, as an IAM user, or by assuming an IAM role.

You can sign in to AWS as a federated identity by using credentials provided through an identity source. AWS IAM Identity Center (IAM Identity Center) users, your company's single sign-on authentication, and your Google or Facebook credentials are examples of federated identities. When you sign in as a federated identity, your administrator previously set up identity federation using IAM roles. When you access AWS by using federation, you are indirectly assuming a role.

Depending on the type of user you are, you can sign in to the AWS Management Console or the AWS access portal. For more information about signing in to AWS, see How to sign in to your AWS account in the AWS Sign-In User Guide.

If you access AWS programmatically, AWS provides a software development kit (SDK) and a command line interface (CLI) to cryptographically sign your requests by using your credentials. If you don't use AWS tools, you must sign requests yourself. For more information about using the recommended method to sign requests yourself, see Signing AWS API requests in the IAM User Guide.

Regardless of the authentication method that you use, you might be required to provide additional security information. For example, AWS recommends that you use multi-factor authentication (MFA) to increase the security of your account. To learn more, see Multi-factor authentication in the AWS IAM Identity Center User Guide and Using multi-factor authentication (MFA) in AWS in the IAM User Guide.

AWS account root user

When you create an AWS account, you begin with one sign-in identity that has complete access to all AWS services and resources in the account. This identity is called the AWS account root user and is accessed by signing in with the email address and password that you used to create the account. We strongly recommend that you don't use the root user for your everyday tasks. Safeguard your root user credentials and use them to perform the tasks that only the root user can perform. For the complete list of tasks that require you to sign in as the root user, see Tasks that require root user credentials in the IAM User Guide.

IAM users and groups

An IAM user is an identity within your AWS account that has specific permissions for a single person or application. Where possible, we recommend relying on temporary credentials instead of creating IAM users who have long-term credentials such as passwords and access keys. However, if you have specific use cases that require long-term credentials with IAM users, we recommend that you rotate access keys. For more information, see Rotate access keys regularly for use cases that require long-term credentials in the IAM User Guide.

An IAM group is an identity that specifies a collection of IAM users. You can't sign in as a group. You can use groups to specify permissions for multiple users at a time. Groups make permissions easier to manage for large sets of users. For example, you could have a group named IAMAdmins and give that group permissions to administer IAM resources.

Users are different from roles. A user is uniquely associated with one person or application, but a role is intended to be assumable by anyone who needs it. Users have permanent long-term credentials, but roles provide temporary credentials. To learn more, see When to create an IAM user (instead of a role) in the IAM User Guide.

IAM roles

An IAM role is an identity within your AWS account that has specific permissions. It is similar to an IAM user, but is not associated with a specific person. You can temporarily assume an IAM role in the AWS Management Console by switching roles. You can assume a role by calling an AWS CLI or AWS API operation or by using a custom URL. For more information about methods for using roles, see Using IAM roles in the IAM User Guide.
IAM roles with temporary credentials are useful in the following situations:

- **Federated user access** – To assign permissions to a federated identity, you create a role and define permissions for the role. When a federated identity authenticates, the identity is associated with the role and is granted the permissions that are defined by the role. For information about roles for federation, see *Creating a role for a third-party Identity Provider* in the IAM User Guide. If you use IAM Identity Center, you configure a permission set. To control what your identities can access after they authenticate, IAM Identity Center correlates the permission set to a role in IAM. For information about permissions sets, see *Permission sets* in the AWS IAM Identity Center User Guide.

- **Temporary IAM user permissions** – An IAM user or role can assume an IAM role to temporarily take on different permissions for a specific task.

- **Cross-account access** – You can use an IAM role to allow someone (a trusted principal) in a different account to access resources in your account. Roles are the primary way to grant cross-account access. However, with some AWS services, you can attach a policy directly to a resource (instead of using a role as a proxy). To learn the difference between roles and resource-based policies for cross-account access, see *How IAM roles differ from resource-based policies* in the IAM User Guide.

- **Cross-service access** – Some AWS services use features in other AWS services. For example, when you make a call in a service, it's common for that service to run applications in Amazon EC2 or store objects in Amazon S3. A service might do this using the calling principal's permissions, using a service role, or using a service-linked role.

- **Principal permissions** – When you use an IAM user or role to perform actions in AWS, you are considered a principal. Policies grant permissions to a principal. When you use some services, you might perform an action that then triggers another action in a different service. In this case, you must have permissions to perform both actions. To see whether an action requires additional dependent actions in a policy, see *Actions, Resources, and Condition Keys for AWS IoT* in the Service Authorization Reference.

- **Service role** – A service role is an IAM role that a service assumes to perform actions on your behalf. An IAM administrator can create, modify, and delete a service role from within IAM. For more information, see *Creating a role to delegate permissions to an AWS service* in the IAM User Guide.

- **Service-linked role** – A service-linked role is a type of service role that is linked to an AWS service. The service can assume the role to perform an action on your behalf. Service-linked roles appear in your AWS account and are owned by the service. An IAM administrator can view, but not edit the permissions for service-linked roles.

- **Applications running on Amazon EC2** – You can use an IAM role to manage temporary credentials for applications that are running on an EC2 instance and making AWS CLI or AWS API requests. This is preferable to storing access keys within the EC2 instance. To assign an AWS role to an EC2 instance and make it available to all of its applications, you create an instance profile that is attached to the instance. An instance profile contains the role and enables programs that are running on the EC2 instance to get temporary credentials. For more information, see *Using an IAM role to grant permissions to applications running on Amazon EC2 instances* in the IAM User Guide.

To learn whether to use IAM roles or IAM users, see *When to create an IAM role (instead of a user)* in the IAM User Guide.

### Managing access using policies

You control access in AWS by creating policies and attaching them to AWS identities or resources. A policy is an object in AWS that, when associated with an identity or resource, defines their permissions. AWS evaluates these policies when a principal (user, root user, or role session) makes a request. Permissions in the policies determine whether the request is allowed or denied. Most policies are stored in AWS as JSON documents. For more information about the structure and contents of JSON policy documents, see *Overview of JSON policies* in the IAM User Guide.

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.
By default, users and roles have no permissions. To grant users permission to perform actions on the resources that they need, an IAM administrator can create IAM policies. The administrator can then add the IAM policies to roles, and users can assume the roles.

IAM policies define permissions for an action regardless of the method that you use to perform the operation. For example, suppose that you have a policy that allows the `iam:GetRole` action. A user with that policy can get role information from the AWS Management Console, the AWS CLI, or the AWS API.

### Identity-based policies

Identity-based policies are JSON permissions policy documents that you can attach to an identity, such as an IAM user, group of users, or role. These policies control what actions users and roles can perform, on which resources, and under what conditions. To learn how to create an identity-based policy, see Creating IAM policies in the IAM User Guide.

Identity-based policies can be further categorized as inline policies or managed policies. Inline policies are embedded directly into a single user, group, or role. Managed policies are standalone policies that you can attach to multiple users, groups, and roles in your AWS account. Managed policies include AWS managed policies and customer managed policies. To learn how to choose between a managed policy or an inline policy, see Choosing between managed policies and inline policies in the IAM User Guide.

### Resource-based policies

Resource-based policies are JSON policy documents that you attach to a resource. Examples of resource-based policies are IAM role trust policies and Amazon S3 bucket policies. In services that support resource-based policies, service administrators can use them to control access to a specific resource. For the resource where the policy is attached, the policy defines what actions a specified principal can perform on that resource and under what conditions. You must specify a principal in a resource-based policy. Principals can include accounts, users, roles, federated users, or AWS services.

Resource-based policies are inline policies that are located in that service. You can't use AWS managed policies from IAM in a resource-based policy.

### Access control lists (ACLs)

Access control lists (ACLs) control which principals (account members, users, or roles) have permissions to access a resource. ACLs are similar to resource-based policies, although they do not use the JSON policy document format.

Amazon S3, AWS WAF, and Amazon VPC are examples of services that support ACLs. To learn more about ACLs, see Access control list (ACL) overview in the Amazon Simple Storage Service Developer Guide.

### Other policy types

AWS supports additional, less-common policy types. These policy types can set the maximum permissions granted to you by the more common policy types.

- **Permissions boundaries** – A permissions boundary is an advanced feature in which you set the maximum permissions that an identity-based policy can grant to an IAM entity (IAM user or role). You can set a permissions boundary for an entity. The resulting permissions are the intersection of an entity’s identity-based policies and its permissions boundaries. Resource-based policies that specify the user or role in the Principal field are not limited by the permissions boundary. An explicit deny in any of these policies overrides the allow. For more information about permissions boundaries, see Permissions boundaries for IAM entities in the IAM User Guide.

- **Service control policies (SCPs)** – SCPs are JSON policies that specify the maximum permissions for an organization or organizational unit (OU) in AWS Organizations. AWS Organizations is a service for grouping and centrally managing multiple AWS accounts that your business owns. If you enable all features in an organization, then you can apply service control policies (SCPs) to any or all of your
accounts. The SCP limits permissions for entities in member accounts, including each AWS account root user. For more information about Organizations and SCPs, see How SCPs work in the AWS Organizations User Guide.

- **Session policies** – Session policies are advanced policies that you pass as a parameter when you programmatically create a temporary session for a role or federated user. The resulting session’s permissions are the intersection of the user or role’s identity-based policies and the session policies. Permissions can also come from a resource-based policy. An explicit deny in any of these policies overrides the allow. For more information, see Session policies in the IAM User Guide.

## Multiple policy types

When multiple types of policies apply to a request, the resulting permissions are more complicated to understand. To learn how AWS determines whether to allow a request when multiple policy types are involved, see Policy evaluation logic in the IAM User Guide.

## How AWS IoT works with IAM

Before you use IAM to manage access to AWS IoT, you should understand which IAM features are available to use with AWS IoT. To get a high-level view of how AWS IoT and other AWS services work with IAM, see AWS Services That Work with IAM in the IAM User Guide.

### AWS IoT identity-based policies

With IAM identity-based policies, you can specify allowed or denied actions and resources as well as the conditions under which actions are allowed or denied. AWS IoT supports specific actions, resources, and condition keys. To learn about all of the elements that you use in a JSON policy, see IAM JSON Policy Elements Reference in the IAM User Guide.

#### Actions

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

The Action element of a JSON policy describes the actions that you can use to allow or deny access in a policy. Policy actions usually have the same name as the associated AWS API operation. There are some exceptions, such as permission-only actions that don’t have a matching API operation. There are also some operations that require multiple actions in a policy. These additional actions are called dependent actions.

Include actions in a policy to grant permissions to perform the associated operation.

The following table lists the IAM IoT actions, the associated AWS IoT API, and the resource the action manipulates.

<table>
<thead>
<tr>
<th>Policy actions</th>
<th>AWS IoT API</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy actions</td>
<td>AWS IoT API</td>
<td>Resources</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>IoT:AttachThingPrincipal</td>
<td>AttachThingPrincipal</td>
<td>arn:aws:iot:region:account-id:cert/cert-id</td>
</tr>
<tr>
<td>IoT:ClearDefaultAuthorizer</td>
<td>ClearDefaultAuthorizer</td>
<td>None</td>
</tr>
<tr>
<td>IoT:CreateAuthorizer</td>
<td>CreateAuthorizer</td>
<td>arn:aws:iot:region:account-id:authorizer/authorizer-function-name</td>
</tr>
<tr>
<td>IoT:CreateCertificateFromCsr</td>
<td>CreateCertificateFromCsr</td>
<td>None</td>
</tr>
<tr>
<td>IoT:CreateDimension</td>
<td>CreateDimension</td>
<td>arn:aws:iot:region:account-id:dimension/dimension-name</td>
</tr>
<tr>
<td>IoT:CreateJob</td>
<td>CreateJob</td>
<td>arn:aws:iot:region:account-id:job/job-id</td>
</tr>
<tr>
<td>IoT:CreateThingGroup</td>
<td>CreateThingGroup</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>Note</td>
<td>The AWS account specified in the ARN must be the account to which the certificate is being transferred.</td>
<td></td>
</tr>
<tr>
<td>Note</td>
<td>The AWS account specified in the ARN must be the account to which the certificate is being transferred.</td>
<td></td>
</tr>
<tr>
<td>Policy actions</td>
<td>AWS IoT API</td>
<td>Resources</td>
</tr>
<tr>
<td>------------------------</td>
<td>----------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>iot:CreateJobTemplate</td>
<td>CreateJobTemplate</td>
<td>arn:aws:iot:region:account-id:job/job-id</td>
</tr>
<tr>
<td>iot:CreateKeysAndCertificate</td>
<td>CreateKeysAndCertificate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note</strong> This must be an AWS IoT policy, not an IAM policy.</td>
</tr>
<tr>
<td>iot:CreateRoleAlias</td>
<td>CreateRoleAlias</td>
<td>(parameter: roleAlias)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arn:aws:iot:region:account-id:rolealias/role-alias-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arn:aws:iot:region:account-id:dimension/dimension-name</td>
</tr>
<tr>
<td>iot:CreateThing</td>
<td>CreateThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:CreateThingGroup</td>
<td>CreateThingGroup</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for group being created and for parent group, if used</td>
</tr>
<tr>
<td>iot:CreateThingType</td>
<td>CreateThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td>iot:DeleteDimension</td>
<td>DeleteDimension</td>
<td>arn:aws:iot:region:account-id:dimension/dimension-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>Policy actions</td>
<td>AWS IoT API</td>
<td>Resources</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arn:aws:iot:region:account-id:dimension/dimension-name</td>
</tr>
<tr>
<td>iot:DeleteThing</td>
<td>DeleteThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:DeleteThingGroup</td>
<td>DeleteThingGroup</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:DeleteThingType</td>
<td>DeleteThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td>iot:DeleteV2LoggingLevel</td>
<td>DeleteV2LoggingLevel</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:DeprecateThingType</td>
<td>DeprecateThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(parameter: authorizedName) none</td>
</tr>
<tr>
<td>iot:DescribeEndpoint</td>
<td>DescribeEndpoint</td>
<td>*</td>
</tr>
<tr>
<td>iot:DescribeEventConfigurations</td>
<td>DescribeEventConfigurations</td>
<td>*</td>
</tr>
<tr>
<td>iot:DescribeIndex</td>
<td>DescribeIndex</td>
<td>arn:aws:iot:region:account-id:index/index-name</td>
</tr>
<tr>
<td>iot:DescribeJobExecution</td>
<td>DescribeJobExecution</td>
<td>None</td>
</tr>
<tr>
<td>Policy actions</td>
<td>AWS IoT API</td>
<td>Resources</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
<td>-----------</td>
</tr>
<tr>
<td>iot:DescribeThing</td>
<td>DescribeThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:DescribeThingGroup</td>
<td>DescribeThingGroup</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:DescribeThingRegistrationTask</td>
<td>DescribeThingRegistrationTask</td>
<td></td>
</tr>
<tr>
<td>iot:DescribeThingType</td>
<td>DescribeThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td>iot:DetachThingPrincipal</td>
<td>DetachThingPrincipal</td>
<td>arn:aws:iot:region:account-id:cert/cert-id</td>
</tr>
<tr>
<td>iot:GetIndexingConfiguration</td>
<td>GetIndexingConfiguration</td>
<td></td>
</tr>
<tr>
<td>iot:GetLoggingOptions</td>
<td>GetLoggingOptions</td>
<td>*</td>
</tr>
<tr>
<td>iot:GetRegistrationCode</td>
<td>GetRegistrationCode</td>
<td>*</td>
</tr>
</tbody>
</table>

398
<table>
<thead>
<tr>
<th>Policy actions</th>
<th>AWS IoT API</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>iot:ListAuthorizers</td>
<td>ListAuthorizers</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListCACertificates</td>
<td>ListCACertificates</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListCertificates</td>
<td>ListCertificates</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListCertificatesByCACertificates</td>
<td>ListCertificatesByCA</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListIndices</td>
<td>ListIndices</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListJobExecutions</td>
<td>ListJobExecutionsForName</td>
<td>If thingGroupName parameter used</td>
</tr>
<tr>
<td>iot:ListJobExecutions</td>
<td>ListJobExecutionsForThing</td>
<td></td>
</tr>
<tr>
<td>iot:ListJobTemplates</td>
<td>ListJobs</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListOutgoingCertificates</td>
<td>ListOutgoingCertificates</td>
<td></td>
</tr>
<tr>
<td>iot:ListPolicies</td>
<td>ListPolicies</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListPolicyPrincipals</td>
<td>ListPolicyPrincipals</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListRoleAliases</td>
<td>ListRoleAliases</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListThingGroups</td>
<td>ListThingGroups</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListThingGroupsForThing</td>
<td>ListThingGroupsForThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:ListThingRegistrationTasks</td>
<td>ListThingRegistrationTasks</td>
<td></td>
</tr>
<tr>
<td>iot:ListThingRegistrationTasksReports</td>
<td>ListThingRegistrationTasksReports</td>
<td></td>
</tr>
<tr>
<td>iot:ListThingTypes</td>
<td>ListThingTypes</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListThings</td>
<td>ListThings</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListTopicRules</td>
<td>ListTopicRules</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListV2LoggingLevels</td>
<td>ListV2LoggingLevels</td>
<td>None</td>
</tr>
<tr>
<td>iot:RegisterCACertificate</td>
<td>RegisterCACertificate</td>
<td></td>
</tr>
<tr>
<td>Policy actions</td>
<td>AWS IoT API</td>
<td>Resources</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>iot:RegisterCertificate</td>
<td>RegisterCertificate</td>
<td>*</td>
</tr>
<tr>
<td>iot:RegisterThing</td>
<td>RegisterThing</td>
<td>None</td>
</tr>
<tr>
<td>iot:RemoveThingFromThingGroup</td>
<td>RemoveThingFromThingGroup</td>
<td>thing-group/thing-group-name</td>
</tr>
<tr>
<td>iot:SearchIndex</td>
<td>SearchIndex</td>
<td>arn:aws:iot:region:account-id:index/index-id</td>
</tr>
<tr>
<td>iot:SetLoggingOptions</td>
<td>SetLoggingOptions</td>
<td>arn:aws:iot:region:account-id:role/role-name</td>
</tr>
<tr>
<td>iot:SetV2LoggingLevel</td>
<td>SetV2LoggingLevel</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:SetV2LoggingOptions</td>
<td>SetV2LoggingOptions</td>
<td>arn:aws:iot:region:account-id:role/role-name</td>
</tr>
<tr>
<td>iot:StartThingRegistrationTask</td>
<td>StartThingRegistrationTask</td>
<td>None</td>
</tr>
<tr>
<td>iot:StopThingRegistrationTask</td>
<td>StopThingRegistrationTask</td>
<td>None</td>
</tr>
<tr>
<td>iot:TestInvokeAuthorizer</td>
<td>TestInvokeAuthorizer</td>
<td>None</td>
</tr>
<tr>
<td>iot:UpdateDimension</td>
<td>UpdateDimension</td>
<td>arn:aws:iot:region:account-id:dimension/dimension-name</td>
</tr>
<tr>
<td>iot:UpdateEventConfigurations</td>
<td>UpdateEventConfigurations</td>
<td>None</td>
</tr>
<tr>
<td>iot:UpdateIndexingConfiguration</td>
<td>UpdateIndexingConfiguration</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arn:aws:iot:region:account-id:dimension/dimension-name</td>
</tr>
</tbody>
</table>
Policy actions in AWS IoT use the following prefix before the action: `iot:`. For example, to grant someone permission to list all IoT things registered in their AWS account with the `ListThings` API, you include the `iot:ListThings` action in their policy. Policy statements must include either an `Action` or `NotAction` element. AWS IoT defines its own set of actions that describe tasks that you can perform with this service.

To specify multiple actions in a single statement, separate them with commas as follows:

```
"Action": [
  "ec2:action1",
  "ec2:action2"
]
```

You can specify multiple actions using wildcards (`*`). For example, to specify all actions that begin with the word `Describe`, include the following action:

```
"Action": "iot:Describe*"
```

To see a list of AWS IoT actions, see [Actions Defined by AWS IoT](https://docs.aws.amazon.com/iot/latest/developerguide/iot-actions.html) in the IAM User Guide.

### Device Advisor actions

The following table lists the IAM IoT Device Advisor actions, the associated AWS IoT Device Advisor API, and the resource the action manipulates.

<table>
<thead>
<tr>
<th>Policy actions</th>
<th>AWS IoT API</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>iotdeviceadvisor:CreateSuiteDefinition</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>iotdeviceadvisor:ListSuiteDefinitions</td>
<td>None</td>
<td></td>
</tr>
</tbody>
</table>
### Policy actions in AWS IoT Device Advisor

Policy actions in AWS IoT Device Advisor use the following prefix before the action: `iotdeviceadvisor:`. For example, to grant someone permission to list all suite definitions registered in their AWS account with the ListSuiteDefinitions API, you include the `iotdeviceadvisor:ListSuiteDefinitions` action in their policy.

### Resources

Administrators can use AWS JSON policies to specify who has access to what. That is, which principal can perform actions on what resources, and under what conditions.

The Resource JSON policy element specifies the object or objects to which the action applies. Statements must include either a Resource or a NotResource element. As a best practice, specify a resource using its Amazon Resource Name (ARN). You can do this for actions that support a specific resource type, known as resource-level permissions.

For actions that don't support resource-level permissions, such as listing operations, use a wildcard (*) to indicate that the statement applies to all resources.

```
"Resource": "*
```

### AWS IoT resources

<table>
<thead>
<tr>
<th>Policy actions</th>
<th>AWS IoT API</th>
<th>Resources</th>
</tr>
</thead>
</table>

Note

The AWS account specified in the ARN must be the account to which the certificate is being transferred.
<table>
<thead>
<tr>
<th>Policy actions</th>
<th>AWS IoT API</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>iot:AddThingToThingGroup</td>
<td>AddThingToThingGroup</td>
<td>arn:aws:iot::account-id:thinggroup/thing-group-name or arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:AssociateTargetsWithJob</td>
<td>AssociateTargetsWithJob</td>
<td>None</td>
</tr>
<tr>
<td>iot:AttachThingPrincipal</td>
<td>AttachThingPrincipal</td>
<td>arn:aws:iot:region:account-id:cert/cert-id</td>
</tr>
<tr>
<td>iot:ClearDefaultAuthorizer</td>
<td>ClearDefaultAuthorizer</td>
<td>None</td>
</tr>
<tr>
<td>iot:CreateAuthorizer</td>
<td>CreateAuthorizer</td>
<td>arn:aws:iot:region:account-id:authorizer/authorizer-function-name</td>
</tr>
<tr>
<td>iot:CreateCertificateFromCsr</td>
<td>CreateCertificateFromCsr</td>
<td>*</td>
</tr>
<tr>
<td>iot:CreateKeysAndCertificate</td>
<td>CreateKeysAndCertificate</td>
<td>*</td>
</tr>
</tbody>
</table>

**Note**

The AWS account specified in the ARN must be the account to which the certificate is being transferred.
<table>
<thead>
<tr>
<th>Policy actions</th>
<th>AWS IoT API</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Note</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>This must be an AWS IoT policy, not an IAM policy.</td>
</tr>
<tr>
<td>iot:CreateRoleAlias</td>
<td>CreateRoleAlias</td>
<td>(parameter: roleAlias)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arn:aws:iot:region:account-id:rolealiases/role-alias-name</td>
</tr>
<tr>
<td>iot:CreateThing</td>
<td>CreateThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:CreateThingGroup</td>
<td>CreateThingGroup</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>for group being created and for parent group, if used</td>
</tr>
<tr>
<td>iot:CreateThingType</td>
<td>CreateThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td>iot:DeleteThing</td>
<td>DeleteThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:DeleteThingGroup</td>
<td>DeleteThingGroup</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:DeleteThingType</td>
<td>DeleteThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td>Policy actions</td>
<td>AWS IoT API</td>
<td>Resources</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>iot:DeleteV2LoggingLevel</td>
<td>DeleteV2LoggingLevel</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:DeprecateThingType</td>
<td>DeprecateThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(parameter: authorizerName)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>none</td>
</tr>
<tr>
<td>iot:DescribeDefaultAuthorizer</td>
<td>DescribeDefaultAuthorizer</td>
<td>None</td>
</tr>
<tr>
<td>iot:DescribeEndpoint</td>
<td>DescribeEndpoint</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DescribableEventConfigurations</td>
</tr>
<tr>
<td>iot:DescribeIndex</td>
<td>DescribeIndex</td>
<td>arn:aws:iot:region:account-id:index/index-name</td>
</tr>
<tr>
<td>iot:DescribeJobExecution</td>
<td>DescribeJobExecution</td>
<td>None</td>
</tr>
<tr>
<td>iot:DescribeThing</td>
<td>DescribeThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:DescribeThingGroup</td>
<td>DescribeThingGroup</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:DescribeThingRegistrationTask</td>
<td>DescribeThingRegistrationTask</td>
<td>None</td>
</tr>
<tr>
<td>iot:DescribeThingType</td>
<td>DescribeThingType</td>
<td>arn:aws:iot:region:account-id:thingtype/thing-type-name</td>
</tr>
<tr>
<td></td>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name</td>
</tr>
<tr>
<td>iot:DetachThingPrincipal</td>
<td>DetachThingPrincipal</td>
<td>arn:aws:iot:region:account-id:cert/cert-id</td>
</tr>
</tbody>
</table>
### Policy actions | AWS IoT API | Resources |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>iot:GetIndexingConfiguration</td>
<td>GetIndexingConfiguration</td>
<td>None</td>
</tr>
<tr>
<td>iot:GetLoggingOptions</td>
<td>GetLoggingOptions</td>
<td>*</td>
</tr>
<tr>
<td>iot:GetRegistrationCode</td>
<td>GetRegistrationCode</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListAuthorizers</td>
<td>ListAuthorizers</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListCACertificates</td>
<td>ListCACertificates</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListCertificates</td>
<td>ListCertificates</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListCertificatesByCA</td>
<td>ListCertificatesByCA</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListIndices</td>
<td>ListIndices</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListJobExecutionsForJob</td>
<td>ListJobExecutionsForJob</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListJobExecutionsForThing</td>
<td>ListJobExecutionsForThing</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListJobs</td>
<td>ListJobs</td>
<td>arn:aws:iot:region:account-id:thinggroup/thing-group-name if thingGroupName parameter used</td>
</tr>
<tr>
<td>iot:ListJobTemplates</td>
<td>ListJobTemplates</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListOutgoingCertificates</td>
<td>ListOutgoingCertificates</td>
<td></td>
</tr>
<tr>
<td>iot:ListPolicies</td>
<td>ListPolicies</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListPrincipalThing</td>
<td>ListPrincipalThing</td>
<td>arn:aws:iot:region:account-id:cert/cert-id</td>
</tr>
<tr>
<td>iot:ListRoleAliases</td>
<td>ListRoleAliases</td>
<td>None</td>
</tr>
</tbody>
</table>
### AWS IoT Core Developer Guide

#### How AWS IoT works with IAM

<table>
<thead>
<tr>
<th>Policy actions</th>
<th>AWS IoT API</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>iot:ListThingGroups</td>
<td>ListThingGroups</td>
<td>None</td>
</tr>
<tr>
<td>iot:ListThingGroupsForThing</td>
<td>ListThingGroupsForThing</td>
<td>arn:aws:iot:region:account-id:thing/thing-name</td>
</tr>
<tr>
<td>iot:ListThingRegistrationTaskReports</td>
<td>ListThingRegistrationTaskReports</td>
<td></td>
</tr>
<tr>
<td>iot:ListThingRegistrationTasks</td>
<td>ListThingRegistrationTasks</td>
<td></td>
</tr>
<tr>
<td>iot:ListThingTypes</td>
<td>ListThingTypes</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListThings</td>
<td>ListThings</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListTopicRules</td>
<td>ListTopicRules</td>
<td>*</td>
</tr>
<tr>
<td>iot:ListV2LoggingLevels</td>
<td>ListV2LoggingLevels</td>
<td>None</td>
</tr>
<tr>
<td>iot:RegisterCACertificate</td>
<td>RegisterCACertificate</td>
<td>*</td>
</tr>
<tr>
<td>iot:RegisterCertificate</td>
<td>RegisterCertificate</td>
<td>*</td>
</tr>
<tr>
<td>iot:RegisterThing</td>
<td>RegisterThing</td>
<td>None</td>
</tr>
<tr>
<td>iot:SearchIndex</td>
<td>SearchIndex</td>
<td>arn:aws:iot:region:account-id:index/index-id</td>
</tr>
<tr>
<td>iot:SetLoggingOptions</td>
<td>SetLoggingOptions</td>
<td>*</td>
</tr>
<tr>
<td>iot:SetV2LoggingLevel</td>
<td>SetV2LoggingLevel</td>
<td>*</td>
</tr>
<tr>
<td>iot:SetV2LoggingOptions</td>
<td>SetV2LoggingOptions</td>
<td>*</td>
</tr>
<tr>
<td>iot:StartThingRegistrationTask</td>
<td>StartThingRegistrationTask</td>
<td></td>
</tr>
<tr>
<td>iot:StopThingRegistrationTask</td>
<td>StopThingRegistrationTask</td>
<td></td>
</tr>
<tr>
<td>iot:TestInvokeAuthorizer</td>
<td>TestInvokeAuthorizer</td>
<td>None</td>
</tr>
</tbody>
</table>
### Policy actions | AWS IoT API | Resources
---|---|---
`iot:UpdateEventConfigurations` | `UpdateEventConfigurations` | None
`iot:UpdateIndexingConfiguration` | `UpdateIndexingConfiguration` | None

For more information about the format of ARNs, see [Amazon Resource Names (ARNs) and AWS Service Namespaces](https://docs.aws.amazon.com/general/latest/gr/aws-arns-and-namespaces.html).

Some AWS IoT actions, such as those for creating resources, cannot be performed on a specific resource. In those cases, you must use the wildcard (`*`).

"Resource": "*"

To see a list of AWS IoT resource types and their ARNs, see [Resources Defined by AWS IoT](https://docs.aws.amazon.com/iot/latest/developerguide/resources-defined-by-aws-iot.html) in the [IAM User Guide](https://docs.aws.amazon.com/IAM/latest/UserGuide/id_policies-resource-level-constrain.html). To learn with which actions you can specify the ARN of each resource, see [Actions Defined by AWS IoT](https://docs.aws.amazon.com/IAM/latest/UserGuide/id_policies-resource-level-constrain.html).

#### Device Advisor resources

To define resource-level restrictions for AWS IoT Device Advisor IAM policies, use the following resource ARN formats for suite definitions and suite runs.

**Suite definition resource ARN format**

```
```

**Suite run resource ARN format**

```
```

#### Condition keys

Administrators can use AWS JSON policies to specify who has access to what. That is, which **principal** can perform **actions** on what **resources**, and under what **conditions**.
The Condition element (or Condition block) lets you specify conditions in which a statement is in effect. The Condition element is optional. You can create conditional expressions that use condition operators, such as equals or less than, to match the condition in the policy with values in the request.

If you specify multiple Condition elements in a statement, or multiple keys in a single Condition element, AWS evaluates them using a logical AND operation. If you specify multiple values for a single condition key, AWS evaluates the condition using a logical OR operation. All of the conditions must be met before the statement's permissions are granted.

You can also use placeholder variables when you specify conditions. For example, you can grant an IAM user permission to access a resource only if it is tagged with their IAM user name. For more information, see IAM policy elements: variables and tags in the IAM User Guide.

AWS supports global condition keys and service-specific condition keys. To see all AWS global condition keys, see AWS global condition context keys in the IAM User Guide.

AWS IoT defines its own set of condition keys and also supports using some global condition keys. To see all AWS global condition keys, see AWS Global Condition Context Keys in the IAM User Guide.

### AWS IoT condition keys

<table>
<thead>
<tr>
<th>AWS IoT condition keys</th>
<th>Description</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>aws:RequestTag/${tag-key}</td>
<td>A tag key that is present in the request that the user makes to AWS IoT.</td>
<td>String</td>
</tr>
<tr>
<td>aws:ResourceTag/${tag-key}</td>
<td>The tag key component of a tag attached to an AWS IoT resource.</td>
<td>String</td>
</tr>
<tr>
<td>aws:TagKeys</td>
<td>The list of all the tag key names associated with the resource in the request.</td>
<td>String</td>
</tr>
</tbody>
</table>

To see a list of AWS IoT condition keys, see Condition Keys for AWS IoT in the IAM User Guide. To learn with which actions and resources you can use a condition key, see Actions Defined by AWS IoT.

### Examples

To view examples of AWS IoT identity-based policies, see AWS IoT identity-based policy examples (p. 410).

### AWS IoT resource-based policies

Resource-based policies are JSON policy documents that specify what actions a specified principal can perform on the AWS IoT resource and under what conditions.

AWS IoT does not support IAM resource-based policies. It does, however, support AWS IoT resource-based policies. For more information, see AWS IoT Core policies (p. 336).
Authorization based on AWS IoT tags

You can attach tags to AWS IoT resources or pass tags in a request to AWS IoT. To control access based on tags, you provide tag information in the condition element of a policy using the `iot:ResourceTag/key-name`, `aws:RequestTag/key-name`, or `aws:TagKeys` condition keys. For more information, see Using tags with IAM policies (p. 292). For more information about tagging AWS IoT resources, see Tagging your AWS IoT resources (p. 291).

To view an example identity-based policy for limiting access to a resource based on the tags on that resource, see Viewing AWS IoT resources based on tags (p. 412).

AWS IoT IAM roles

An IAM role is an entity within your AWS account that has specific permissions.

Using temporary credentials with AWS IoT

You can use temporary credentials to sign in with federation, assume an IAM role, or to assume a cross-account role. You obtain temporary security credentials by calling AWS STS API operations such as AssumeRole or GetFederationToken.

AWS IoT supports using temporary credentials.

Service-linked roles

Service-linked roles allow AWS services to access resources in other services to complete an action on your behalf. Service-linked roles appear in your IAM account and are owned by the service. An IAM administrator can view but not edit the permissions for service-linked roles.

AWS IoT does not support service-linked roles.

Service roles

This feature allows a service to assume a service role on your behalf. This role allows the service to access resources in other services to complete an action on your behalf. Service roles appear in your IAM account and are owned by the account. This means that an IAM administrator can change the permissions for this role. However, doing so might break the functionality of the service.

AWS IoT identity-based policy examples

By default, IAM users and roles don't have permission to create or modify AWS IoT resources. They also can't perform tasks using the AWS Management Console, AWS CLI, or AWS API. An IAM administrator must create IAM policies that grant users and roles permission to perform specific API operations on the specified resources they need. The administrator must then attach those policies to the users or groups that require those permissions.

To learn how to create an IAM identity-based policy using these example JSON policy documents, see Creating Policies on the JSON Tab in the IAM User Guide.

Topics

- Policy best practices (p. 411)
- Using the AWS IoT console (p. 411)
- Allow users to view their own permissions (p. 411)
- Viewing AWS IoT resources based on tags (p. 412)
- Viewing AWS IoT Device Advisor resources based on tags (p. 413)
Policy best practices

Identity-based policies determine whether someone can create, access, or delete AWS IoT resources in your account. These actions can incur costs for your AWS account. When you create or edit identity-based policies, follow these guidelines and recommendations:

- **Get started with AWS managed policies and move toward least-privilege permissions** – To get started granting permissions to your users and workloads, use the AWS managed policies that grant permissions for many common use cases. They are available in your AWS account. We recommend that you reduce permissions further by defining AWS customer managed policies that are specific to your use cases. For more information, see [AWS managed policies](https://docs.aws.amazon.com/iot/latest/developerguide/managed-policies.html) or [AWS managed policies for job functions](https://docs.aws.amazon.com/iot/latest/developerguide/job-managed-policies.html) in the [IAM User Guide](https://docs.aws.amazon.com/iam/latest/userguide/)

- **Apply least-privilege permissions** – When you set permissions with IAM policies, grant only the permissions required to perform a task. You do this by defining the actions that can be taken on specific resources under specific conditions, also known as least-privilege permissions. For more information about using IAM to apply permissions, see [Policies and permissions in IAM](https://docs.aws.amazon.com/iam/latest/userguide/policies-and-permissions.html) in the [IAM User Guide](https://docs.aws.amazon.com/iam/latest/userguide/)

- **Use conditions in IAM policies to further restrict access** – You can add a condition to your policies to limit access to actions and resources. For example, you can write a policy condition to specify that all requests must be sent using SSL. You can also use conditions to grant access to service actions if they are used through a specific AWS service, such as AWS CloudFormation. For more information, see [IAM JSON policy elements: Condition](https://docs.aws.amazon.com/iam/latest/userguide/iam-policyelements-condition.html) in the [IAM User Guide](https://docs.aws.amazon.com/iam/latest/userguide/)

- **Use IAM Access Analyzer to validate your IAM policies to ensure secure and functional permissions** – IAM Access Analyzer validates new and existing policies so that the policies adhere to the IAM policy language (JSON) and IAM best practices. IAM Access Analyzer provides more than 100 policy checks and actionable recommendations to help you author secure and functional policies. For more information, see [IAM Access Analyzer policy validation](https://docs.aws.amazon.com/iam/latest/userguide/iam-access-analyzer.html) in the [IAM User Guide](https://docs.aws.amazon.com/iam/latest/userguide/)

- **Require multi-factor authentication (MFA)** – If you have a scenario that requires IAM users or a root user in your AWS account, turn on MFA for additional security. To require MFA when API operations are called, add MFA conditions to your policies. For more information, see [Configuring MFA-protected API access](https://docs.aws.amazon.com/iam/latest/userguide/configuring-mfa-api-access.html) in the [IAM User Guide](https://docs.aws.amazon.com/iam/latest/userguide/)

For more information about best practices in IAM, see [Security best practices in IAM](https://docs.aws.amazon.com/iam/latest/userguide/security-bp.html) in the [IAM User Guide](https://docs.aws.amazon.com/iam/latest/userguide/)

Using the AWS IoT console

To access the AWS IoT console, you must have a minimum set of permissions. These permissions must allow you to list and view details about the AWS IoT resources in your AWS account. If you create an identity-based policy that is more restrictive than the minimum required permissions, the console won't function as intended for entities (users or roles) with that policy.

To ensure that those entities can still use the AWS IoT console, also attach the following AWS managed policy to the entities: [AWSIoTFullAccess](https://docs.aws.amazon.com/iot/latest/developerguide/iot-full-access.html). For more information, see [Adding Permissions to a User](https://docs.aws.amazon.com/iot/latest/developerguide/iot-full-access.html) in the [IAM User Guide](https://docs.aws.amazon.com/iam/latest/userguide/)

You don't need to allow minimum console permissions for users that are making calls only to the AWS CLI or the AWS API. Instead, allow access to only the actions that match the API operation that you're trying to perform.

Allow users to view their own permissions

This example shows how you might create a policy that allows IAM users to view the inline and managed policies that are attached to their user identity. This policy includes permissions to complete this action on the console or programmatically using the AWS CLI or AWS API.
### Identity-based policy examples

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "ViewOwnUserInfo",
         "Effect": "Allow",
         "Action": [
            "iam:GetUserPolicy",
            "iam:ListGroupsForUser",
            "iam:ListAttachedUserPolicies",
            "iam:ListUserPolicies",
            "iam:GetUser"
         ],
         "Resource": ["arn:aws:iam::*:user/${aws:username}"
      },
      {
         "Sid": "NavigateInConsole",
         "Effect": "Allow",
         "Action": [
            "iam:GetGroupPolicy",
            "iam:GetPolicyVersion",
            "iam:GetPolicy",
            "iam:ListAttachedGroupPolicies",
            "iam:ListGroupPolicies",
            "iam:ListPolicies",
            "iam:ListUsers"
         ],
         "Resource": "*"
      }
   ]
}
```

### Viewing AWS IoT resources based on tags

You can use conditions in your identity-based policy to control access to AWS IoT resources based on tags. This example shows how you might create a policy that allows viewing a thing. However, permission is granted only if the thing tag **Owner** has the value of that user’s user name. This policy also grants the permissions necessary to complete this action on the console.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "ListBillingGroupsInConsole",
         "Effect": "Allow",
         "Action": "iot:ListBillingGroups",
         "Resource": "*"
      },
      {
         "Sid": "ViewBillingGroupsIfOwner",
         "Effect": "Allow",
         "Action": "iot:DescribeBillingGroup",
         "Resource": ["arn:aws:iot::*:billinggroup/*"],
         "Condition": {
            "StringEquals": ["aws:ResourceTag/Owner": "$\{aws:username\}"
         }
      }
   ]
}
```
You can attach this policy to the IAM users in your account. If a user named richard-roe attempts to view an AWS IoT billing group, the billing group must be tagged Owner=richard-roe or owner=richard-roe. Otherwise, he is denied access. The condition tag key Owner matches both Owner and owner because condition key names are not case-sensitive. For more information, see IAM JSON Policy Elements: Condition in the IAM User Guide.

Viewing AWS IoT Device Advisor resources based on tags

You can use conditions in your identity-based policy to control access to AWS IoT Device Advisor resources based on tags. The following example shows how you can create a policy that allows viewing a particular suite definition. However, permission is granted only if the suite definition tag has SuiteType set to the value of MQTT. This policy also grants the permissions necessary to complete this action on the console.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "ViewSuiteDefinition",
      "Effect": "Allow",
      "Action": "iotdeviceadvisor:GetSuiteDefinition",
      "Resource": "arn:aws:iotdeviceadvisor:*:*:suitedefinition/*",
      "Condition": {
        "StringEquals": {"aws:ResourceTag/SuiteType": "MQTT"}
      }
    }
  ]
}
```

AWS managed policies for AWS IoT

To add permissions to users, groups, and roles, it is easier to use AWS managed policies than to write policies yourself. It takes time and expertise to create IAM customer managed policies that provide your team with only the permissions they need. To get started quickly, you can use our AWS managed policies. These policies cover common use cases and are available in your AWS account. For more information about AWS managed policies, see AWS managed policies in the IAM User Guide.

AWS services maintain and update AWS managed policies. You can't change the permissions in AWS managed policies. Services occasionally add additional permissions to an AWS managed policy to support new features. This type of update affects all identities (users, groups, and roles) where the policy is attached. Services are most likely to update an AWS managed policy when a new feature is launched or when new operations become available. Services do not remove permissions from an AWS managed policy, so policy updates won’t break your existing permissions.

Additionally, AWS supports managed policies for job functions that span multiple services. For example, the ReadOnlyAccess: AWS managed policy provides read-only access to all AWS services and resources. When a service launches a new feature, AWS adds read-only permissions for new operations and resources. For a list and descriptions of job function policies, see AWS managed policies for job functions in the IAM User Guide.

Note
AWS IoT works with both AWS IoT and IAM policies. This topic discusses only IAM policies, which defines a policy action for control plane and data plane API operations. See also AWS IoT Core policies (p. 336).
AWS managed policy: AWSIoTConfigAccess

You can attach the AWSIoTConfigAccess policy to your IAM identities.

This policy grants the associated identity permissions that allow access to all AWS IoT configuration operations. This policy can affect data processing and storage. To view this policy in the AWS Management Console, see AWSIoTConfigAccess.

Permissions details

This policy includes the following permissions.

- `iot` – Retrieve AWS IoT data and perform IoT configuration actions.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:AcceptCertificateTransfer",
        "iot:AddThingToThingGroup",
        "iot:AssociateTargetsWithJob",
        "iot:AttachPolicy",
        "iot:AttachPrincipalPolicy",
        "iot:AttachPrincipal",
        "iot:CancelCertificateTransfer",
        "iot:CancelJob",
        "iot:CancelJobExecution",
        "iot:ClearDefaultAuthorizer",
        "iot:CreateAuthorizer",
        "iot:CreateCertificateFromCsr",
        "iot:CreateJob",
        "iot:CreateKeysAndCertificate",
        "iot:CreateOTAUpdate",
        "iot:CreatePolicy",
        "iot:CreatePolicyVersion",
        "iot:CreateRoleAlias",
        "iot:CreateStream",
        "iot:CreateThing",
        "iot:CreateThingGroup",
        "iot:CreateThingType",
        "iot:CreateTopicRule",
        "iot:DeleteAuthorizer",
        "iot:DeleteCACertificate",
        "iot:DeleteCertificate",
        "iot:DeleteJob",
        "iot:DeleteJobExecution",
        "iot:DeleteOTAUpdate",
        "iot:DeletePolicy",
        "iot:DeletePolicyVersion",
        "iot:DeleteRegistrationCode",
        "iot:DeleteRoleAlias",
```
"iot:DeleteStream",
"iot:DeleteThing",
"iot:DeleteThingGroup",
"iot:DeleteThingType",
"iot:DeleteTopicRule",
"iot:DeleteV2LoggingLevel",
"iot:DeprecateThingType",
"iot:DescribeAuthorizer",
"iot:DescribeCACertificate",
"iot:DescribeCertificate",
"iot:DescribeDefaultAuthorizer",
"iot:DescribeEndpoint",
"iot:DescribeEventConfigurations",
"iot:DescribeIndex",
"iot:DescribeJob",
"iot:DescribeJobExecution",
"iot:DescribeRoleAlias",
"iot:DescribeStream",
"iot:DescribeThing",
"iot:DescribeThingGroup",
"iot:DescribeThingRegistrationTask",
"iot:DescribeThingType",
"iot:DetachPolicy",
"iot:DetachPrincipalPolicy",
"iot:DetachThingPrincipal",
"iot:DisableTopicRule",
"iot:EnableTopicRule",
"iot:GetEffectivePolicies",
"iot:GetIndexingConfiguration",
"iot:GetJobDocument",
"iot:GetLoggingOptions",
"iot:GetOTAUpdate",
"iot:GetPolicy",
"iot:GetPolicyVersion",
"iot:GetRegistrationCode",
"iot:GetTopicRule",
"iot:GetV2LoggingOptions",
"iot:GetAttacheresPolicies",
"iot:GetAuthorizers",
"iot:GetCACertificates",
"iot:GetCertificates",
"iot:GetCertificatesByCA",
"iot:GetIndices",
"iot:GetJobExecutionsForJob",
"iot:GetJobExecutionsForThing",
"iot:GetJobs",
"iot:GetOTAUpdates",
"iot:GetOutgoingCertificates",
"iot:GetPolicies",
"iot:GetPolicyPrincipalPolicies",
"iot:GetPolicyVersions",
"iot:GetPrincipalPolicies",
"iot:GetPrincipalThings",
"iot:GetPolicyAliases",
"iot:GetStreams",
"iot:GetTargetsForPolicy",
"iot:GetThingGroups",
"iot:GetThingGroupsForThing",
"iot:GetThingPrincipals",
"iot:GetThingRegistrationTaskReports",
"iot:GetThingRegistrationTasks",
"iot:GetThings",
"iot:GetThingsInThingGroup",
"iot:GetThingTypes",
"iot:GetTopicRules",
"iot:GetV2LoggingLevels",

415
AWS managed policy: AWSIoTConfigReadOnlyAccess

You can attach the AWSIoTConfigReadOnlyAccess policy to your IAM identities.
This policy grants the associated identity permissions that allow read-only access to all AWS IoT configuration operations. To view this policy in the AWS Management Console, see AWSIoTConfigReadOnlyAccess.

Permissions details

This policy includes the following permissions.

- **iot** – Perform read-only operations of IoT configuration actions.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:DescribeAuthorizer",
                "iot:DescribeCACertificate",
                "iot:DescribeCertificate",
                "iot:DescribeDefaultAuthorizer",
                "iot:DescribeEndpoint",
                "iot:DescribeEventConfigurations",
                "iot:DescribeIndex",
                "iot:DescribeJob",
                "iot:DescribeJobExecution",
                "iot:DescribeRoleAlias",
                "iot:DescribeStream",
                "iot:DescribeThing",
                "iot:DescribeThingGroup",
                "iot:DescribeThingRegistrationTask",
                "iot:DescribeThingType",
                "iot:GetEffectivePolicies",
                "iot:GetIndexingConfiguration",
                "iot:GetJobDocument",
                "iot:GetLoggingOptions",
                "iot:GetOTAUpdate",
                "iot:GetPolicy",
                "iot:GetPolicyVersion",
                "iot:GetRegistrationCode",
                "iot:GetTopicRule",
                "iot:GetV2LoggingOptions",
                "iot:ListAttachedPolicies",
                "iot:ListAuthorizers",
                "iot:ListCACertificates",
                "iot:ListCertificates",
                "iot:ListCertificatesByCA",
                "iot:ListIndices",
                "iot:ListJobExecutionsForJob",
                "iot:ListJobExecutionsForThing",
                "iot:ListJobs",
                "iot:ListOTAUpdates",
                "iot:ListOutgoingCertificates",
                "iot:ListPolicies",
                "iot:ListPolicyPrincipals",
                "iot:ListPolicyVersions",
                "iot:ListPrincipalPolicies",
                "iot:ListPrincipalThings",
                "iot:ListRoleAliases",
                "iot:ListStreams",
                "iot:ListTargetsForPolicy"
            ]
        }
    ]
}
```
AWS managed policy: AWSIoTDataAccess

You can attach the AWSIoTDataAccess policy to your IAM identities.

This policy grants the associated identity permissions that allow access to all AWS IoT data operations. Data operations send data over MQTT or HTTP protocols. To view this policy in the AWS Management Console, see AWSIoTDataAccess.

Permissions details

This policy includes the following permissions.

- **iot** – Retrieve AWS IoT data and allow full access to AWS IoT messaging actions.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect",
        "iot:Publish",
        "iot:Subscribe",
        "iot:ListThingGroups",
        "iot:ListThingGroupsForThing",
        "iot:ListThingPrincipals",
        "iot:ListThingRegistrationTaskReports",
        "iot:ListThingRegistrationTasks",
        "iot:ListThings",
        "iot:ListThingsInThingGroup",
        "iot:ListThingTypes",
        "iot:ListTopicRules",
        "iot:ListV2LoggingLevels",
        "iot:SearchIndex",
        "iot:TestAuthorization",
        "iot:TestInvokeAuthorizer",
        "iot:DescribeAccountAuditConfiguration",
        "iot:DescribeAuditTask",
        "iot:ListAuditTasks",
        "iot:DescribeScheduledAudit",
        "iot:ListScheduledAudits",
        "iot:ListAuditFindings",
        "iot:DescribeSecurityProfile",
        "iot:ListSecurityProfiles",
        "iot:ListSecurityProfilesForTarget",
        "iot:ListTargetsForSecurityProfile",
        "iot:ListActiveViolations",
        "iot:ListViolationEvents",
        "iot:ValidateSecurityProfileBehaviors"
      ],
      "Resource": "*"
    }
  ]
}
```
You can attach the AWSIoTFullAccess policy to your IAM identities.

This policy grants the associated identity permissions that allow access to all AWS IoT configuration and messaging operations. To view this policy in the AWS Management Console, see AWSIoTFullAccess.

Permissions details
This policy includes the following permissions.

- **iot** – Retrieve AWS IoT data and allow full access to AWS IoT configuration and messaging actions.
- **iotjobsdata** – Retrieve AWS IoT Jobs data and allow full access to AWS IoT Jobs data plane API operations.

You can attach the AWSIoTLogging policy to your IAM identities.

This policy grants the associated identity permissions that allow access to create Amazon CloudWatch Logs groups and stream logs to the groups. This policy is attached to your CloudWatch logging role. To view this policy in the AWS Management Console, see AWSIoTLogging.

Permissions details
This policy includes the following permissions.

- **logs** – Retrieve CloudWatch logs. Also allows creation of CloudWatch Logs groups and stream logs to the groups.

```json
```

**AWS managed policy: AWSIoTOTAUpdate**

You can attach the **AWSIoTOTAUpdate** policy to your IAM identities.

This policy grants the associated identity permissions that allow access to create AWS IoT jobs, AWS IoT code signing jobs, and to describe AWS code signer jobs. To view this policy in the AWS Management Console, see **AWSIoTOTAUpdate**.

**Permissions details**

This policy includes the following permissions.

- **iot** – Create AWS IoT jobs and code signing jobs.
- **signer** – Perform creation of AWS code signer jobs.

```json
```
AWS managed policy: AWSIoTRuleActions

You can attach the AWSIoTRuleActions policy to your IAM identities.

This policy grants the associated identity permissions that allow access to all AWS services supported in AWS IoT rule actions. To view this policy in the AWS Management Console, see AWSIoTRuleActions.

Permissions details

This policy includes the following permissions.

- **iot** - Perform actions for publishing rule action messages.
- **dynamodb** - Insert a message into a DynamoDB table or split a message into multiple columns of a DynamoDB table.
- **s3** - Store an object in an Amazon S3 bucket.
- **kinesis** - Send a message to an Amazon Kinesis stream object.
- **firehose** - Insert a record in a Kinesis Data Firehose stream object.
- **cloudwatch** - Change CloudWatch alarm state or send message data to CloudWatch metric.
- **sns** - Perform operation to publish a notification using Amazon SNS. This operation is scoped to AWS IoT SNS topics.
- **sqs** - Insert a message to add to the SQS queue.
- **es** - Send a message to the OpenSearch Service service.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "dynamodb:PutItem",
                "kinesis:PutRecord",
                "iot:Publish",
                "s3:PutObject",
                "sns:Publish",
                "sqs:SendMessage",
                "cloudwatch:SetAlarmState",
                "cloudwatch:PutMetricData",
                "es:ESHttpPost",
                "firehose:PutRecord"
            ],
            "Resource": "*
        }
    ]
}
```

AWS managed policy: AWSIoTThingsRegistration
You can attach the AWSIoTThingsRegistration policy to your IAM identities.

This policy grants the associated identity permissions that allow access to register things in bulk using the StartThingRegistrationTask API. This policy can affect data processing and storage. To view this policy in the AWS Management Console, see AWSIoTThingsRegistration.

Permissions details

This policy includes the following permissions.

- **iot** - Perform actions for creating things and attaching policies and certificates when registering in bulk.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:AddThingToThingGroup",
        "iot:AttachPrincipalPolicy",
        "iot:AttachPrincipal",
        "iot:CreateCertificateFromCsr",
        "iot:CreatePolicy",
        "iot:CreateThing",
        "iot:DescribeCertificate",
        "iot:DescribeThing",
        "iot:DescribeThingType",
        "iot:DetachPolicy",
        "iot:DetachPrincipalPolicy",
        "iot:GetPolicy",
        "iot:ListAttachedPolicies",
        "iot:ListPolicyPrincipals",
        "iot:ListPrincipalPolicies",
        "iot:ListPrincipalThings",
        "iot:ListTargetsForPolicy",
        "iot:ListThingGroupsForThing",
        "iot:ListThingPrincipals",
        "iot:RegisterCertificate",
        "iot:RegisterPrincipal",
        "iot:RemoveThingFromThingGroup",
        "iot:UpdateCertificate",
        "iot:UpdatePrincipal",
        "iot:UpdatePrincipalPolicy",
        "iot:UpdateThingGroupsForThing",
        "iot:AddThingToBillingGroup",
        "iot:DescribeBillingGroup",
        "iot:RemoveThingFromBillingGroup"
      ],
      "Resource": ["*"]
    }
  ]
}
```
AWS IoT updates to AWS managed policies

View details about updates to AWS managed policies for AWS IoT since this service began tracking these changes. For automatic alerts about changes to this page, subscribe to the RSS feed on the AWS IoT Document history page.

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>AWSIoTFullAccess (p. 419) – Update to an existing policy</td>
<td>AWS IoT added new permissions to allow users to access AWS IoT Jobs data plane API operations using the HTTP protocol. A new IAM policy prefix, iot:jobsdata:, provides you finer grained access control to access AWS IoT Jobs data plane endpoints. For control plane API operations, you still use the iot: prefix. For more information, see AWS IoT Core policies for HTTPS protocol (p. 803).</td>
<td>May 11, 2022</td>
</tr>
<tr>
<td>AWS IoT started tracking changes</td>
<td>AWS IoT started tracking changes for its AWS managed policies.</td>
<td>May 11, 2022</td>
</tr>
</tbody>
</table>

Troubleshooting AWS IoT identity and access

Use the following information to help you diagnose and fix common issues that you might encounter when working with AWS IoT and IAM.

**Topics**
- I am not authorized to perform an action in AWS IoT (p. 423)
- I am not authorized to perform iam:PassRole (p. 424)
- I want to allow people outside of my AWS account to access my AWS IoT resources (p. 424)

I am not authorized to perform an action in AWS IoT

If you receive an error that you're not authorized to perform an action, your policies must be updated to allow you to perform the action.

The following example error occurs when the IAM user, mateojackson, tries to use the console to view details about a thing resource but doesn't have the iot:DescribeThing permissions.

User: arn:aws:iam::123456789012:user/mateojackson is not authorized to perform: iot:DescribeThing on resource: MyIoTThing

In this case, the policy for the mateojackson user must be updated to allow access to the thing resource by using the iot:DescribeThing action.
If you need help, contact your AWS administrator. Your administrator is the person who provided you with your sign-in credentials.

Using AWS IoT Device Advisor

If you're using AWS IoT Device Advisor, the following example error occurs when the user mateo.jackson tries to use the console to view details about a suite definition but doesn't have the iotdeviceadvisor: GetSuiteDefinition permissions.

User: arn:aws:iam::123456789012:user/mateo.jackson is not authorized to perform: iotdeviceadvisor:GetSuiteDefinition on resource: MySuiteDefinition

In this case, the policy for the mateo.jackson user must be updated to allow access to the MySuiteDefinition resource using the iotdeviceadvisor:GetSuiteDefinition action.

I am not authorized to perform iam:PassRole

If you receive an error that you're not authorized to perform the iam:PassRole action, your policies must be updated to allow you to pass a role to AWS IoT.

Some AWS services allow you to pass an existing role to that service instead of creating a new service role or service-linked role. To do this, you must have permissions to pass the role to the service.

The following example error occurs when an IAM user named mary.major tries to use the console to perform an action in AWS IoT. However, the action requires the service to have permissions that are granted by a service role. Mary does not have permissions to pass the role to the service.

User: arn:aws:iam::123456789012:user/mary.major is not authorized to perform: iam:PassRole

In this case, Mary's policies must be updated to allow her to perform the iam:PassRole action.

If you need help, contact your AWS administrator. Your administrator is the person who provided you with your sign-in credentials.

I want to allow people outside of my AWS account to access my AWS IoT resources

You can create a role that users in other accounts or people outside of your organization can use to access your resources. You can specify who is trusted to assume the role. For services that support resource-based policies or access control lists (ACLs), you can use those policies to grant people access to your resources.

To learn more, consult the following:

- To learn whether AWS IoT supports these features, see How AWS IoT works with IAM (p. 394).
- To learn how to provide access to your resources across AWS accounts that you own, see Providing access to an IAM user in another AWS account that you own in the IAM User Guide.
- To learn how to provide access to your resources to third-party AWS accounts, see Providing access to AWS accounts owned by third parties in the IAM User Guide.
- To learn how to provide access through identity federation, see Providing access to externally authenticated users (identity federation) in the IAM User Guide.
- To learn the difference between using roles and resource-based policies for cross-account access, see How IAM roles differ from resource-based policies in the IAM User Guide.
Logging and Monitoring

Monitoring is an important part of maintaining the reliability, availability, and performance of AWS IoT and your AWS solutions. You should collect monitoring data from all parts of your AWS solution so that you can more easily debug a multi-point failure, if one occurs. For information on logging and monitoring procedures, see Monitoring AWS IoT (p. 439)

Monitoring Tools

AWS provides tools that you can use to monitor AWS IoT. You can configure some of these tools to do the monitoring for you. Some of the tools require manual intervention. We recommend that you automate monitoring tasks as much as possible.

Automated Monitoring Tools

You can use the following automated monitoring tools to watch AWS IoT and report when something is wrong:

- **Amazon CloudWatch Alarms** – Watch a single metric over a time period that you specify, and perform one or more actions based on the value of the metric relative to a given threshold over a number of time periods. The action is a notification sent to an Amazon Simple Notification Service (Amazon SNS) topic or Amazon EC2 Auto Scaling policy. CloudWatch alarms do not invoke actions simply because they are in a particular state. The state must have changed and been maintained for a specified number of periods. For more information, see Monitor AWS IoT alarms and metrics using Amazon CloudWatch (p. 446).

- **Amazon CloudWatch Logs** – Monitor, store, and access your log files from AWS CloudTrail or other sources. Amazon CloudWatch Logs also allows you to see critical steps AWS IoT Device Advisor test cases take, generated events and MQTT messages sent from your devices or AWS IoT Core during test execution. These logs make it possible to debug and take corrective actions on your devices. For more information, see Monitor AWS IoT using CloudWatch Logs (p. 461) For more information about using Amazon CloudWatch, see Monitoring Log Files in the Amazon CloudWatch User Guide.

- **Amazon CloudWatch Events** – Match events and route them to one or more target functions or streams to make changes, capture state information, and take corrective action. For more information, see What Is Amazon CloudWatch Events in the Amazon CloudWatch User Guide.

- **AWS CloudTrail Log Monitoring** – Share log files between accounts, monitor CloudTrail log files in real time by sending them to CloudWatch Logs, write log processing applications in Java, and validate that your log files have not changed after delivery by CloudTrail. For more information, see Logging AWS IoT API calls using AWS CloudTrail (p. 492) and also Working with CloudTrail Log Files in the AWS CloudTrail User Guide.

Manual Monitoring Tools

Another important part of monitoring AWS IoT involves manually monitoring those items that the CloudWatch alarms don't cover. The AWS IoT, CloudWatch, and other AWS service console dashboards provide an at-a-glance view of the state of your AWS environment. We recommend that you also check the log files on AWS IoT.

- AWS IoT dashboard shows:
  - CA certificates
  - Certificates
  - Polices
  - Rules
• Things
• CloudWatch home page shows:
  • Current alarms and status.
  • Graphs of alarms and resources.
  • Service health status.

You can use CloudWatch to do the following:
• Create customized dashboards to monitor the services you care about.
• Graph metric data to troubleshoot issues and discover trends.
• Search and browse all your AWS resource metrics.
• Create and edit alarms to be notified of problems.

Compliance validation for AWS IoT Core

To learn whether an AWS service is within the scope of specific compliance programs, see AWS services in Scope by Compliance Program and choose the compliance program that you are interested in. For general information, see AWS Compliance Programs.

You can download third-party audit reports using AWS Artifact. For more information, see Downloading Reports in AWS Artifact.

Your compliance responsibility when using AWS services is determined by the sensitivity of your data, your company's compliance objectives, and applicable laws and regulations. AWS provides the following resources to help with compliance:

• Security and Compliance Quick Start Guides – These deployment guides discuss architectural considerations and provide steps for deploying baseline environments on AWS that are security and compliance focused.
• Architecting for HIPAA Security and Compliance on Amazon Web Services – This whitepaper describes how companies can use AWS to create HIPAA-eligible applications.

  Note
  Not all AWS services are HIPAA eligible. For more information, see the HIPAA Eligible Services Reference.
• AWS Compliance Resources – This collection of workbooks and guides might apply to your industry and location.
• Evaluating Resources with Rules in the AWS Config Developer Guide – The AWS Config service assesses how well your resource configurations comply with internal practices, industry guidelines, and regulations.
• AWS Security Hub – This AWS service provides a comprehensive view of your security state within AWS. Security Hub uses security controls to evaluate your AWS resources and to check your compliance against security industry standards and best practices. For a list of supported services and controls, see Security Hub controls reference.
• AWS Audit Manager – This AWS service helps you continuously audit your AWS usage to simplify how you manage risk and compliance with regulations and industry standards.

Resilience in AWS IoT Core

The AWS global infrastructure is built around AWS Regions and Availability Zones. AWS Regions provide multiple physically separated and isolated Availability Zones, which are connected with low-latency,
high-throughput, and highly redundant networking. With Availability Zones, you can design and operate applications and databases that automatically fail over between Availability Zones without interruption. Availability Zones are more highly available, fault tolerant, and scalable than traditional single or multiple data center infrastructures.

For more information about AWS Regions and Availability Zones, see [AWS Global Infrastructure](#).

AWS IoT Core stores information about your devices in the device registry. It also stores CA certificates, device certificates, and device shadow data. In the event of hardware or network failures, this data is automatically replicated across Availability Zones but not across Regions.

AWS IoT Core publishes MQTT events when the device registry is updated. You can use these messages to back up your registry data and save it somewhere, like a DynamoDB table. You are responsible for saving certificates that AWS IoT Core creates for you or those you create yourself. Device shadow stores state data about your devices and can be resent when a device comes back online. AWS IoT Device Advisor stores information about your test suite configuration. This data is automatically replicated in the event of hardware or network failures.

AWS IoT Core resources are Region-specific and aren't replicated across AWS Regions unless you specifically do so.

For information about Security best practices, see [Security best practices in AWS IoT Core](p. 433).

**Using AWS IoT Core with interface VPC endpoints**

With AWS IoT Core, you can create [IoT data endpoints](#) within your virtual private cloud (VPC) by using [interface VPC endpoints](#). Interface VPC endpoints are powered by AWS PrivateLink, an AWS technology that you can use to access services running on AWS by using private IP addresses. For more information, see [Amazon Virtual Private Cloud](#).

In order to connect devices in the field on remote networks, such as a corporate network to your Amazon VPC, refer to the options listed in the [Network-to-Amazon VPC connectivity matrix](#).

**Contents**

- Creating VPC endpoints for AWS IoT Core data plane (p. 427)
- Creating VPC endpoints for AWS IoT Core credential provider (p. 428)
- Creating an Amazon VPC interface endpoint (p. 429)
- Configuring private hosted zone (p. 429)
- Controlling Access to AWS IoT Core over VPC endpoints (p. 431)
- Limitations (p. 431)
- Scaling VPC endpoints with AWS IoT Core (p. 432)
- Using custom domains with VPC endpoints (p. 432)
- Availability of VPC endpoints for AWS IoT Core (p. 432)

**Creating VPC endpoints for AWS IoT Core data plane**

You can create a VPC endpoint for AWS IoT Core data plane API to connect your devices to AWS IoT services and other AWS services. To get started with VPC endpoints, create an interface VPC endpoint and select AWS IoT Core as the AWS service. If you are using the CLI, first call describe-vpc-endpoint-services to ensure that you are choosing an Availability Zone where AWS IoT Core is present in your particular AWS Region. For example, in us-east-1, this command would look like:
aws ec2 describe-vpc-endpoint-services --service-name com.amazonaws.us-east-1.iot.data

Note
The VPC feature for automatically creating a DNS record is disabled. To connect to these endpoints, you must manually create a Private DNS record. For more information about Private VPC DNS records, see Private DNS for interface endpoints. For more information about AWS IoT Core VPC limitations, see Limitations (p. 431).

To connect MQTT clients to the VPC endpoint interfaces:

• You must manually create DNS records in a private hosted zone that is attached to your VPC. To get started, see Creating a private hosted zone.

• Within your private hosted zone, create an alias record for each elastic network interface IP for the VPC endpoint. If you have multiple network interface IPs for multiple VPC endpoints, create weighted DNS records with equal weights across all the weighted records. These IP addresses are available from the DescribeNetworkInterfaces API call when filtered by the VPC endpoint ID in the description field.

See the detailed instructions below to Create an Amazon VPC interface endpoint (p. 429) and Configure private hosted zone (p. 429) for AWS IoT Core data plane.

Creating VPC endpoints for AWS IoT Core credential provider

You can create a VPC endpoint for AWS IoT Core credential provider to connect devices using client certificate-based authentication and get temporary AWS credentials in AWS Signature Version 4 format. To get started with VPC endpoints for AWS IoT Core credential provider, run the create-vpc-endpoint CLI command to create an interface VPC endpoint and select AWS IoT Core credential provider as the AWS service. To ensure that you are choosing an Availability Zone where AWS IoT Core is present in your particular AWS Region, your first run the describe-vpc-endpoint-services command. For example, in us-east-1, this command would look like:

aws ec2 describe-vpc-endpoint-services --service-name com.amazonaws.us-east-1.iot.credentials

Note
The VPC feature for automatically creating a DNS record is disabled. To connect to these endpoints, you must manually create a Private DNS record. For more information about Private VPC DNS records, see Private DNS for interface endpoints. For more information about AWS IoT Core VPC limitations, see Limitations (p. 431).

To connect HTTP clients to the VPC endpoint interfaces:

• You must manually create DNS records in a private hosted zone that is attached to your VPC. To get started, see Creating a private hosted zone.

• Within your private hosted zone, create an alias record for each elastic network interface IP for the VPC endpoint. If you have multiple network interface IPs for multiple VPC endpoints, create weighted DNS records with equal weights across all the weighted records. These IP addresses are available from the DescribeNetworkInterfaces API call when filtered by the VPC endpoint ID in the description field.

See the detailed instructions below to Create an Amazon VPC interface endpoint (p. 429) and Configure private hosted zone (p. 429) for AWS IoT Core credential provider.
Creating an Amazon VPC interface endpoint

You can create an interface VPC endpoint to connect to AWS services powered by AWS PrivateLink. Use the following procedure to create an interface VPC endpoint that connects to AWS IoT Core data plane or AWS IoT Core credential provider. For more information, see Access an AWS service using an interface VPC endpoint.

**Note**
The processes to create an Amazon VPC interface endpoint for AWS IoT Core data plane and AWS IoT Core credential provider are similar, but you must make endpoint specific changes to make the connection work.

**To create an interface VPC endpoint using VPC Endpoints console**

1. Navigate to the VPC Endpoints console, under Virtual private cloud on the left menu, choose Endpoints then Create Endpoint.
2. In the Create endpoint page, specify the following information.
   - **Choose AWS services** for Service category.
   - For **Service Name**, search by entering the keyword iot. In the list of iot services displayed, choose the endpoint.
     - If you create a VPC endpoint for AWS IoT Core data plane, choose the AWS IoT Core data plane API endpoint for your Region. The endpoint will be of the format com.amazonaws.region.iot.data.
     - If you create a VPC endpoint for AWS IoT Core credential provider, choose the AWS IoT Core credential provider endpoint for your Region. The endpoint will be of the format com.amazonaws.region.iot.credentials.
       **Note**
The service name for AWS IoT Core data plane in China Region will be of the format cn.com.amazonaws.region.iot.data. Creating VPC endpoints for AWS IoT Core credential provider is not supported in China Region.
   - **For VPC and Subnets**, choose the VPC where you want to create the endpoint, and the Availability Zones (AZs) in which you want to create the endpoint network.
   - For **Enable DNS name**, make sure that Enable for this endpoint is not selected. Neither AWS IoT Core data plane nor AWS IoT Core credential provider supports private DNS names yet.
   - **For Security group**, choose the security groups you want to associate with the endpoint network interfaces.
   - Optionally, you can add or remove tags. Tags are name-value pairs that you use to associate with your endpoint.
3. To create your VPC endpoint, choose Create endpoint.

After you create the AWS PrivateLink endpoint, in the Details tab of your endpoint, you'll see a list of DNS names. You can use one of these DNS names you created in this section to configure your private hosted zone (p. 429).

**Configuring private hosted zone**

You can use one of these DNS names you created in the previous section to configure your private hosted zone.

**For AWS IoT Core data plane**

The DNS name must be your domain configuration name or your IoT:Data-ATS endpoint. An example DNS name can be: *xxx-ats.data.iot.region.amazonaws.com*. 
For AWS IoT Core credential provider

The DNS name must be your iot:CredentialProvider endpoint. An example DNS name can be: xxxxx.credentials.iot.region.amazonaws.com.

Note
The processes to configure private hosted zone for AWS IoT Core data plane and AWS IoT Core credential provider are similar, but you must make endpoint specific changes to make the connection work.

Create a private hosted zone

To create a private hosted zone using Route 53 console

1. Navigate to the Route 53 Hosted zones console and choose Create hosted zone.
2. In the Create hosted zone page, specify the following information.
   - For Domain name, enter the endpoint address for your iot:Data-ATS or iot:CredentialProvider endpoint. The following AWS CLI command shows how to get the endpoint through a public network: aws iot describe-endpoint --endpoint-type iot:Data-ATS, or aws iot describe-endpoint --endpoint-type iot:CredentialProvider.
     Note
     If you're using custom domains, see Using custom domains with VPC endpoints. Custom domains are not supported for AWS IoT Core credential provider.
   - For Type, choose Private hosted zone.
   - Optionally, you can add or remove tags to associate with your hosted zone.
3. To create your private hosted zone, choose Create hosted zone.

For more information, see Creating a private hosted zone.

Create a record

After you have created a private hosted zone, you can create a record that tells the DNS how you want traffic to be routed to that domain.

To create a record

1. In the list of hosted zones displayed, choose the private hosted zone that you created earlier and choose Create record.
2. Use the wizard method to create the record. If the console presents you the Quick create method, choose Switch to wizard.
3. Choose Simple Routing for Routing policy and then choose Next.
4. In the Configure records page, choose Define simple record.
5. In the Define simple record page:
   - For Record name, enter iot:Data-ATS endpoint or iot:CredentialProvider endpoint. This must be the same as the private hosted zone name.
   - For Record type, keep the value as A - Routes traffic to an IPv4 address and some AWS resources.
   - For Value/Route traffic to, choose Alias to VPC endpoint. Then choose your Region and then choose the endpoint that you created previously, as described in ?? (p. 429) from the list of endpoints displayed.
6. Choose Define simple record to create your record.
Controlling Access to AWS IoT Core over VPC endpoints

You can restrict device access to AWS IoT Core to be allowed only through VPC endpoint by using VPC condition context keys. AWS IoT Core supports the following VPC related context keys:

- SourceVpc
- SourceVpce
- VPCSourceIp

**Note**
AWS IoT Core doesn’t support Endpoints policies for VPC endpoints.

For example, the following policy grants permission to connect to AWS IoT Core using a client ID that matches the thing name, and to publish to any topic prefixed by the thing name, conditional on the device connecting to a VPC endpoint with a particular VPC Endpoint ID. This policy would deny connection attempts to your public IoT data endpoint.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Connect"],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"
      ],
      "Condition": {
        "StringEquals": {
          "aws:SourceVpce": "vpce-1a2b3c4d"
        }
      }
    },
    {
      "Effect": "Allow",
      "Action": ["iot:Publish"],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topic/${iot:Connection.Thing.ThingName}/**"
      ]
    }
  ]
}
```

**Limitations**

VPC endpoints are currently supported only for AWS IoT Core data endpoints and AWS IoT Core credential provider endpoints.

**Limitations of IoT data VPC endpoints**

This section covers the limitations of IoT data VPC endpoints.
MQTT keep alive periods are limited to 230 seconds. Keep alive periods longer than that will be automatically reduced to 230 seconds.

Each VPC endpoint supports 100,000 total concurrent connected devices. If you require more connections see Scaling VPC endpoints with AWS IoT Core (p. 432).

VPC endpoints support IPv4 traffic only.

VPC endpoints will serve ATS certificates only, except for custom domains.

VPC endpoint policies are not supported.

For VPC endpoints that are created for the AWS IoT Core data plane, AWS IoT Core doesn't support using zonal or regional public DNS records.

Limitations of credential provider endpoints

This section covers the limitations of credential provider VPC endpoints.

VPC endpoints support IPv4 traffic only.

VPC endpoints will serve ATS certificates only.

VPC endpoint policies are not supported.

Custom domains are not supported for credential provider endpoints.

For VPC endpoints that are created for the AWS IoT Core credential provider, AWS IoT Core doesn't support using zonal or regional public DNS records.

Scaling VPC endpoints with AWS IoT Core

AWS IoT Core Interface VPC endpoints are limited to 100,000 connected devices over a single interface endpoint. If your use case calls for more concurrent connections to the broker, then we recommend using multiple VPC endpoints and manually routing your devices across your interface endpoints.

When creating private DNS records to route traffic to your VPC endpoints, make sure to create as many weighted records as you have VPC endpoints to distribute traffic across your multiple endpoints.

Using custom domains with VPC endpoints

If you want to use custom domains with VPC endpoints, you must create your custom domain name records in a private hosted zone and create routing records in Route53. For more information, see Creating A private hosted zone.

Note

Custom domains are only supported for AWS IoT Core data endpoints.

Availability of VPC endpoints for AWS IoT Core

AWS IoT Core Interface VPC endpoints are available in all AWS IoT Core supported regions. AWS IoT Core Interface VPC endpoints for AWS IoT Core credential provider are not supported in China Region and AWS GovCloud (US) Regions.

Infrastructure security in AWS IoT

As a collection of managed services, AWS IoT is protected by the AWS global network security procedures that are described in the Amazon Web Services: Overview of Security Processes whitepaper.
You use AWS published API calls to access AWS IoT through the network. Clients must support Transport Layer Security (TLS) 1.2 or later. Clients must also support cipher suites with perfect forward secrecy (PFS) such as Ephemeral Diffie-Hellman (DHE) or Elliptic Curve Ephemeral Diffie-Hellman (ECDHE). Most modern systems, such as Java 7 and later, support these modes. For more information, see *Transport security in AWS IoT Core* (p. 386).

Requests must be signed by using an access key ID and a secret access key that is associated with an IAM principal. Or you can use the *AWS Security Token Service* (AWS STS) to generate temporary security credentials to sign requests.

**Security monitoring of production fleets or devices with AWS IoT Core**

IoT fleets can consist of large numbers of devices that have diverse capabilities, are long-lived, and are geographically distributed. These characteristics make fleet setup complex and prone to errors. And because devices are often constrained in computational power, memory, and storage capabilities, this limits the use of encryption and other forms of security on the devices themselves. Also, devices often use software with known vulnerabilities. These factors make IoT fleets an attractive target for hackers and make it difficult to secure your device fleet on an ongoing basis.

AWS IoT Device Defender addresses these challenges by providing tools to identify security issues and deviations from best practices. You can use AWS IoT Device Defender to analyze, audit, and monitor connected devices to detect abnormal behavior, and mitigate security risks. AWS IoT Device Defender can audit device fleets to ensure they adhere to security best practices and detect abnormal behavior on devices. This makes it possible to enforce consistent security policies across your AWS IoT device fleet and respond quickly when devices are compromised. For more information, see *AWS IoT Device Defender* (p. 929).

AWS IoT Device Advisor pushes updates and patches your fleet as needed. AWS IoT Device Advisor updates test cases automatically. The test cases that you select are always with latest version. For more information, see *Device Advisor* (p. 1103).

**Security best practices in AWS IoT Core**

This section contains information about security best practices for AWS IoT Core. For information about security rules for Industrial IoT solutions, see *Ten security golden rules for Industrial IoT solutions*.

**Protecting MQTT connections in AWS IoT**

*AWS IoT Core* is a managed cloud service that makes it possible for connected devices to interact with cloud applications and other devices easily and securely. AWS IoT Core supports HTTP, WebSocket, and MQTT, a lightweight communication protocol specifically designed to tolerate intermittent connections. If you are connecting to AWS IoT using MQTT, each of your connections must be associated with an identifier known as a client ID. MQTT client IDs uniquely identify MQTT connections. If a new connection is established using a client ID that is already claimed for another connection, the AWS IoT message broker drops the old connection to allow the new connection. Client IDs must be unique within each AWS account and each AWS Region. This means that you don’t need to enforce global uniqueness of client IDs outside of your AWS account or across Regions within your AWS account.

The impact and severity of dropping MQTT connections on your device fleet depends on many factors. These include:
• Your use case (for example, the data your devices send to AWS IoT, how much data, and the frequency
that the data is sent).
• Your MQTT client configuration (for example, auto reconnect settings, associated back-off timings, and
use of MQTT persistent sessions (p. 90)).
• Device resource constraints.
• The root cause of the disconnections, its aggressiveness, and persistence.

To avoid client ID conflicts and their potential negative impacts, make sure that each device or mobile application has an AWS IoT or IAM policy that restricts which client IDs can be used for MQTT connections to the AWS IoT message broker. For example, you can use an IAM policy to prevent a device from unintentionally closing another device's connection by using a client ID that is already in use. For more information, see Authorization (p. 334).

All devices in your fleet must have credentials with privileges that authorize intended actions only, which include (but not limited to) AWS IoT MQTT actions such as publishing messages or subscribing to topics with specific scope and context. The specific permission policies can vary for your use cases. Identify the permission policies that best meet your business and security requirements.

To simplify creation and management of permission policies, you can use AWS IoT Core policy variables (p. 340) and IAM policy variables. Policy variables can be placed in a policy and when the policy is evaluated, the variables are replaced by values that come from the device's request. Using policy variables, you can create a single policy for granting permissions to multiple devices. You can identify the relevant policy variables for your use case based on your AWS IoT account configuration, authentication mechanism, and network protocol used in connecting to AWS IoT message broker. However, to write the best permission policies, consider the specifics of your use case and your threat model.

For example, if you registered your devices in the AWS IoT registry, you can use thing policy variables (p. 342) in AWS IoT policies to grant or deny permissions based on thing properties like thing names, thing types, and thing attribute values. The thing name is obtained from the client ID in the MQTT connect message sent when a thing connects to AWS IoT. The thing policy variables are replaced when a thing connects to AWS IoT over MQTT using TLS mutual authentication or MQTT over the WebSocket protocol using authenticated Amazon Cognito identities. You can use the AttachThingPrincipal API to attach certificates and authenticated Amazon Cognito identities to a thing. iot:Connection.Thing.ThingName is a useful thing policy variable to enforce client ID restrictions. The following example AWS IoT policy requires a registered thing's name to be used as the client ID for MQTT connections to the AWS IoT message broker:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iot:Connect",
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"
      ]
    }
  ]
}
```

If you want to identify ongoing client ID conflicts, you can enable and use CloudWatch Logs for AWS IoT (p. 461). For every MQTT connection that the AWS IoT message broker disconnects due to client ID conflicts, a log record similar to the following is generated:

```
{
  "timestamp": "2019-04-28 22:05:30.105",
  "logLevel": "ERROR",
}
```
Keep your device's clock in sync

It's important to have an accurate time on your device. X.509 certificates have an expiry date and time. The clock on your device is used to verify that a server certificate is still valid. If you're building commercial IoT devices, remember that your products may be stored for extended periods before being sold. Real-time clocks can drift during this time and batteries can get discharged, so setting time in the factory is not sufficient.

For most systems, this means that the device's software must include a network time protocol (NTP) client. The device should wait until it synchronizes with an NTP server before it tries to connect to AWS IoT Core. If this isn't possible, the system should provide a way for a user to set the device's time so that subsequent connections succeed.

After the device synchronizes with an NTP server, it can open a connection with AWS IoT Core. How much clock skew that is allowed depends on what you're trying to do with the connection.

Validate the server certificate

The first thing a device does to interact with AWS IoT is to open a secure connection. When you connect your device to AWS IoT, ensure that you're talking to AWS IoT and not another server impersonating AWS IoT. Each of the AWS IoT servers is provisioned with a certificate issued for the iot.amazonaws.com domain.
domain. This certificate was issued to AWS IoT by a trusted certificate authority that verified our identity and ownership of the domain.

One of the first things AWS IoT Core does when a device connects is send the device a server certificate. Devices can verify that they were expecting to connect to iot.amazonaws.com and that the server on the end of that connection possesses a certificate from a trusted authority for that domain.

TLS certificates are in X.509 format and include a variety of information such as the organization’s name, location, domain name, and a validity period. The validity period is specified as a pair of time values called notBefore and notAfter. Services like AWS IoT Core use limited validity periods (for example, one year) for their server certificates and begin serving new ones before the old ones expire.

Use a single identity per device

Use a single identity per client. Devices generally use X.509 client certificates. Web and mobile applications use Amazon Cognito Identity. This enables you to apply fine-grained permissions to your devices.

For example, you have an application that consists of a mobile phone device that receives status updates from two different smart home objects – a light bulb and a thermostat. The light bulb sends the status of its battery level, and a thermostat sends messages that report the temperature.

AWS IoT authenticates devices individually and treats each connection individually. You can apply fine-grained access controls using authorization policies. You can define a policy for the thermostat that allows it to publish to a topic space. You can define a separate policy for the light bulb that allows it to publish to a different topic space. Finally, you can define a policy for the mobile app that only allows it to connect and subscribe to the topics for the thermostat and the light bulb to receive messages from these devices.

Apply the principle of least privilege and scope down the permissions per device as much as possible. All devices or users should have an AWS IoT policy in AWS IoT that only allows it to connect with a known client ID, and to publish and subscribe to an identified and fixed set of topics.

Use a second AWS Region as backup

Consider storing a copy of your data in a second AWS Region as a backup. For more information, see Disaster Recovery for AWS IoT.

Use just in time provisioning

Manually creating and provisioning each device can be time consuming. AWS IoT provides a way to define a template to provision devices when they first connect to AWS IoT. For more information, see Just-in-time provisioning (p. 860).

Permissions to run AWS IoT Device Advisor tests

The following policy template shows the minimum permissions and IAM entity required to run AWS IoT Device Advisor test cases. You will need to replace your-device-role-arn with the device role Amazon Resource Name (ARN) that you created under the prerequisites.

```json
{
    "Version": "2012-10-17",
    "Statement": [
    {
        "Sid": "VisualEditor0",
        "Effect": "Allow",
```

436
Cross-service confused deputy prevention for Device Advisor

The confused deputy problem is a security issue where an entity that doesn't have permission to perform an action can coerce a more-privileged entity to perform the action. In AWS, cross-service impersonation can result in the confused deputy problem. Cross-service impersonation can occur when one service (the calling service) calls another service (the called service). The calling service can be manipulated to use its permissions to act on another customer's resources in a way it should not otherwise have permission to access. To prevent this, AWS provides tools that help you protect your data for all services with service principals that have been given access to resources in your account.
We recommend using the `aws:SourceArn` and `aws:SourceAccount` global condition context keys in resource policies to limit the permissions that Device Advisor gives another service to the resource. If you use both global condition context keys, the `aws:SourceAccount` value and the account in the `aws:SourceArn` value must use the same account ID when used in the same policy statement.

The value of `aws:SourceArn` must be the ARN of your suite definition resource. The suite definition resource refers to the test suite you created with Device Advisor.

The most effective way to protect against the confused deputy problem is to use the `aws:SourceArn` global condition context key with the full ARN of the resource. If you don’t know the full ARN of the resource or if you are specifying multiple resources, use the `aws:SourceArn` global context condition key with wildcards (*) for the unknown portions of the ARN. For example, `arn:aws:iotdeviceadvisor::*:account-id:suitedefinition/*`

The following example shows how you can use the `aws:SourceArn` and `aws:SourceAccount` global condition context keys in Device Advisor to prevent the confused deputy problem.

```json
{
    "Version": "2012-10-17",
    "Statement": {
        "Sid": "ConfusedDeputyPreventionExamplePolicy",
        "Effect": "Allow",
        "Principal": {
            "Service": "iotdeviceadvisor.amazonaws.com"
        },
        "Action": "sts:AssumeRole",
        "Condition": {
            "ArnLike": {
                "aws:SourceArn": "arn:aws:iotdeviceadvisor:us-east-1:123456789012:suitedefinition/ygp6rx3tzn"
            },
            "StringEquals": {
                "aws:SourceAccount": "123456789012"
            }
        }
    }
}
```

**AWS training and certification**

Take the following course to learn about key concepts for AWS IoT security: [AWS IoT Security Primer](#).
Monitoring AWS IoT

Monitoring is an important part of maintaining the reliability, availability, and performance of AWS IoT and your AWS solutions.

We strongly encourage you to collect monitoring data from all parts of your AWS solution to make it easier to debug a multi-point failure, if one occurs. Start by creating a monitoring plan that answers the following questions. If you're not sure how to answer these, you can still continue to enable logging (p. 439) and establish your performance baselines.

- What are your monitoring goals?
- Which resources will you monitor?
- How often will you monitor these resources?
- Which monitoring tools will you use?
- Who will perform the monitoring tasks?
- Who should be notified when something goes wrong?

Your next step is to enable logging (p. 439) and establish a baseline of normal AWS IoT performance in your environment by measuring performance at various times and under different load conditions. As you monitor AWS IoT, keep historical monitoring data so that you can compare it with current performance data. This will help you identify normal performance patterns and performance anomalies, and devise methods to address issues.

To establish your baseline performance for AWS IoT, you should monitor these metrics to start. You can always monitor more metrics later.

- PublishIn.Success (p. 452)
- PublishOut.Success (p. 452)
- Subscribe.Success (p. 452)
- Ping.Success (p. 452)
- Connect.Success (p. 452)
- GetThingShadow.Accepted (p. 456)
- UpdateThingShadow.Accepted (p. 456)
- DeleteThingShadow.Accepted (p. 456)
- RulesExecuted (p. 450)

The topics in this section can help you start logging and monitoring AWS IoT.

Topics
- Configure AWS IoT logging (p. 439)
- Monitor AWS IoT alarms and metrics using Amazon CloudWatch (p. 446)
- Monitor AWS IoT using CloudWatch Logs (p. 461)
- Upload device-side logs to Amazon CloudWatch (p. 484)
- Logging AWS IoT API calls using AWS CloudTrail (p. 492)

Configure AWS IoT logging

You must enable logging by using the AWS IoT console, CLI, or API before you can monitor and log AWS IoT activity.
You can enable logging for all of AWS IoT or only specific thing groups. You can configure AWS IoT logging by using the AWS IoT console, CLI, or API; however, you must use the CLI or API to configure logging for specific thing groups.

When considering how to configure your AWS IoT logging, the default logging configuration determines how AWS IoT activity will be logged unless specified otherwise. Starting out, you might want to obtain detailed logs with a default log level (p. 445) of INFO or DEBUG. After reviewing the initial logs, you can change the default log level to a less verbose level such as WARN or ERROR and set a more verbose resource-specific log level on resources that might need more attention. Log levels can be changed whenever you want.

This topic covers cloud-side logging in AWS IoT. For information on device-side logging and monitoring, see Upload device-side logs to CloudWatch.

For information on logging and monitoring AWS IoT Greengrass, see Logging and monitoring in AWS IoT Greengrass. As of June 30, 2023, the AWS IoT Greengrass Core software has migrated to AWS IoT Greengrass Version 2.

Configure logging role and policy

Before you can enable logging in AWS IoT, you must create an IAM role and a policy that gives AWS permission to monitor AWS IoT activity on your behalf. You can also generate an IAM role with the policies needed in the Logs section of the AWS IoT console.

Note
Before you enable AWS IoT logging, make sure you understand the CloudWatch Logs access permissions. Users with access to CloudWatch Logs can see debugging information from your devices. For more information, see Authentication and Access Control for Amazon CloudWatch Logs.

If you expect high traffic patterns in AWS IoT Core due to load testing, consider turning off IoT logging to prevent throttling. If high traffic is detected, our service may disable logging in your account.

Following shows how to create a logging role and policy for AWS IoT Core resources. For information about how you can create an IAM logging role and policy for AWS IoT Core for LoRaWAN, see Create logging role and policy for AWS IoT Wireless (p. 1391).

Create a logging role

To create a logging role, open the Roles hub of the IAM console and choose Create role.

1. Under Select trusted entity, choose AWS Service. Then choose IoT under Use case. If you don't see IoT, enter and search IoT from the Use cases for other AWS services: drop-down menu. Select Next.
2. On the Add permissions page, you will see the policies that are automatically attached to the service role. Choose Next.
3. On the Name, review, and create page, enter a Role name and Role description for the role, then choose Create role.
4. In the list of Roles, find the role you created, open it, and copy the Role ARN (logging-role-arn) to use when you Configure default logging in the AWS IoT (console) (p. 441).

Logging role policy

The following policy documents provide the role policy and trust policy that allow AWS IoT to submit log entries to CloudWatch on your behalf. If you also allowed AWS IoT Core for LoRaWAN to submit log entries, you'll see a policy document created for you that logs both activities. For information about how
Configure default logging in the AWS IoT (console)

This section describes how use the AWS IoT console to configure logging for all of AWS IoT. To configure logging for only specific thing groups, you must use the CLI or API. For information about configuring logging for specific thing groups, see Configure resource-specific logging in AWS IoT (CLI) (p. 444).

To use the AWS IoT console to configure default logging for all of AWS IoT

1. Sign in to the AWS IoT console. For more information, see Open the AWS IoT console (p. 19).
2. In the left navigation pane, choose **Settings**. In the **Logs** section of the **Settings** page, choose **Manage logs**.

The **Logs** page displays the logging role and level of verbosity used by all of AWS IoT.

3. On the **Logs** page, choose **Select role** to specify a role that you created in [Create a logging role](p. 440), or **Create Role** to create a new role to use for logging.

4. Choose the **Log level** that describes the *level of detail* (p. 445) of the log entries that you want to appear in the CloudWatch logs.
5. Choose **Update** to save your changes.

After you've enabled logging, visit Viewing AWS IoT logs in the CloudWatch console (p. 461) to learn more about viewing the log entries.

## Configure default logging in AWS IoT (CLI)

This section describes how to configure global logging for AWS IoT by using the CLI.

**Note**

You need the Amazon Resource Name (ARN) of the role that you want to use. If you need to create a role to use for logging, see Create a logging role (p. 440) before continuing. The principal used to call the API must have Pass role permissions (p. 496) for your logging role.

You can also perform this procedure with the API by using the methods in the AWS API that correspond to the CLI commands shown here.

### To use the CLI to configure default logging for AWS IoT

1. Use the `set-v2-logging-options` command to set the logging options for your account.

   ```shell
   aws iot set-v2-logging-options \
   --role-arn logging-role-arn \
   --default-log-level log-level
   ```

   where:

   **--role-arn**
   
   The role ARN that grants AWS IoT permission to write to your logs in CloudWatch Logs.

   **--default-log-level**
   
   The log level (p. 445) to use. Valid values are: ERROR, WARN, INFO, DEBUG, or DISABLED

   **--no-disable-all-logs**
   
   An optional parameter that enables all AWS IoT logging. Use this parameter to enable logging when it is currently disabled.

   **--disable-all-logs**
   
   An optional parameter that disables all AWS IoT logging. Use this parameter to disable logging when it is currently enabled.

2. Use the `get-v2-logging-options` command to get your current logging options.

   ```shell
   aws iot get-v2-logging-options
   ```

After you've enabled logging, visit Viewing AWS IoT logs in the CloudWatch console (p. 461) to learn more about viewing the log entries.

**Note**

AWS IoT continues to support older commands (set-logging-options and get-logging-options) to set and get global logging on your account. Be aware that when these commands are used, the resulting logs contain plain-text, rather than JSON payloads and logging latency is generally higher. No further improvements will be made to the implementation of these older commands. We recommend that you use the "v2" versions to configure your logging options and, when possible, change legacy applications that use the older versions.
Configure resource-specific logging in AWS IoT (CLI)

This section describes how to configure resource-specific logging for AWS IoT by using the CLI. Resource-specific logging allows you to specify a logging level for a specific thing group (p. 276).

Thing groups can contain other thing groups to create a hierarchical relationship. This procedure describes how to configure the logging of a single thing group. You can apply this procedure to the parent thing group in a hierarchy to configure the logging for all thing groups in the hierarchy. You can also apply this procedure to a child thing group to override the logging configuration of its parent.

In addition to thing groups, you can also log targets such as a device's client ID, source IP, and principal ID.

Note: You need the Amazon Resource Name (ARN) of the role you want to use. If you need to create a role to use for logging, see Create a logging role (p. 440) before continuing. The principal used to call the API must have Pass role permissions (p. 496) for your logging role.

You can also perform this procedure with the API by using the methods in the AWS API that correspond to the CLI commands shown here.

To use the CLI to configure resource-specific logging for AWS IoT

1. Use the set-v2-logging-options command to set the logging options for your account.

```
aws iot set-v2-logging-options \\n--role-arn logging-role-arn \n--default-log-level log-level
```

where:

--role-arn

The role ARN that grants AWS IoT permission to write to your logs in CloudWatch Logs.

--default-log-level

The log level (p. 445) to use. Valid values are: ERROR, WARN, INFO, DEBUG, or DISABLED

--no-disable-all-logs

An optional parameter that enables all AWS IoT logging. Use this parameter to enable logging when it is currently disabled.

--disable-all-logs

An optional parameter that disables all AWS IoT logging. Use this parameter to disable logging when it is currently enabled.

2. Use the set-v2-logging-level command to configure resource-specific logging for a thing group.

```
aws iot set-v2-logging-level \\n--log-target targetType=THING_GROUP,targetName=thing_group_name \n--log-level log_level
```

--log-target

The type and name of the resource for which you are configuring logging. The targetType value must be one of: THING_GROUP | CLIENT_ID | SOURCE_IP | PRINCIPAL_ID. The log-target parameter value can be text, as shown in the preceding command example, or a JSON string, such as the following example.
aws iot set-v2-logging-level \
   --log-target '{"targetType": "THING_GROUP","targetName": "thing_group_name"}'; \
   --log-level log_level

--log-level

The logging level used when generating logs for the specified resource. Valid values are: DEBUG, INFO, ERROR, WARN, and DISABLED

3. Use the list-v2-logging-levels command to list the currently configured logging levels.

aws iot list-v2-logging-levels

4. Use the delete-v2-logging-level command to delete a resource-specific logging level, such as the following examples.

aws iot delete-v2-logging-level \
   --target-type "THING_GROUP" \
   --target-name "thing_group_name"

aws iot delete-v2-logging-level \
   --target-type=CLIENT_ID \n   --target-name=ClientId1

--targetType

The target_type value must be one of: THING_GROUP | CLIENT_ID | SOURCE_IP | PRINCIPAL_ID.

--targetName

The name of the thing group for which to remove the logging level.

After you've enabled logging, visit Viewing AWS IoT logs in the CloudWatch console (p. 461) to learn more about viewing the log entries.

Log levels

These log levels determine the events that are logged and apply to default and resource-specific log levels.

ERROR

Any error that causes an operation to fail.

Logs include ERROR information only.

WARN

Anything that can potentially cause inconsistencies in the system, but might not cause the operation to fail.
Monitor AWS IoT alarms and metrics using Amazon CloudWatch

You can monitor AWS IoT using CloudWatch, which collects and processes raw data from AWS IoT into readable, near real-time metrics. These statistics are recorded for a period of two weeks, so that you can access historical information and gain a better perspective on how your web application or service is performing. By default, AWS IoT metric data is sent automatically to CloudWatch in one minute intervals. For more information, see What Are Amazon CloudWatch, Amazon CloudWatch Events, and Amazon CloudWatch Logs? in the Amazon CloudWatch User Guide.

Using AWS IoT metrics

The metrics reported by AWS IoT provide information that you can analyze in different ways. The following use cases are based on a scenario where you have ten things that connect to the internet once a day. Each day:

- Ten things connect to AWS IoT at roughly the same time.
- Each thing subscribes to a topic filter, and then waits for an hour before disconnecting. During this period, things communicate with one another and learn more about the state of the world.
- Each thing publishes some perception it has based on its newly found data using UpdateThingShadow.
- Each thing disconnects from AWS IoT.

To help you get started, these topics explore some of the questions that you might have.

- How can I be notified if my things do not connect successfully each day? (p. 447)
- How can I be notified if my things are not publishing data each day? (p. 448)
- How can I be notified if my thing's shadow updates are being rejected each day? (p. 448)
- How can I create a CloudWatch alarm for Jobs? (p. 449)

More about CloudWatch alarms and metrics

- Creating CloudWatch alarms to monitor AWS IoT (p. 447)
- AWS IoT metrics and dimensions (p. 450)
Creating CloudWatch alarms to monitor AWS IoT

You can create a CloudWatch alarm that sends an Amazon SNS message when the alarm changes state. An alarm watches a single metric over a time period you specify. When the value of the metric exceeds a given threshold over a number of time periods, one or more actions are performed. The action can be a notification sent to an Amazon SNS topic or Auto Scaling policy. Alarms trigger actions for sustained state changes only. CloudWatch alarms do not trigger actions simply because they are in a particular state; the state must have changed and been maintained for a specified number of periods.

The following topics describe some examples of using CloudWatch alarms.

- How can I be notified if my things do not connect successfully each day? (p. 447)
- How can I be notified if my things are not publishing data each day? (p. 448)
- How can I be notified if my thing's shadow updates are being rejected each day? (p. 448)
- How can I create a CloudWatch alarm for jobs? (p. 449)

You can see all the metrics that CloudWatch alarms can monitor at AWS IoT metrics and dimensions (p. 450).

How can I be notified if my things do not connect successfully each day?

1. Create an Amazon SNS topic named things-not-connecting-successfully, and record its Amazon Resource Name (ARN). This procedure will refer to your topic's ARN as sns-topic-arn.

   For more information on how to create an Amazon SNS notification, see Getting Started with Amazon SNS.

2. Create the alarm.

   ```
   aws cloudwatch put-metric-alarm \
   --alarm-name ConnectSuccessAlarm \
   --alarm-description "Alarm when my Things don't connect successfully" \
   --namespace AWS/IoT \
   --metric-name Connect.Success \
   --dimensions Name=Protocol,Value=MQTT \n   --statistic Sum \n   --threshold 10 \n   --comparison-operator LessThanThreshold \n   --period 86400 \
   --evaluation-periods 1 \n   --alarm-actions sns-topic-arn
   ```

3. Test the alarm.

   ```
   aws cloudwatch set-alarm-state --alarm-name ConnectSuccessAlarm --state-reason "initializing" --state-value OK
   ```

   ```
   aws cloudwatch set-alarm-state --alarm-name ConnectSuccessAlarm --state-reason "initializing" --state-value ALARM
   ```

4. Verify that the alarm appears in your CloudWatch console.
How can I be notified if my things are not publishing data each day?

1. Create an Amazon SNS topic named things-not-publishing-data, and record its Amazon Resource Name (ARN). This procedure will refer to your topic's ARN as sns-topic-arn.

For more information on how to create an Amazon SNS notification, see Getting Started with Amazon SNS.

2. Create the alarm.

```bash
aws cloudwatch put-metric-alarm \
  --alarm-name PublishInSuccessAlarm \
  --alarm-description "Alarm when my Things don't publish their data" \
  --namespace AWS/IoT \
  --metric-name PublishIn.Success \
  --dimensions Name=Protocol,Value=MQTT \
  --statistic Sum \
  --threshold 10 \
  --comparison-operator LessThanThreshold \
  --period 86400 \
  --evaluation-periods 1 \
  --alarm-actions sns-topic-arn
```

3. Test the alarm.

```bash
aws cloudwatch set-alarm-state --alarm-name PublishInSuccessAlarm --state-reason "initializing" --state-value OK
aws cloudwatch set-alarm-state --alarm-name PublishInSuccessAlarm --state-reason "initializing" --state-value ALARM
```

4. Verify that the alarm appears in your CloudWatch console.

How can I be notified if my thing's shadow updates are being rejected each day?

1. Create an Amazon SNS topic named things-shadow-updates-rejected, and record its Amazon Resource Name (ARN). This procedure will refer to your topic's ARN as sns-topic-arn.

For more information on how to create an Amazon SNS notification, see Getting Started with Amazon SNS.

2. Create the alarm.

```bash
aws cloudwatch put-metric-alarm \
  --alarm-name UpdateThingShadowSuccessAlarm \
  --alarm-description "Alarm when my Things Shadow updates are getting rejected" \
  --namespace AWS/IoT \
  --metric-name UpdateThingShadow.Success \
  --dimensions Name=Protocol,Value=MQTT \
  --statistic Sum \
  --threshold 10 \
  --comparison-operator LessThanThreshold \
  --period 86400 \
  --unit Count \
  --evaluation-periods 1 \
```

448
3. Test the alarm.

```bash
aws cloudwatch set-alarm-state --alarm-name UpdateThingShadowSuccessAlarm --state-reason "initializing" --state-value OK

aws cloudwatch set-alarm-state --alarm-name UpdateThingShadowSuccessAlarm --state-reason "initializing" --state-value ALARM
```

4. Verify that the alarm appears in your CloudWatch console.

**How can I create a CloudWatch alarm for jobs?**

The Jobs service provides CloudWatch metrics for you to monitor your jobs. You can create CloudWatch alarms to monitor any Jobs metrics (p. 456).

The following command creates a CloudWatch alarm to monitor the total number of failed job executions for Job `SampleOTAJob` and notifies you when more than 20 job executions have failed. The alarm monitors the Jobs metric `FailedJobExecutionTotalCount` by checking the reported value every 300 seconds. It is activated when a single reported value is greater than 20, meaning there were more than 20 failed job executions since the job started. When the alarm goes off, it sends a notification to the provided Amazon SNS topic.

```bash
aws cloudwatch put-metric-alarm \
  --alarm-name TotalFailedJobExecution-SampleOTAJob \
  --alarm-description "Alarm when total number of failed job execution exceeds the threshold for SampleOTAJob" \
  --namespace AWS/IoT \
  --metric-name FailedJobExecutionTotalCount \
  --dimensions Name=JobId,Value=SampleOTAJob \
  --statistic Sum \
  --threshold 20 \
  --comparison-operator GreaterThanThreshold \
  --period 300 \
  --unit Count \
  --evaluation-periods 1 \
```

The following command creates a CloudWatch alarm to monitor the number of failed job executions for Job `SampleOTAJob` in a given period. It then notifies you when more than five job executions have failed during that period. The alarm monitors the Jobs metric `FailedJobExecutionCount` by checking the reported value every 3600 seconds. It is activated when a single reported value is greater than 5, meaning there were more than 5 failed job executions in the past hour. When the alarm goes off, it sends a notification to the provided Amazon SNS topic.

```bash
aws cloudwatch put-metric-alarm \
  --alarm-name FailedJobExecution-SampleOTAJob \
  --alarm-description "Alarm when number of failed job execution per hour exceeds the threshold for SampleOTAJob" \
  --namespace AWS/IoT \
  --metric-name FailedJobExecutionCount \
  --dimensions Name=JobId,Value=SampleOTAJob \
  --statistic Sum \
  --threshold 5 \
  --comparison-operator GreaterThanThreshold \
  --period 3600 \
```
AWS IoT metrics and dimensions

When you interact with AWS IoT, the service sends the following metrics and dimensions to CloudWatch every minute. You can use the following procedures to view the metrics for AWS IoT.

To view metrics (CloudWatch console)

Metrics are grouped first by the service namespace, and then by the various dimension combinations within each namespace.

1. Open the CloudWatch console.
2. In the navigation pane, choose Metrics and then choose All metrics.
3. In the Browse tab, search for AWS IoT to view the list of metrics.

To view metrics (CLI)

• At a command prompt, use the following command:

```bash
aws cloudwatch list-metrics --namespace "AWS/IoT"
```

CloudWatch displays the following groups of metrics for AWS IoT:

- AWS IoT metrics (p. 450)
- AWS IoT Core credential provider metrics (p. 451)
- Rule metrics (p. 451)
- Rule action metrics (p. 451)
- HTTP action specific metrics (p. 452)
- Message broker metrics (p. 452)
- Device shadow metrics (p. 456)
- Jobs metrics (p. 456)
- Device Defender audit metrics (p. 458)
- Device Defender detect metrics (p. 458)
- Device provisioning metrics (p. 459)
- Fleet indexing metrics (p. 460)
- Dimensions for metrics (p. 460)

AWS IoT metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AddThingToDynamicThingGroupsFailed</td>
<td>The number of failure events associated with adding a thing to a dynamic thing group. The DynamicThingGroupName dimension contains the name of the dynamic groups that failed to add things.</td>
</tr>
</tbody>
</table>
## AWS IoT metrics and dimensions

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NumLogBatchesFailedToPublishThrottled</td>
<td>The singular batch of log events that has failed to publish due to throttling errors.</td>
</tr>
<tr>
<td>NumLogEventsFailedToPublishThrottled</td>
<td>The number of log events within the batch that have failed to publish due to throttling errors.</td>
</tr>
</tbody>
</table>

### AWS IoT Core credential provider metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CredentialExchangeSuccess</td>
<td>The number of successful AssumeRoleWithCertificate requests to AWS IoT Core credentials provider.</td>
</tr>
</tbody>
</table>

### Rule metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ParseError</td>
<td>The number of JSON parse errors that occurred in messages published on a topic on which a rule is listening. The RuleName dimension contains the name of the rule.</td>
</tr>
<tr>
<td>RuleMessageThrottled</td>
<td>The number of messages throttled by the rules engine because of malicious behavior or because the number of messages exceeds the rules engine's throttle limit. The RuleName dimension contains the name of the rule to be triggered.</td>
</tr>
<tr>
<td>RuleNotFound</td>
<td>The rule to be triggered could not be found. The RuleName dimension contains the name of the rule.</td>
</tr>
<tr>
<td>RulesExecuted</td>
<td>The number of AWS IoT rules executed.</td>
</tr>
<tr>
<td>TopicMatch</td>
<td>The number of incoming messages published on a topic on which a rule is listening. The RuleName dimension contains the name of the rule.</td>
</tr>
</tbody>
</table>

### Rule action metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure</td>
<td>The number of failed rule action invocations. The RuleName dimension contains the name of the rule that specifies the action. The ActionType dimension contains the type of action that was invoked.</td>
</tr>
<tr>
<td>Success</td>
<td>The number of successful rule action invocations. The RuleName dimension contains the name of the rule.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ErrorActionFailure</td>
<td>The number of failed error actions. The RuleName dimension contains the name of the rule that specifies the action. The ActionType dimension contains the type of action that was invoked.</td>
</tr>
<tr>
<td>ErrorActionSuccess</td>
<td>The number of successful error actions. The RuleName dimension contains the name of the rule that specifies the action. The ActionType dimension contains the type of action that was invoked.</td>
</tr>
</tbody>
</table>

### HTTP action specific metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HttpCode_Other</td>
<td>Generated if the status code of the response from the downstream web service/application is not 2xx, 4xx or 5xx.</td>
</tr>
<tr>
<td>HttpCode_4XX</td>
<td>Generated if the status code of the response from the downstream web service/application is between 400 and 499.</td>
</tr>
<tr>
<td>HttpCode_5XX</td>
<td>Generated if the status code of the response from the downstream web service/application is between 500 and 599.</td>
</tr>
<tr>
<td>HttpInvalidUrl</td>
<td>Generated if an endpoint URL, after substitution templates are replaced, does not start with https://.</td>
</tr>
<tr>
<td>HttpRequestTimeout</td>
<td>Generated if the downstream web service/application does not return response within request timeout limit. More information, see Service Quotas.</td>
</tr>
<tr>
<td>HttpUnknownHost</td>
<td>Generated if the URL is valid, but the service does not exist or is unreachable.</td>
</tr>
</tbody>
</table>

### Message broker metrics

**Note**
The message broker metrics are displayed in the CloudWatch console under Protocol Metrics.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect.AuthError</td>
<td>The number of connection requests that could not be authorized by the message broker. The Protocol dimension contains the protocol used to send the CONNECT message.</td>
</tr>
<tr>
<td>Connect.ClientError</td>
<td>The number of connection requests rejected because the MQTT message did not meet the requirements defined in AWS IoT quotas (p. 1450). The Protocol</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Connect.ClientIDThrottle</td>
<td>The number of connection requests throttled because the client exceeded the allowed connect request rate for a specific client ID. The Protocol dimension contains the protocol used to send the CONNECT message.</td>
</tr>
<tr>
<td>Connect.ServerError</td>
<td>The number of connection requests that failed because an internal error occurred. The Protocol dimension contains the protocol used to send the CONNECT message.</td>
</tr>
<tr>
<td>Connect.Success</td>
<td>The number of successful connections to the message broker. The Protocol dimension contains the protocol used to send the CONNECT message.</td>
</tr>
<tr>
<td>Connect.Throttle</td>
<td>The number of connection requests that were throttled because the account exceeded the allowed connect request rate. The Protocol dimension contains the protocol used to send the CONNECT message.</td>
</tr>
<tr>
<td>Ping.Success</td>
<td>The number of ping messages received by the message broker. The Protocol dimension contains the protocol used to send the ping message.</td>
</tr>
<tr>
<td>PublishIn.AuthError</td>
<td>The number of publish requests the message broker was unable to authorize. The Protocol dimension contains the protocol used to publish the message. HTTP Publish doesn't support this metric.</td>
</tr>
<tr>
<td>PublishIn.ClientError</td>
<td>The number of publish requests rejected by the message broker because the message did not meet the requirements defined in AWS IoT quotas (p. 1450). The Protocol dimension contains the protocol used to publish the message. HTTP Publish doesn't support this metric.</td>
</tr>
<tr>
<td>PublishIn.ServerError</td>
<td>The number of publish requests the message broker failed to process because an internal error occurred. The Protocol dimension contains the protocol used to send the PUBLISH message. HTTP Publish doesn't support this metric.</td>
</tr>
<tr>
<td>PublishIn.Success</td>
<td>The number of publish requests successfully processed by the message broker. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishIn.Throttle</td>
<td>The number of publish request that were throttled because the client exceeded the allowed inbound message rate. The Protocol dimension contains the protocol used to send the PUBLISH message. HTTP Publish doesn't support this metric.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>PublishOut.AuthError</td>
<td>The number of publish requests made by the message broker that could not be authorized by AWS IoT. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishOut.ClientError</td>
<td>The number of publish requests made by the message broker that were rejected because the message did not meet the requirements defined in AWS IoT quotas (<a href="#">p. 1450</a>). The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishOut.Success</td>
<td>The number of publish requests successfully made by the message broker. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishOut.Throttle</td>
<td>The number of publish requests that were throttled because the client exceeded the allowed outbound message rate. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishRetained.AuthError</td>
<td>The number of publish requests with the RETAIN flag set that the message broker was unable to authorize. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishRetained.ServerError</td>
<td>The number of retained publish requests the message broker failed to process because an internal error occurred. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishRetained.Success</td>
<td>The number of publish requests with the RETAIN flag set that were successfully processed by the message broker. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>PublishRetained.Throttle</td>
<td>The number of publish requests with the RETAIN flag set that were throttled because the client exceeded the allowed inbound message rate. The Protocol dimension contains the protocol used to send the PUBLISH message.</td>
</tr>
<tr>
<td>Queued.Success</td>
<td>The number of stored messages that were successfully processed by the message broker for clients that were disconnected from their persistent session. Messages with a QoS of 1 are stored while a client with a persistent session is disconnected.</td>
</tr>
<tr>
<td>Queued.Throttle</td>
<td>The number of messages that couldn't be stored and were throttled while clients with persistent sessions were disconnected. This occurs when clients exceed the Queued messages per second per account limit. Messages with a QoS of 1 are stored while a client with a persistent session is disconnected.</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Queued.ServerError</td>
<td>The number of messages that haven't been stored for a persistent session because of an internal error. When clients with a persistent session are disconnected, messages with a Quality of Service (QoS) of 1 are stored.</td>
</tr>
<tr>
<td>Subscribe.AuthError</td>
<td>The number of subscription requests made by a client that could not be authorized. The Protocol dimension contains the protocol used to send the SUBSCRIBE message.</td>
</tr>
<tr>
<td>Subscribe.ClientError</td>
<td>The number of subscribe requests that were rejected because the SUBSCRIBE message did not meet the requirements defined in <a href="#">AWS IoT quotas</a>. The Protocol dimension contains the protocol used to send the SUBSCRIBE message.</td>
</tr>
<tr>
<td>Subscribe.ServerError</td>
<td>The number of subscribe requests that were rejected because an internal error occurred. The Protocol dimension contains the protocol used to send the SUBSCRIBE message.</td>
</tr>
<tr>
<td>Subscribe.Success</td>
<td>The number of subscribe requests that were successfully processed by the message broker. The Protocol dimension contains the protocol used to send the SUBSCRIBE message.</td>
</tr>
<tr>
<td>Subscribe.Throttle</td>
<td>The number of subscribe requests that were throttled because the client exceeded the allowed subscribe request rate. The Protocol dimension contains the protocol used to send the SUBSCRIBE message.</td>
</tr>
<tr>
<td>Throttle.Exceeded</td>
<td>This metric will display in CloudWatch when an MQTT client is throttled on packets per second per connection level limits. This metric doesn't apply to HTTP connections.</td>
</tr>
<tr>
<td>Unsubscribe.ClientError</td>
<td>The number of unsubscribe requests that were rejected because the UNSUBSCRIBE message did not meet the requirements defined in <a href="#">AWS IoT quotas</a>. The Protocol dimension contains the protocol used to send the UNSUBSCRIBE message.</td>
</tr>
<tr>
<td>Unsubscribe.ServerError</td>
<td>The number of unsubscribe requests that were rejected because an internal error occurred. The Protocol dimension contains the protocol used to send the UNSUBSCRIBE message.</td>
</tr>
<tr>
<td>Unsubscribe.Success</td>
<td>The number of unsubscribe requests that were successfully processed by the message broker. The Protocol dimension contains the protocol used to send the UNSUBSCRIBE message.</td>
</tr>
</tbody>
</table>
AWS IoT Core Developer Guide
AWS IoT metrics and dimensions

### Metric Description

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsubscribe.Throttle</td>
<td>The number of unsubscribe requests that were rejected because the client exceeded the allowed unsubscribe request rate. The Protocol dimension contains the protocol used to send the UNSUBSCRIBE message.</td>
</tr>
</tbody>
</table>

### Device shadow metrics

**Note**
The device shadow metrics are displayed in the CloudWatch console under **Protocol Metrics**.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DeleteThingShadow.Accepted</td>
<td>The number of DeleteThingShadow requests processed successfully. The Protocol dimension contains the protocol used to make the request.</td>
</tr>
<tr>
<td>GetThingShadow.Accepted</td>
<td>The number of GetThingShadow requests processed successfully. The Protocol dimension contains the protocol used to make the request.</td>
</tr>
<tr>
<td>ListThingShadow.Accepted</td>
<td>The number of ListThingShadow requests processed successfully. The Protocol dimension contains the protocol used to make the request.</td>
</tr>
<tr>
<td>UpdateThingShadow.Accepted</td>
<td>The number of UpdateThingShadow requests processed successfully. The Protocol dimension contains the protocol used to make the request.</td>
</tr>
</tbody>
</table>

### Jobs metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CanceledJobExecutionCount</td>
<td>The number of job executions whose status has changed to CANCELED within a time period that is determined by CloudWatch. (For more information about CloudWatch metrics, see Amazon CloudWatch Metrics.) The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>CanceledJobExecutionTotalCount</td>
<td>The total number of job executions whose status is CANCELED for the given job. The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>ClientErrorCount</td>
<td>The number of client errors generated while executing the job. The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>FailedJobExecutionCount</td>
<td>The number of job executions whose status has changed to FAILED within a time period that is determined by CloudWatch. (For more information about CloudWatch metrics, see Amazon CloudWatch Metrics.)</td>
</tr>
<tr>
<td>Metric</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Metric</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td></td>
<td>The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>FailedJobExecutionTotalCount</td>
<td>The total number of job executions whose status is FAILED for the given job. The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>InProgressJobExecutionCount</td>
<td>The number of job executions whose status has changed to IN_PROGRESS within a time period that is determined by CloudWatch. (For more information about CloudWatch metrics, see Amazon CloudWatch Metrics.) The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>InProgressJobExecutionTotalCount</td>
<td>The total number of job executions whose status is IN_PROGRESS for the given job. The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>RejectedJobExecutionTotalCount</td>
<td>The total number of job executions whose status is REJECTED for the given job. The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>RemovedJobExecutionTotalCount</td>
<td>The total number of job executions whose status is REMOVED for the given job. The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>QueuedJobExecutionCount</td>
<td>The number of job executions whose status has changed to QUEUED within a time period that is determined by CloudWatch. (For more information about CloudWatch metrics, see Amazon CloudWatch Metrics.) The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>QueuedJobExecutionTotalCount</td>
<td>The total number of job executions whose status is QUEUED for the given job. The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>RejectedJobExecutionCount</td>
<td>The number of job executions whose status has changed to REJECTED within a time period that is determined by CloudWatch. (For more information about CloudWatch metrics, see Amazon CloudWatch Metrics.) The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>RemovedJobExecutionCount</td>
<td>The number of job executions whose status has changed to REMOVED within a time period that is determined by CloudWatch. (For more information about CloudWatch metrics, see Amazon CloudWatch Metrics.) The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>ServerErrorCount</td>
<td>The number of server errors generated while executing the job. The JobId dimension contains the ID of the job.</td>
</tr>
</tbody>
</table>
## AWS IoT metrics and dimensions

### Metric

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SucceededJobExecutionCount</td>
<td>The number of job executions whose status has changed to SUCCESS within a time period that is determined by CloudWatch. (For more information about CloudWatch metrics, see <a href="https://docs.aws.amazon.com/AmazonCloudWatch/latest/MetricViewer/metric-viewer.html">Amazon CloudWatch Metrics</a>.) The JobId dimension contains the ID of the job.</td>
</tr>
<tr>
<td>SucceededJobExecutionTotalCount</td>
<td>The total number of job executions whose status is SUCCESS for the given job. The JobId dimension contains the ID of the job.</td>
</tr>
</tbody>
</table>

### Device Defender audit metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NonCompliantResources</td>
<td>The number of resources that were found to be noncompliant with a check. The system reports the number of resources that were out of compliance for each check of each audit performed.</td>
</tr>
<tr>
<td>ResourcesEvaluated</td>
<td>The number of resources that were evaluated for compliance. The system reports the number of resources that were evaluated for each check of each audit performed.</td>
</tr>
</tbody>
</table>

### Device Defender detect metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violations</td>
<td>The number of new violations of security profile behaviors that have been found since the last time an evaluation was performed. The system reports the number of new violations for the account, for a specific security profile, and for a specific behavior of a specific security profile.</td>
</tr>
<tr>
<td>ViolationsCleared</td>
<td>The number of violations of security profile behaviors that have been resolved since the last time an evaluation was performed. The system reports the number of resolved violations for the account, for a specific security profile, and for a specific behavior of a specific security profile.</td>
</tr>
<tr>
<td>ViolationsInvalidated</td>
<td>The number of violations of security profile behaviors for which information is no longer available since the last time an evaluation was performed (because the reporting device stopped reporting, or is no longer being monitored for some reason). The system reports the number of invalidated violations for the entire account, for a specific security profile, and for a specific behavior of a specific security profile.</td>
</tr>
</tbody>
</table>

---

458
## Device provisioning metrics

### AWS IoT Fleet provisioning metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ApproximateNumberOfThingsRegistered</td>
<td>The count of things that have been registered by Fleet Provisioning. While the count is generally accurate, the distributed architecture of AWS IoT Core makes it difficult to maintain a precise count of registered things. The statistic to use for this metric is:</td>
</tr>
<tr>
<td></td>
<td>• Max to report the total number of things that have been registered. For a count of things registered during the CloudWatch aggregation window, see the RegisterThingFailed metric.</td>
</tr>
<tr>
<td></td>
<td>Dimensions: ClaimCertificateId (p. 460)</td>
</tr>
<tr>
<td>CreateKeysAndCertificateFailed</td>
<td>The number of failures that occurred by calls to the CreateKeysAndCertificate MQTT API. The metric is emitted in both Success (value = 0) and Failure (value = 1) cases. This metric can be used to track the number of certificates created and registered during the CloudWatch-supported aggregation windows, such as 5 min. or 1 hour. The statistics available for this metric are:</td>
</tr>
<tr>
<td></td>
<td>• Sum to report the number of failed calls.</td>
</tr>
<tr>
<td></td>
<td>• SampleCount to report the total number of successful and failed calls.</td>
</tr>
<tr>
<td>CreateCertificateFromCsrFailed</td>
<td>The number of failures that occurred by calls to the CreateCertificateFromCsr MQTT API. The metric is emitted in both Success (value = 0) and Failure (value = 1) cases. This metric can be used to track the number of things registered during the CloudWatch-supported aggregation windows, such as 5 min. or 1 hour. The statistics available for this metric are:</td>
</tr>
<tr>
<td></td>
<td>• Sum to report the number of failed calls.</td>
</tr>
<tr>
<td></td>
<td>• SampleCount to report the total number of successful and failed calls.</td>
</tr>
</tbody>
</table>
| RegisterThingFailed                        | The number of failures that occurred by calls to the RegisterThing MQTT API. The metric is emitted in both Success (value = 0) and Failure (value = 1) cases. This metric can be used to track the number of things
### AWS IoT metrics and dimensions

<table>
<thead>
<tr>
<th>Metric</th>
<th>Description</th>
</tr>
</thead>
</table>
| registered during the CloudWatch-supported aggregation windows, such as 5 min. or 1 hour. For the total number of things registered, see the `ApproximateNumberOfThingsRegistered` metric. The statistics available for this metric are:  
  - **Sum** to report the number of failed calls.  
  - **SampleCount** to report the total number of successful and failed calls.  
| **Dimensions:** | **TemplateName (p. 460)** |

<p>| <strong>Just-in-time provisioning metrics</strong> |</p>
<table>
<thead>
<tr>
<th><strong>Metric</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ProvisionThing.ClientError</code></td>
<td>The number of times a device failed to provision due to a client error. For example, the policy specified in the template did not exist.</td>
</tr>
<tr>
<td><code>ProvisionThing.ServerError</code></td>
<td>The number of times a device failed to provision due to a server error. Customers can retry to provision the device after waiting and they can contact AWS IoT if the issue remains the same.</td>
</tr>
<tr>
<td><code>ProvisionThing.Success</code></td>
<td>The number of times a device was successfully provisioned.</td>
</tr>
</tbody>
</table>

<p>| <strong>Fleet indexing metrics</strong> |
| <strong>AWS IoT fleet indexing metrics</strong> |</p>
<table>
<thead>
<tr>
<th><strong>Metric</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>NamedShadowCountForDynamicGroupQueryLimitExceeded</code></td>
<td>A maximum of 25 named shadows per thing are processed for query terms that are not data source specific in dynamic thing groups. When this limit is breached for a thing, the <code>NamedShadowCountForDynamicGroupQueryLimitExceeded</code> event type will be emitted.</td>
</tr>
</tbody>
</table>

<p>| <strong>Dimensions for metrics</strong> |
| <strong>Metrics use the namespace and provide metrics for the following dimensions</strong> |</p>
<table>
<thead>
<tr>
<th><strong>Dimension</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ActionType</code></td>
<td>The <code>action type (p. 502)</code> specified by the rule that triggered the request.</td>
</tr>
</tbody>
</table>
Monitor AWS IoT using CloudWatch Logs

When AWS IoT logging is enabled (p. 439), AWS IoT sends progress events about each message as it passes from your devices through the message broker and rules engine. In the CloudWatch console, CloudWatch logs appear in a log group named AWSIotLogs.

For more information about CloudWatch Logs, see CloudWatch Logs. For information about supported AWS IoT CloudWatch Logs, see CloudWatch Logs AWS IoT log entries (p. 462).

Viewing AWS IoT logs in the CloudWatch console

Note
The AWSIotLogsV2 log group is not visible in the CloudWatch console until:

- You’ve enabled logging in AWS IoT. For more info on how to enable logging in AWS IoT, see Configure AWS IoT logging (p. 439)
- Some log entries have been written by AWS IoT operations.

To view your AWS IoT logs in the CloudWatch console

2. In the Filter text box, enter AWSIotLogsV2, and then press Enter.
3. Double-click the AWSIotLogsV2 log group.
4. Choose Search All. A complete list of the AWS IoT logs generated for your account is displayed.
5. Choose the expand icon to look at an individual stream.
You can also enter a query in the Filter events text box. Here are some interesting queries to try:

- `{ $.logLevel = "INFO" }`  
  Find all logs that have a log level of INFO.
- `{ $.status = "Success" }`  
  Find all logs that have a status of Success.
- `{ $.status = "Success" && $.eventType = "GetThingShadow" }`  
  Find all logs that have a status of Success and an event type of GetThingShadow.

For more information about creating filter expressions, see CloudWatch Logs Queries.

## CloudWatch Logs AWS IoT log entries

Each component of AWS IoT generates its own log entries. Each log entry has an eventType that specifies the operation that caused the log entry to be generated. This section describes the log entries generated by the following AWS IoT components. For information about AWS IoT Core for LoRaWAN monitoring, see View CloudWatch AWS IoT Wireless log entries (p. 1401).

### Topics
- Message broker log entries (p. 462)
- Device Shadow log entries (p. 470)
- Rules engine log entries (p. 472)
- Job log entries (p. 477)
- Device provisioning log entries (p. 480)
- Dynamic thing group log entries (p. 482)
- Fleet indexing log entries (p. 483)
- Common CloudWatch Logs attributes (p. 483)

### Message broker log entries

The AWS IoT message broker generates log entries for the following events:

### Topics
- Connect log entry (p. 462)
- Disconnect log entry (p. 463)
- GetRetainedMessage log entry (p. 464)
- ListRetainedMessage log entry (p. 465)
- Publish-In log entry (p. 465)
- Publish-Out log entry (p. 466)
- Queued log entry (p. 467)
- Subscribe log entry (p. 469)

### Connect log entry

The AWS IoT message broker generates a log entry with an eventType of Connect when an MQTT client connects.
Connect log entry example

```json
{
  "timestamp": "2017-08-10 15:37:23.476",
  "logLevel": "INFO",
  "traceId": "20b23f5f-d7f1-feae-169f-82263394fbdb",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "Connect",
  "protocol": "MQTT",
  "clientId": "abf27092886e49a8a5c1922749736453",
  "principalId": "145179c4e2219e18a909d896a5340b74cf97a39641beec2fc3eeaf5a932167",
  "sourceIp": "205.251.233.181",
  "sourcePort": 13490
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), Connect log entries contain the following attributes:

- **clientId**
  
  The ID of the client making the request.

- **principalId**
  
  The ID of the principal making the request.

- **protocol**
  
  The protocol used to make the request. Valid values are MQTT or HTTP.

- **sourceIp**
  
  The IP address where the request originated.

- **sourcePort**
  
  The port where the request originated.

Disconnect log entry

The AWS IoT message broker generates a log entry with an eventType of Disconnect when an MQTT client disconnects.

Disconnect log entry example

```json
{
  "timestamp": "2017-08-10 15:37:23.476",
  "logLevel": "INFO",
  "traceId": "20b23f5f-d7f1-feae-169f-82263394fbdb",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "Disconnect",
  "protocol": "MQTT",
  "clientId": "abf27092886e49a8a5c1922749736453",
  "principalId": "145179c4e2219e18a909d896a5340b74cf97a39641beec2fc3eeaf5a932167",
  "sourceIp": "205.251.233.181",
  "sourcePort": 13490,
  "reason": "DUPLICATE_CLIENT_ID",
  "details": "A new connection was established with the same client ID",
  "disconnectReason": "CLIENT_INITIATED_DISCONNECT"
}
```
In addition to the [Common CloudWatch Logs attributes](#), Disconnect log entries contain the following attributes:

- **clientId**
  - The ID of the client making the request.
- **principalId**
  - The ID of the principal making the request.
- **protocol**
  - The protocol used to make the request. Valid values are MQTT or HTTP.
- **sourceIp**
  - The IP address where the request originated.
- **sourcePort**
  - The port where the request originated.
- **reason**
  - The reason why the client is disconnecting.
- **details**
  - A brief explanation of the error.
- **disconnectReason**
  - The reason why the client is disconnecting.

**GetRetainedMessage log entry**

The AWS IoT message broker generates a log entry with an **eventType** of **GetRetainedMessage** when the **GetRetainedMessage** is called.

**GetRetainedMessage log entry example**

```json
{
   "timestamp": "2017-08-07 18:47:56.664",
   "logLevel": "INFO",
   "traceId": "1a60d02e-15b9-605b-7096-a9f584a6ad3f",
   "accountId": "123456789012",
   "status": "Success",
   "eventType": "GetRetainedMessage",
   "protocol": "HTTP",
   "topicName": "a/b/c",
   "qos": "1",
   "lastModifiedDate": "2017-08-07 18:47:56.664"
}
```

In addition to the [Common CloudWatch Logs attributes](#), GetRetainedMessage log entries contain the following attributes:

- **lastModifiedDate**
  - The Epoch date and time, in milliseconds, when the retained message was stored by AWS IoT.
- **protocol**
  - The protocol used to make the request. Valid value: HTTP.
qos

The Quality of Service (QoS) level used in the publish request. Valid values are 0 or 1.

topicName

The name of the subscribed topic.

ListRetainedMessage log entry

The AWS IoT message broker generates a log entry with an eventType of ListRetainedMessage when ListRetainedMessages is called.

ListRetainedMessage log entry example

```json
{
    "timestamp": "2017-08-07 18:47:56.664",
    "logLevel": "INFO",
    "traceId": "1a60d02e-15b9-605b-7096-a9f584a6ad3f",
    "accountId": "123456789012",
    "status": "Success",
    "eventType": "ListRetainedMessage",
    "protocol": "HTTP"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), ListRetainedMessage log entries contain the following attribute:

protocol

The protocol used to make the request. Valid value: HTTP.

Publish-In log entry

When the AWS IoT message broker receives an MQTT message, it generates a log entry with an eventType of Publish-In.

Publish-In log entry example

```json
{
    "timestamp": "2017-08-10 15:39:30.961",
    "logLevel": "INFO",
    "traceId": "672ec480-31ce-fd8b-b5fb-22e3ac420699",
    "accountId": "123456789012",
    "status": "Success",
    "eventType": "Publish-In",
    "protocol": "MQTT",
    "topicName": "$aws/things/MyThing/shadow/get",
    "clientId": "abf27092886e49a8a5c1922749736453",
    "principalId": "145179c40e2219e18a909d896a534b74cf97a39641beec2fc3eeafc5a932167",
    "sourceIp": "205.251.233.181",
    "sourcePort": 13490,
    "retain": "True"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), Publish-In log entries contain the following attributes:
clientld
The ID of the client making the request.

principalId
The ID of the principal making the request.

protocol
The protocol used to make the request. Valid values are MQTT or HTTP.

retain
The attribute used when a message has the RETAIN flag set with a value of True. If the message doesn't have the RETAIN flag set, this attribute doesn't appear in the log entry. For more information, see MQTT retained messages (p. 92).

sourceIp
The IP address where the request originated.

sourcePort
The port where the request originated.

topicName
The name of the subscribed topic.

Publish-Out log entry

When the message broker publishes an MQTT message, it generates a log entry with an eventType of Publish-Out.

Publish-Out log entry example

```json
{
  "timestamp": "2017-08-10 15:39:30.961",
  "logLevel": "INFO",
  "traceId": "672ec480-31ce-fd8b-b5fb-22e3ac420699",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "Publish-Out",
  "protocol": "MQTT",
  "topicName": "$aws/things/MyThing/shadow/get",
  "clientId": "abf27092886e49a8a5c1922749736453",
  "principalId": "145179c40e2219e18a909d896a5340b74cf97a39641beec2fc3eeafc5a932167",
  "sourceIp": "205.251.233.181",
  "sourcePort": 13490
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), Publish-Out log entries contain the following attributes:

clientld
The ID of the subscribed client that receives messages on that MQTT topic.

principalId
The ID of the principal making the request.
protocol

The protocol used to make the request. Valid values are MQTT or HTTP.

sourceIp

The IP address where the request originated.

sourcePort

The port where the request originated.

topicName

The name of the subscribed topic.

Queued log entry

When a device with a persistent session is disconnected, the MQTT message broker stores the device's messages and AWS IoT generates log entries with an eventType of Queued. For more information about MQTT persistent sessions, see MQTT persistent sessions (p. 90).

Queued server error log entry example

```
{
    "timestamp": "2022-08-10 15:39:30.961",
    "logLevel": "ERROR",
    "traceId": "672ec480-31ce-fd8b-b5fb-22e3ac420699",
    "accountId": "123456789012",
    "topicName": "$aws/things/MyThing/get",
    "clientId": "123123123",
    "qos": "1",
    "protocol": "MQTT",
    "eventType": "Queued",
    "status": "Failure",
    "details": "Server Error"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), Queued server error log entries contain the following attributes:

clientld

The ID of the client to which the message is queued.

details

**Server Error**

A server error prevented the message from being stored.

protocol

The protocol used to make the request. The value will always be MQTT.

qos

The Quality of Service (QoS) level of the request. The value will always be 1 because the messages with QoS of 0 aren't stored.

topicName

The name of the subscribed topic.
Queued success log entry example

```
{
    "timestamp": "2022-08-10 15:39:30.961",
    "logLevel": "INFO",
    "traceId": "672ec480-31ce-fd8b-b5fb-22e3ac420699",
    "accountId": "123456789012",
    "topicName": "$aws/things/MyThing/get",
    "clientId": "123123123",
    "qos": "1",
    "protocol": "MQTT",
    "eventType": "Queued",
    "status": "Success"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), Queued success log entries contain the following attributes:

- **clientId**
  - The ID of the client to which the message is queued.

- **protocol**
  - The protocol used to make the request. The value will always be MQTT.

- **qos**
  - The Quality of Service (QoS) level of the request. The value will always be 1 because the messages with QoS of 0 aren't stored.

- **topicName**
  - The name of the subscribed topic.

Queued throttled log entry example

```
{
    "timestamp": "2022-08-10 15:39:30.961",
    "logLevel": "ERROR",
    "traceId": "672ec480-31ce-fd8b-b5fb-22e3ac420699",
    "accountId": "123456789012",
    "topicName": "$aws/things/MyThing/get",
    "clientId": "123123123",
    "qos": "1",
    "protocol": "MQTT",
    "eventType": "Queued",
    "status": "Failure",
    "details": "Throttled while queueing offline message"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), Queued throttled log entries contain the following attributes:

- **clientId**
  - The ID of the client to which the message is queued.

- **details**
  - **Throttled while queueing offline message**
The client exceeded the [Queued messages per second per account](https://docs.aws.amazon.com/iot/latest/developerguide/iot-logs.html) limit, so the message wasn't stored.

**protocol**

The protocol used to make the request. The value will always be MQTT.

**qos**

The Quality of Service (QoS) level of the request. The value will always be 1 because the messages with QoS of 0 aren't stored.

**topicName**

The name of the subscribed topic.

### Subscribe log entry

The AWS IoT message broker generates a log entry with an `eventType` of Subscribe when an MQTT client subscribes to a topic.

**MQTT 3 Subscribe log entry example**

```json
{
  "timestamp": "2017-08-10 15:39:04.413",
  "logLevel": "INFO",
  "traceId": "7aa5c38d-1b49-3753-15dc-513ce4ab9fa6",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "Subscribe",
  "protocol": "MQTT",
  "topicName": "$aws/things/MyThing/shadow/#",
  "clientId": "abf27092886e49a8a5c192749736453",
  "principalId": "145179c40e2219e18a909d896a534b74c3eaf05a932167",
  "sourceIp": "205.251.233.181",
  "sourcePort": 13490
}
```

In addition to the [Common CloudWatch Logs attributes](https://docs.aws.amazon.com/iot/latest/developerguide/iot-logs.html) (p. 483), Subscribe log entries contain the following attributes:

**clientId**

The ID of the client making the request.

**principalId**

The ID of the principal making the request.

**protocol**

The protocol used to make the request. Valid values are MQTT or HTTP.

**sourceIp**

The IP address where the request originated.

**sourcePort**

The port where the request originated.

**topicName**

The name of the subscribed topic.
MQTT 5 Subscribe log entry example

```json
{
  "timestamp": "2022-11-30 16:24:15.628",
  "logLevel": "INFO",
  "traceId": "7aa5c38d-1b49-3753-15dc-513ce4ab9fa6",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "Subscribe",
  "protocol": "MQTT",
  "topicName": "test/topic1,$invalid/reserved/topic",
  "subscriptions": [
    {
      "topicName": "test/topic1",
      "reasonCode": 1
    },
    {
      "topicName": "$invalid/reserved/topic",
      "reasonCode": 143
    }
  ],
  "clientId": "abf27092886e49a8a5c1922749736453",
  "principalId": "145179c40e2219e18a909d896a5340b74cf97a39641beec2fc5eeafc5a932167",
  "sourceIp": "205.251.233.181",
  "sourcePort": 13490
}
```

For MQTT 5 Subscribe operations, in addition to the [Common CloudWatch Logs attributes](#) and the [MQTT 3 Subscribe log entry attributes](#), MQTT 5 Subscribe log entries contain the following attribute:

**subscriptions**

A list of mappings between the requested topics in the Subscribe request and the individual MQTT 5 reason code. For more information, see [MQTT reason codes](#).

### Device Shadow log entries

The AWS IoT Device Shadow service generates log entries for the following events:

**Topics**

- [DeleteThingShadow log entry](#)
- [GetThingShadow log entry](#)
- [UpdateThingShadow log entry](#)

### DeleteThingShadow log entry

The Device Shadow service generates a log entry with an **eventType** of DeleteThingShadow when a request to delete a device's shadow is received.

**DeleteThingShadow log entry example**

```json
{
  "timestamp": "2017-08-07 18:47:56.664",
  "logLevel": "INFO",
  "traceId": "1a60d02e-15b9-605b-7096-a9f584a6ad3f",
  "accountId": "123456789012",
```

470
In addition to the Common CloudWatch Logs attributes (p. 483), DeleteThingShadow log entries contain the following attributes:

- **deviceShadowName**: The name of the shadow to update.
- **protocol**: The protocol used to make the request. Valid values are MQTT or HTTP.
- **topicName**: The name of the topic on which the request was published.

**GetThingShadow log entry**

The Device Shadow service generates a log entry with an `eventType` of GetThingShadow when a get request for a shadow is received.

**GetThingShadow log entry example**

```
{
  "timestamp": "2017-08-09 17:56:30.941",
  "logLevel": "INFO",
  "traceId": "b575f19a-97a2-cf72-0ed0-c64a783a2504",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "GetThingShadow",
  "protocol": "MQTT",
  "deviceShadowName": "MyThing",
  "topicName": "$aws/things/MyThing/shadow/get"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), GetThingShadow log entries contain the following attributes:

- **deviceShadowName**: The name of the requested shadow.
- **protocol**: The protocol used to make the request. Valid values are MQTT or HTTP.
- **topicName**: The name of the topic on which the request was published.

**UpdateThingShadow log entry**

The Device Shadow service generates a log entry with an `eventType` of UpdateThingShadow when a request to update a device's shadow is received.
UpdateThingShadow log entry example

```
{
  "timestamp": "2017-08-07 18:43:59.436",
  "logLevel": "INFO",
  "traceId": "d0074ba8-0c4b-a400-69df-76326d414c28",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "UpdateThingShadow",
  "protocol": "MQTT",
  "deviceShadowName": "Jack",
  "topicName": "/aws/things/Jack/shadow/update"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), UpdateThingShadow log entries contain the following attributes:

- **deviceShadowName**
  - The name of the shadow to update.
- **protocol**
  - The protocol used to make the request. Valid values are MQTT or HTTP.
- **topicName**
  - The name of the topic on which the request was published.

## Rules engine log entries

The AWS IoT rules engine generates logs for the following events:

### Topics

- [FunctionExecution log entry (p. 472)]
- [RuleExecution log entry (p. 473)]
- [RuleMatch log entry (p. 474)]
- [RuleExecutionThrottled log entry (p. 474)]
- [RuleNotFound log entry (p. 475)]
- [StartingRuleExecution log entry (p. 476)]

## FunctionExecution log entry

The rules engine generates a log entry with an eventType of FunctionExecution when a rule's SQL query calls an external function. An external function is called when a rule's action makes an HTTP request to AWS IoT or another web service (for example, calling get_thing_shadow or machinelearning_predict).

**FunctionExecution log entry example**

```
{
  "timestamp": "2017-07-13 18:33:51.903",
  "logLevel": "DEBUG",
  "traceId": "180532b7-0cc7-057b-687a-5ca1824838f5",
  "status": "Success",
  "eventType": "FunctionExecution",
```
In addition to the Common CloudWatch Logs attributes (p. 483), FunctionExecution log entries contain the following attributes:

clientId

N/A for FunctionExecution logs.

principalId

The ID of the principal making the request.

resources

A collection of resources used by the rule's actions.

ruleName

The name of the matching rule.

topicName

The name of the subscribed topic.

RuleExecution log entry

When the AWS IoT rules engine triggers a rule's action, it generates a RuleExecution log entry.

RuleExecution log entry example

```
{
    "timestamp": "2017-08-10 16:32:46.070",
    "logLevel": "INFO",
    "traceId": "30aa7ccc-1d23-0b97-aa7b-76196d83537e",
    "accountId": "123456789012",
    "status": "Success",
    "eventType": "RuleExecution",
    "clientId": "abf27092886e49a8a5c1922749736453",
    "topicName": "rules/test",
    "ruleName": "JSONLogsRule",
    "ruleAction": "RepublishAction",
    "resources": {
        "RepublishTopic": "rules/republish"
    },
    "principalId": "145179c40e2219e18a909d896a5340b74cf97a39641beec2fc3eeafc5a932167"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), RuleExecution log entries contain the following attributes:

clientId

The ID of the client making the request.
principalId
   The ID of the principal making the request.
resources
   A collection of resources used by the rule's actions.
ruleAction
   The name of the action triggered.
ruleName
   The name of the matching rule.
topicName
   The name of the subscribed topic.

**RuleMatch log entry**

The AWS IoT rules engine generates a log entry with an eventType of RuleMatch when the message broker receives a message that matches a rule.

**RuleMatch log entry example**

```json
{
   "timestamp": "2017-08-10 16:32:46.002",
   "logLevel": "INFO",
   "traceId": "30aa7ccc-1d23-0b97-aa7b-76196d83537e",
   "accountId": "123456789012",
   "status": "Success",
   "eventType": "RuleMatch",
   "clientId": "abf27092886e49a8a5c1922749736453",
   "topicName": "rules/test",
   "ruleName": "JSONLogsRule",
   "principalId": "145179c40e2219e18a909d896a5340b74cf97a39641beec2fc3eeafc5a932167"
}
```

In addition to the [Common CloudWatch Logs attributes (p. 483)](aws-iot-core-developer-guide), RuleMatch log entries contain the following attributes:

**clientId**
   The ID of the client making the request.
**principalId**
   The ID of the principal making the request.
**ruleName**
   The name of the matching rule.
**topicName**
   The name of the subscribed topic.

**RuleExecutionThrottled log entry**

When an execution is throttled, the AWS IoT rules engine generates a log entry with an eventType of RuleExecutionThrottled.
RuleExecutionThrottled log entry example

```
{
    "timestamp": "2017-10-04 19:25:46.070",
    "logLevel": "ERROR",
    "traceId": "30aa7ccc-1d23-0b97-aa7b-76196d83537e",
    "accountId": "123456789012",
    "status": "Failure",
    "eventType": "RuleMessageThrottled",
    "clientId": "abf27092886e49a8a5c1922749736453",
    "topicName": "$aws/rules/example_rule",
    "ruleName": "example_rule",
    "principalId": "145179c40e2219e18a909d896a5340b74cf97a39641beec2fc3eeafc5a932167",
    "reason": "RuleExecutionThrottled",
    "details": "Execution of Rule example_rule throttled"
}
```

In addition to the [Common CloudWatch Logs attributes (p. 483)](aws-iot-core-developer-guide#common-cloudwatch-logs-attributes), RuleExecutionThrottled log entries contain the following attributes:

- **clientId**
  - The ID of the client making the request.
- **details**
  - A brief explanation of the error.
- **principalId**
  - The ID of the principal making the request.
- **reason**
  - The string "RuleExecutionThrottled".
- **ruleName**
  - The name of the rule to be triggered.
- **topicName**
  - The name of the topic that was published.

RuleNotFound log entry

When the AWS IoT rules engine cannot find a rule with a given name, it generates a log entry with an `eventType` of `RuleNotFound`.

RuleNotFound log entry example

```
{
    "timestamp": "2017-10-04 19:25:46.070",
    "logLevel": "ERROR",
    "traceId": "30aa7ccc-1d23-0b97-aa7b-76196d83537e",
    "accountId": "123456789012",
    "status": "Failure",
    "eventType": "RuleNotFound",
    "clientId": "abf27092886e49a8a5c1922749736453",
    "topicName": "$aws/rules/example_rule",
    "ruleName": "example_rule",
    "principalId": "145179c40e2219e18a909d896a5340b74cf97a39641beec2fc3eeafc5a932167",
    "reason": "RuleNotFound",
    "details": "Rule example_rule not found"
}
```
In addition to the Common CloudWatch Logs attributes (p. 483), RuleNotFound log entries contain the following attributes:

- `clientId`
  - The ID of the client making the request.
- `details`
  - A brief explanation of the error.
- `principalId`
  - The ID of the principal making the request.
- `reason`
  - The string "RuleNotFound".
- `ruleName`
  - The name of the rule that could not be found.
- `topicName`
  - The name of the topic that was published.

**StartingRuleExecution log entry**

When the AWS IoT rules engine starts to trigger a rule's action, it generates a log entry with an `eventType` of `StartingRuleExecution`.

**StartingRuleExecution log entry example**

```
{
  "timestamp": "2017-08-10 16:32:46.002",
  "logLevel": "DEBUG",
  "traceId": "30aa7ccc-1d23-0b97-aa7b-76196d83537e",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "StartingRuleExecution",
  "clientId": "abf27092886e49a8a5c1922749736453",
  "topicName": "rules/test",
  "ruleName": "JSONLogsRule",
  "ruleAction": "RepublishAction",
  "principalId": "145179c40e2219e18a909d896a5340b74cf97a39641beec2fc3eeafc5a932167"
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), rule- log entries contain the following attributes:

- `clientId`
  - The ID of the client making the request.
- `principalId`
  - The ID of the principal making the request.
- `ruleAction`
  - The name of the action triggered.
ruleName

The name of the matching rule.

topicName

The name of the subscribed topic.

Job log entries

The AWS IoT Job service generates log entries for the following events. Log entries are generated when an MQTT or HTTP request is received from the device.

Topics

- DescribeJobExecution log entry (p. 477)
- GetPendingJobExecution log entry (p. 478)
- ReportFinalJobExecutionCount log entry (p. 478)
- StartNextPendingJobExecution log entry (p. 479)
- UpdateJobExecution log entry (p. 480)

DescribeJobExecution log entry

The AWS IoT Jobs service generates a log entry with an eventType of DescribeJobExecution when the service receives a request to describe a job execution.

DescribeJobExecution log entry example

```
{
    "timestamp": "2017-08-10 19:13:22.841",
    "logLevel": "DEBUG",
    "accountId": "123456789012",
    "status": "Success",
    "eventType": "DescribeJobExecution",
    "protocol": "MQTT",
    "clientId": "thingOne",
    "jobId": "002",
    "topicName": "$aws/things/thingOne/jobs/002/get",
    "clientToken": "myToken",
    "details": "The request status is SUCCESS."
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), GetJobExecution log entries contain the following attributes:

clid

The ID of the client making the request.

cclientToken

A unique, case-sensitive identifier to ensure the idempotency of the request. For more information, see How to Ensure Idempotency.

details

Other information from the Jobs service.

jobId

The job ID for the job execution.
**GetPendingJobExecution log entry**

The AWS IoT Jobs service generates a log entry with an `eventType` of `GetPendingJobExecution` when the service receives a job execution request.

**GetPendingJobExecution log entry example**

```json
{
  "timestamp": "2018-06-13 17:45:17.197",
  "logLevel": "DEBUG",
  "accountId": "123456789012",
  "status": "Success",
  "eventType": "GetPendingJobExecution",
  "protocol": "MQTT",
  "clientId": "299966ad-54de-40b4-99d3-4fc8b52da0c5",
  "topicName": "$aws/things/299966ad-54de-40b4-99d3-4fc8b52da0c5/jobs/get",
  "clientToken": "24b9a741-15a7-44fc-bd3c-1ff2e34e5e82",
  "details": "The request status is SUCCESS."
}
```

In addition to the [Common CloudWatch Logs attributes (p. 483)](#), `GetPendingJobExecution` log entries contain the following attributes:

- **clientId**
  - The ID of the client making the request.

- **clientToken**
  - A unique, case sensitive identifier to ensure the idempotency of the request. For more information, see [How to Ensure Idempotency](#).

- **details**
  - Other information from the Jobs service.

- **protocol**
  - The protocol used to make the request. Valid values are MQTT or HTTP.

- **topicName**
  - The name of the subscribed topic.

**ReportFinalJobExecutionCount log entry**

The AWS IoT Jobs service generates a log entry with an `entryType` of `ReportFinalJobExecutionCount` when a job is completed.

**ReportFinalJobExecutionCount log entry example**

```json
{
}
```
In addition to the Common CloudWatch Logs attributes (p. 483), ReportFinalJobExecutionCount log entries contain the following attributes:

**details**

Other information from the Jobs service.

**jobId**

The job ID for the job execution.

### StartNextPendingJobExecution log entry

When it receives a request to start the next pending job execution, the AWS IoT Jobs service generates a log entry with an eventType of StartNextPendingJobExecution.

**StartNextPendingJobExecution log entry example**

```json
{
    "timestamp": "2018-06-13 17:49:51.036",
    "logLevel": "DEBUG",
    "accountId": "123456789012",
    "status": "Success",
    "eventType": "StartNextPendingJobExecution",
    "protocol": "MQTT",
    "clientId": "95c47808-b1ca-4794-bc68-a588d6d9216c",
    "topicName": "$aws/things/95c47808-b1ca-4794-bc68-a588d6d9216c/jobs/start-next",
    "clientToken": "bd447c4-3a05-49f4-8517-dd891b2c68d94",
    "details": "The request status is SUCCESS."
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), StartNextPendingJobExecution log entries contain the following attributes:

**clientId**

The ID of the client making the request.

**clientToken**

A unique, case sensitive identifier to ensure the idempotency of the request. For more information, see [How to Ensure Idempotency](#).

**details**

Other information from the Jobs service.

**protocol**

The protocol used to make the request. Valid values are MQTT or HTTP.
TopicName

The topic used to make the request.

UpdateJobExecution log entry

The AWS IoT Jobs service generates a log entry with an eventType of UpdateJobExecution when the service receives a request to update a job execution.

UpdateJobExecution log entry example

```
{
    "timestamp": "2017-08-10 19:25:14.758",
    "logLevel": "DEBUG",
    "accountId": "123456789012",
    "status": "Success",
    "eventType": "UpdateJobExecution",
    "protocol": "MQTT",
    "clientId": "thingOne",
    "jobId": "002",
    "topicName": "$aws/things/thingOne/jobs/002/update",
    "clientToken": "myClientToken",
    "versionNumber": "1",
    "details": "The destination status is IN_PROGRESS. The request status is SUCCESS."
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), UpdateJobExecution log entries contain the following attributes:

- clientId
  
  The ID of the client making the request.

- clientToken
  
  A unique, case sensitive identifier to ensure the idempotency of the request. For more information, see How to Ensure Idempotency.

- details
  
  Other information from the Jobs service.

- jobId
  
  The job ID for the job execution.

- protocol
  
  The protocol used to make the request. Valid values are MQTT or HTTP.

- topicName
  
  The topic used to make the request.

- versionNumber
  
  The version of the job execution.

Device provisioning log entries

The AWS IoT Device Provisioning service generates logs for the following events.

Topics
GetDeviceCredentials log entry

The AWS IoT Device Provisioning service generates a log entry with an eventType of GetDeviceCredential when a client calls GetDeviceCredential.

GetDeviceCredentials log entry example

```json
{
  "timestamp": "2019-02-20 20:31:22.932",
  "logLevel": "INFO",
  "traceId": "8d9c016f-6cc7-441e-8909-7ee3d5563405",
  "accountId": "123456789101",
  "status": "Success",
  "eventType": "GetDeviceCredentials",
  "deviceCertificateId": "e3b0c44298fc1c149afbf4c8996fb92427ae41e46d9b934ca495991b7852b855",
  "details": "Additional details about this log."
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), GetDeviceCredentials log entries contain the following attributes:

- **details**
  A brief explanation of the error.
- **deviceCertificateId**
  The ID of the device certificate.

ProvisionDevice log entry

The AWS IoT Device Provisioning service generates a log entry with an eventType of ProvisionDevice when a client calls ProvisionDevice.

ProvisionDevice log entry example

```json
{
  "timestamp": "2019-02-20 20:31:22.932",
  "logLevel": "INFO",
  "traceId": "8d9c016f-6cc7-441e-8909-7ee3d5563405",
  "accountId": "123456789101",
  "status": "Success",
  "eventType": "ProvisionDevice",
  "provisioningTemplateName": "myTemplate",
  "deviceCertificateId": "e3b0c44298fc1c149afbf4c8996fb92427ae41e46d9b934ca495991b7852b855",
  "details": "Additional details about this log."
}
```

In addition to the Common CloudWatch Logs attributes (p. 483), ProvisionDevice log entries contain the following attributes:

- **details**
  A brief explanation of the error.
deviceCertificateId

The ID of the device certificate.

provisioningTemplateName

The name of the provisioning template.

**Dynamic thing group log entries**

AWS IoT Dynamic Thing Groups generate logs for the following event.

**Topics**

- [AddThingToDynamicThingGroupsFailed log entry (p. 482)]

**AddThingToDynamicThingGroupsFailed log entry**

When AWS IoT was not able to add a thing to the specified dynamic groups, it generates a log entry with an eventType of AddThingToDynamicThingGroupsFailed. This happens when a thing met the criteria to be in the dynamic thing group; however, it could not be added to the dynamic group or it was removed from the dynamic group. This can happen because:

- The thing already belongs to the maximum number of groups.
- The --override-dynamic-groups option was used to add the thing to a static thing group. It was removed from a dynamic thing group to make that possible.

For more information, see [Dynamic Thing Group Limitations and Conflicts (p. 288)].

**AddThingToDynamicThingGroupsFailed log entry example**

This example shows the log entry of an AddThingToDynamicThingGroupsFailed error. In this example, TestThing met the criteria to be in the dynamic thing groups listed in dynamicThingGroupNames, but could not be added to those dynamic groups, as described in reason.

```json
{
  "timestamp": "2020-03-16 22:24:43.804",
  "logLevel": "ERROR",
  "traceId": "70b1f2f5-d95e-f897-9dcc-31e68c3e1a30",
  "accountId": "57EXAMPLE833",
  "status": "Failure",
  "eventType": "AddThingToDynamicThingGroupsFailed",
  "thingName": "TestThing",
  "dynamicThingGroupNames": [
    "DynamicThingGroup11",
    "DynamicThingGroup12",
    "DynamicThingGroup13",
    "DynamicThingGroup14"
  ],
  "reason": "The thing failed to be added to the given dynamic thing group(s) because the thing already belongs to the maximum allowed number of groups."
}
```

In addition to the [Common CloudWatch Logs attributes (p. 483)], AddThingToDynamicThingGroupsFailed log entries contain the following attributes:

**dynamicThingGroupNames**

An array of the dynamic thing groups to which the thing could not be added.
reason

The reason why the thing could not be added to the dynamic thing groups.

tingName

The name of the thing that could not be added to a dynamic thing group.

Fleet indexing log entries

AWS IoT fleet indexing generates log entries for the following events.

Topics

- **NamedShadowCountForDynamicGroupQueryLimitExceeded log entry** *(p. 483)*

NamedShadowCountForDynamicGroupQueryLimitExceeded log entry

A maximum of 25 named shadows per thing are processed for query terms that are not data source specific in dynamic groups. When this limit is breached for a thing, the NamedShadowCountForDynamicGroupQueryLimitExceeded event type will be emitted.

NamedShadowCountForDynamicGroupQueryLimitExceeded log entry example

This example shows the log entry of a NamedShadowCountForDynamicGroupQueryLimitExceeded error. In this example, all-values based DynamicGroup results can be inaccurate, as described in the reason field.

```json
{
  "timestamp": "2020-03-16 22:24:43.804",
  "logLevel": "ERROR",
  "traceId": "70b1f2f5-d95e-f897-9dcc-31e68c3e1a30",
  "accountId": "571032923833",
  "status": "Failure",
  "eventType": "NamedShadowCountForDynamicGroupQueryLimitExceeded",
  "thingName": "TestThing",
  "reason": "A maximum of 25 named shadows per thing are processed for non-data source specific query terms in dynamic groups."
}
```

Common CloudWatch Logs attributes

All CloudWatch Logs log entries include these attributes:

accountID

Your AWS account ID.

eventType

The event type for which the log was generated. The value of the event type depends on the event that generated the log entry. Each log entry description includes the value of eventType for that log entry.

logLevel

The log level being used. For more information, see the section called "Log levels" *(p. 445)*.

status

The status of the request.
Upload device-side logs to Amazon CloudWatch

You can upload historical, device-side logs into Amazon CloudWatch to monitor and analyze a device's activity in the field. Device-side logs can include system, application, and device logs files. This process uses a CloudWatch Logs rules action parameter to publish device-side logs into a customer-defined log group.

How it works

The process begins when an AWS IoT device sends MQTT messages containing formatted log files to an AWS IoT topic. An AWS IoT rule monitors the message topic and sends the log files to a CloudWatch Logs group that you define. You can then review and analyze the information.

Topics

- MQTT topics (p. 484)
- Rule action (p. 484)

MQTT topics

Choose an MQTT topic name space that you will use to publish the logs. We recommend using this format for the common topic space, $aws/rules/things/thing_name/logs, and this format for error topics, $aws/rules/things/thing_name/logs/errors. The naming structure for logs and error topics is recommended, but not required. For more information, see Designing MQTT Topics for AWS IoT Core.

By using the recommended common topic space, you utilize AWS IoT Basic Ingest reserved topics. AWS IoT Basic Ingest securely sends device data to the AWS services that are supported by AWS IoT rule actions. It removes the publish/subscribe message broker from the ingestion path, making it more cost effective. For more information, see Reducing messaging costs with Basic Ingest.

If you use batchMode to upload log files, your messages must follow a specific format that includes a UNIX timestamp and message. For more information, see the MQTT message format requirements for batchMode topic within CloudWatch Logs rule action.

Rule action

When AWS IoT receives the MQTT messages from the client devices, an AWS IoT rule monitors the customer-defined topic and publishes the contents into a CloudWatch log group that you define. This process uses a CloudWatch Logs rule action to monitor MQTT for batches of log files. For more information, see the CloudWatch Logs AWS IoT rule action.

Batch mode

batchMode is a Boolean parameter within the AWS IoT CloudWatch Logs rule action. This parameter is optional and is off (false) by default. To upload device-side log files in batches, you must turn this parameter on (true) when you create the AWS IoT rule. For more information, see CloudWatch Logs in the AWS IoT rule actions section.
Uploading device-side logs by using AWS IoT rules

You can use the AWS IoT rules engine to upload log records from existing device-side log files (system, application, and device-client logs) to Amazon CloudWatch. When device-side logs are published to an MQTT topic, the CloudWatch Logs rules action transfers the messages to CloudWatch Logs. This process outlines how to upload device logs in batches using the rules action batchMode parameter turned on (set to true).

To begin uploading device-side logs to CloudWatch, complete the following prerequisites.

**Prerequisites**

Before you begin, do the following:

- Create at least one target IoT device that's registered with AWS IoT Core as an AWS IoT thing. For more information, see Create a thing object.
- Determine the MQTT topic space for ingestion and errors. For more information about MQTT topics and recommended naming conventions, see the MQTT topics section in Upload device-side logs to Amazon CloudWatch.

For more information about these prerequisites, see Upload device-side logs to CloudWatch.

**Creating a CloudWatch log group**

To create a CloudWatch log group, complete the following steps. Choose the appropriate tab depending on whether you prefer to perform the steps through the AWS Management Console or the AWS Command Line Interface (AWS CLI).

**AWS Management Console**

To create a CloudWatch log group by using the AWS Management Console

1. Open the AWS Management Console and navigate to CloudWatch.
2. On the navigation bar, choose Logs, and then Log groups.
3. Choose Create log group.
4. Update the Log group name and, optionally, update the Retention setting fields.
5. Choose Create.

**AWS CLI**

To create a CloudWatch log group by using the AWS CLI

1. To create the log group, run the following command. For more information, see create-log-group in the AWS CLI v2 Command Reference.

   ```bash
   aws logs create-log-group --log-group-name uploadLogsGroup
   ```

   Replace the log group name in the example (uploadLogsGroup) with your preferred name.

2. To confirm that the log group was created correctly, run the following command.

   ```bash
   aws logs describe-log-groups --log-group-name-prefix uploadLogsGroup
   ```

   Sample output:
Creating a topic rule

To create an AWS IoT rule, complete the following steps. Choose the appropriate tab depending on whether you prefer to perform the steps through the AWS Management Console or the AWS Command Line Interface (AWS CLI).

AWS Management Console

**To create a topic rule by using the AWS Management Console**

1. Open the Rule hub.
   a. Open the AWS Management Console and navigate to [AWS IoT](https://aws.amazon.com/iot/).
   b. On the navigation bar, choose **Message routing** and then **Rules**.
   c. Choose **Create rule**.
2. Enter the rule properties.
   a. Enter an alphanumeric **Rule name**.
   b. (Optional) Enter a **Rule description** and **Tags**.
   c. Choose **Next**.
3. Enter a SQL statement.
   a. Enter a SQL statement using the MQTT topic that you defined for ingestion.
      - For example, `SELECT * FROM '$aws/rules/things/thing_name/logs'`
   b. Choose **Next**.
4. Enter rule actions.
   a. On the **Action 1** menu, choose **CloudWatch logs**.
   b. Choose the **Log group name** and then choose the log group that you created.
   c. Select **Use batch mode**.
   d. Specify the IAM role for the rule.
      - If you have an IAM role for the rule, do the following.
      1. On the **IAM role** menu, choose your IAM role.
      
      If you don’t have an IAM role for the rule, do the following.
      1. Choose **Create new role**.
      2. For **Role name**, enter a unique name and choose **Create**.

```json
{
  "logGroups": [
    {
      "logGroupName": "uploadLogsGroup",
      "creationTime": 1674521804657,
      "metricFilterCount": 0,
      "storedBytes": 0
    }
  ]
}
```
3. Confirm that the IAM role name is correct in the IAM role field.
   e. Choose Next.

5. Review the template configuration.
   a. Review the settings for the Job template to verify they're correct.
   b. When you're done, choose Create.

AWS CLI

To create an IAM role and a topic rule by using the AWS CLI

1. Create an IAM role that grants rights to the AWS IoT rule.
   a. Create an IAM policy.

   To create an IAM policy, run the following command. Make sure you update the policy-name parameter value. For more information, see create-policy in the AWS CLI v2 Command Reference.

   **Note**
   If you're using a Microsoft Windows operating system, you might need to replace the end of line marker (\) with a tick (\`) or another character.

   ```bash
   aws iam create-policy \
   --policy-name uploadLogsPolicy \
   --policy-document \
   '{
   "Version": "2012-10-17",
   "Statement": [
   "Effect": "Allow",
   "Action": [
   "iot:CreateTopicRule",
   "iot:Publish",
   "logs:CreateLogGroup",
   "logs:CreateLogStream",
   "logs:PutLogEvents",
   "logs:GetLogEvents"
   ],
   "Resource": "*"
   }
   }
   
   b. Copy the policy ARN from your output into a text editor.

   Sample output:

   ```json
   {
   "Policy": {
   "PolicyName": "uploadLogsPolicy",
   "PermissionsBoundaryUsageCount": 0,
   "CreateDate": "2023-01-23T18:30:10Z",
   "AttachmentCount": 0,
   "IsAttachable": true,
   "PolicyId": "AAABBBCCDDEEEFFFGGGG",
   "DefaultVersionId": "v1",
   "Path": "/",
   "Arn": "arn:aws:iam::111122223333:policy/uploadLogsPolicy",
   "UpdateDate": "2023-01-23T18:30:10Z"
   }
   }
   ```

487
c. Create an IAM role and trust policy.

To create an IAM policy, run the following command. Make sure you update the `role-name` parameter value. For more information, see `create-role` in the AWS CLI v2 Command Reference.

```bash
code
aws iam create-role
   --role-name uploadLogsRole
   --assume-role-policy-document
   '{
       "Version": "2012-10-17",
       "Statement": [
           {
               "Sid": "",
               "Effect": "Allow",
               "Principal": {
                   "Service": "iot.amazonaws.com"
               },
               "Action": "sts:AssumeRole"
           }
       ]
   }
'
```

d. Attach the IAM policy to the rule.

To create an IAM policy, run the following command. Make sure you update the `role-name` and `policy-arn` parameter values. For more information, see `attach-role-policy` in the AWS CLI v2 Command Reference.

```bash
code
aws iam attach-role-policy
   --role-name uploadLogsRole
   --policy-arn arn:aws:iam::111122223333:policy/uploadLogsPolicy
```

e. Review the role.

To confirm that the IAM role was created correctly, run the following command. Make sure you update the `role-name` parameter value. For more information, see `get-role` in the AWS CLI v2 Command Reference.

```bash
code
aws iam get-role --role-name uploadLogsRole
```

Sample output:

```json
code
{
    "Role": {
        "Path": "/",
        "RoleName": "uploadLogsRole",
        "RoleId": "AAABBBCCDDEEEFFGGG",
        "Arn": "arn:aws:iam::111122223333:role/uploadLogsRole",
        "CreateDate": "2023-01-23T19:17:15+00:00",
        "AssumeRolePolicyDocument": {
            "Version": "2012-10-17",
            "Statement": [
                {
                    "Sid": "Statement1",
                    "Effect": "Allow",
                    "Principal": {
                        "Service": "iot.amazonaws.com"
                    },
                    "Action": "sts:AssumeRole"
                }
            ]
        }
    }
}
```
2. Create an AWS IoT topic rule in the AWS CLI.

   a. To create an AWS IoT topic rule, run the following command. Make sure you update the --rule-name, sql statement, description, roleARN, and logGroupName parameter values. For more information, see create-topic-rule in the AWS CLI v2 Command Reference.

   ```bash
   aws iot create-topic-rule
   --rule-name uploadLogsRule
   --topic-rule-payload
   '{
   "sql":"SELECT * FROM 'rules/things/thing_name/logs'",
   "description": "Upload logs test rule",
   "ruleDisabled":false,
   "awsIotSqlVersion":"2016-03-23",
   "actions": [ 
   {"cloudwatchLogs": 
   {"roleArn":"arn:aws:iam::111122223333:role/uploadLogsRole",
   "logGroupName": "uploadLogsGroup",
   "batchMode": true}
   }
   ]
   }'
   
   b. To confirm that the rule was created correctly, run the following command. Make sure you update the role-name parameter value. For more information, see get-topic-rule in the AWS CLI v2 Command Reference.

   ```bash
   aws iot get-topic-rule --rule-name uploadLogsRule
   ```

Sample output:

```json
{
   "ruleArn": "arn:aws:iot:us-east-1:111122223333:rule/uploadLogsRule",
   "rule": {
      "ruleName": "uploadLogsRule",
      "sql": "SELECT * FROM rules/things/thing_name/logs",
      "description": "Upload logs test rule",
      "createdAt": "2023-01-24T16:28:15+00:00",
      "actions": [
         {"cloudwatchLogs": {
            "roleArn": "arn:aws:iam::111122223333:role/uploadLogsRole",
            "logGroupName": "uploadLogsGroup",
            "batchMode": true
         }
      ]
   },
   "ruleDisabled": false,
   "awsIotSqlVersion": "2016-03-23"
}
```
Sending device-side logs to AWS IoT

To send device-side logs to AWS IoT

1. To send historical logs to AWS IoT, communicate with your devices to ensure the following.
   - The log information is sent to the correct topic namespace as specified within the Prerequisites section of this procedure.
     For example, $aws/rules/things/thing_name/logs
   - The MQTT message payload is formatted correctly. For more information about MQTT topic and recommended naming convention, see the MQTT topics section within Upload device-side logs to Amazon CloudWatch (p. 484).

2. Confirm that the MQTT messages are received within the AWS IoT MQTT client.
   a. Open the AWS Management Console and navigate to AWS IoT.
   b. To view the MQTT test client, on the navigation bar, choose Test, MQTT test client.
   c. For Subscribe to a topic, Topic filter, enter the topic namespace.
   d. Choose Subscribe.
      MQTT messages appear in the Subscriptions and Topic table, as seen in the following. These messages can take up to five minutes to appear.
Viewing the log data

**To review your log records in CloudWatch Logs**

1. Open the AWS Management Console, and navigate to CloudWatch.
2. On the navigation bar, choose Logs, Logs Insights.
3. On the Select log group(s) menu, choose the log group you specified in the AWS IoT rule.
4. On the **Logs insights** page, choose **Run query**.

**Logging AWS IoT API calls using AWS CloudTrail**

AWS IoT is integrated with AWS CloudTrail, a service that provides a record of actions taken by a user, role, or an AWS service in AWS IoT. CloudTrail captures all API calls for AWS IoT as events, including calls from the AWS IoT console and from code calls to the AWS IoT APIs. If you create a trail, you can enable continuous delivery of CloudTrail events to an Amazon S3 bucket, including events for AWS IoT. If you don't configure a trail, you can still view the most recent events in the CloudTrail console in **Event history**. Using the information collected by CloudTrail, you can determine the request that was made to AWS IoT, the IP address from which the request was made, who made the request, when it was made, and other details.

To learn more about CloudTrail, see the [AWS CloudTrail User Guide](https://docs.aws.amazon.com/CloudTrail/latest/ug/).

**AWS IoT information in CloudTrail**

CloudTrail is enabled on your AWS account when you create the account. When activity occurs in AWS IoT, that activity is recorded in a CloudTrail event along with other AWS service events in **Event history**. You can view, search, and download recent events in your AWS account. For more information, see [Viewing Events with CloudTrail Event History](https://docs.aws.amazon.com/CloudTrail/latest/ug/).

For an ongoing record of events in your AWS account, including events for AWS IoT, create a trail. A trail enables CloudTrail to deliver log files to an Amazon S3 bucket. By default, when you create a trail in the console, the trail applies to all AWS Regions. The trail logs events from all AWS Regions in the AWS partition and delivers the log files to the Amazon S3 bucket that you specify. You can configure other AWS services to further analyze and act upon the event data collected in CloudTrail logs. For more information, see:

- **Overview for Creating a Trail**
- **CloudTrail Supported Services and Integrations**
- **Configuring Amazon SNS Notifications for CloudTrail**
- **Receiving CloudTrail Log Files from Multiple Regions** and **Receiving CloudTrail Log Files from Multiple Accounts**

**Note**

AWS IoT data plane actions (device side) are not logged by CloudTrail. Use CloudWatch to monitor these actions.

Generally speaking, AWS IoT control plane actions that make changes are logged by CloudTrail. Calls such as `CreateThing`, `CreateKeysAndCertificate`, and `UpdateCertificate` leave CloudTrail entries, while calls such as `ListThings` and `ListTopicRules` do not.

Every event or log entry contains information about who generated the request. The identity information helps you determine the following:

- Whether the request was made with root or IAM user credentials.
- Whether the request was made with temporary security credentials for a role or federated user.
- Whether the request was made by another AWS service.

For more information, see the [CloudTrail userIdentity Element](https://docs.aws.amazon.com/CloudTrail/latest/ug/).

Understanding AWS IoT log file entries

A trail is a configuration that enables delivery of events as log files to an Amazon S3 bucket that you specify. CloudTrail log files contain one or more log entries. An event represents a single request from any source and includes information about the requested action, the date and time of the action, request parameters, and so on. CloudTrail log files are not an ordered stack trace of the public API calls, so they do not appear in any specific order.

The following example shows a CloudTrail log entry that demonstrates the **AttachPolicy** action.

```json
{
    "timestamp": "1460159496",
    "AdditionalEventData": "",
    "Annotation": "",
    "ApiVersion": "",
    "ErrorCode": "",
    "ErrorMessage": "",
    "EventID": "8bff4fed-c229-4d2d-8264-4ab28a487505",
    "EventName": "AttachPolicy",
    "EventTime": "2016-04-08T23:51:36Z",
    "EventType": "AwsApiCall",
    "ReadOnly": "",
    "RecipientAccountList": "",
    "RequestID": "d4875df2-fde4-11e5-b829-23bf9b56cbed",
    "RequestParameters": {
        "principal": "arn:aws:iot:us-east-1:123456789012:cert/528ce36e8047f6a75ee51ab7beddb4eb268ad41d2ea881a10b67e8e7924b984",
        "policyName": "ExamplePolicyForIoT"
    },
    "Resources": "",
    "ResponseElements": "",
    "SourceIpAddress": "52.90.213.26",
    "UserAgent": "aws-internal/3",
    "UserIdentity": {
        "type": "AssumedRole",
        "principalId": "AKIAI44QH8DHEXAMPLE",
        "arn": "arn:aws:sts::123456789012:assumed-role/iotmonitor-us-east-1-beta-InstanceRole-1CST1YCMHPYT/1-35d0a4b6",
        "accountId": "222222222222",
        "accessKeyId": "access-key-id",
        "sessionContext": {
            "attributes": {
                "mfaAuthenticated": "false",
                "creationDate": "Fri Apr 08 23:51:10 UTC 2016"
            },
            "sessionIssuer": {
                "type": "Role",
                "principalId": "AKIAI44QH8DHEXAMPLE",
                "arn": "arn:aws:iam::123456789012:role/executionServiceEC2Role/iotmonitor-us-east-1-beta-InstanceRole-1CST1YCMHPYT",
                "accountId": "222222222222",
                "userName": "iotmonitor-us-east-1-InstanceRole-1CST1YCMHPYT"
            }
        },
        "invokedBy": {
            "serviceAccountId": "111111111111"
        }
    },
    "VpcEndpointId": ""
}
"
Rules for AWS IoT

Rules give your devices the ability to interact with AWS services. Rules are analyzed and actions are performed based on the MQTT topic stream. You can use rules to support the following tasks:

- Augment or filter data received from a device.
- Write data received from a device to an Amazon DynamoDB database.
- Save a file to Amazon S3.
- Send a push notification to all users who are using Amazon SNS.
- Publish data to an Amazon SQS queue.
- Invoke a Lambda function to extract data.
- Process messages from a large number of devices using Amazon Kinesis.
- Send data to Amazon OpenSearch Service.
- Capture a CloudWatch metric.
- Change a CloudWatch alarm.
- Send the data from an MQTT message to Amazon SageMaker to make predictions based on a machine learning (ML) model.
- Send a message to a Salesforce IoT Input Stream.
- Send message data to an AWS IoT Analytics channel.
- Start process of a Step Functions state machine.
- Send message data to an AWS IoT Events input.
- Send message data to an asset property in AWS IoT SiteWise.
- Send message data to a web application or service.

Your rules can use MQTT messages that pass through the publish/subscribe protocol supported by the section called “Device communication protocols” (p. 85). You can also use the Basic Ingest (p. 585) feature to securely send device data to the AWS services listed previously, without incurring messaging costs. The Basic Ingest (p. 585) feature optimizes data flow by removing the publish/subscribe message broker from the ingestion path. This makes it cost effective while still keeping the security and data processing features of AWS IoT.

Before AWS IoT can perform these actions, you must grant it permission to access your AWS resources on your behalf. When the actions are performed, you incur the standard charges for the AWS services that you use.

Contents
- Granting an AWS IoT rule the access it requires (p. 495)
- Pass role permissions (p. 496)
- Creating an AWS IoT rule (p. 497)
- Viewing your rules (p. 501)
- Deleting a rule (p. 501)
- AWS IoT rule actions (p. 502)
- Troubleshooting a rule (p. 577)
- Accessing cross-account resources using AWS IoT rules (p. 577)
- Error handling (error action) (p. 583)
Granting an AWS IoT rule the access it requires

Use IAM roles to control the AWS resources to which each rule has access. Before you create a rule, you must create an IAM role with a policy that allows access to the required AWS resources. AWS IoT assumes this role when implementing a rule.

Complete the following steps to create the IAM role and AWS IoT policy that grant an AWS IoT rule the access it requires (AWS CLI).

1. Save the following trust policy document, which grants AWS IoT permission to assume the role, to a file named `iot-role-trust.json`.

   ```json
   {
     "Version": "2012-10-17",
     "Statement": [ {
       "Effect": "Allow",
       "Principal": { "Service": "iot.amazonaws.com" },
       "Action": "sts:AssumeRole"
     } ]
   }
   ```

   Use the `create-role` command to create an IAM role specifying the `iot-role-trust.json` file:

   ```
   aws iam create-role --role-name my-iot-role --assume-role-policy-document file://iot-role-trust.json
   ```

   The output of this command looks like the following:

   ```
   {
     "Role": {
       "AssumeRolePolicyDocument": "url-encoded-json",
       "RoleId": "AKIAIOSFODNN7EXAMPLE",
       "CreateDate": "2015-09-30T18:43:32.821Z",
       "RoleName": "my-iot-role",
       "Path": "/",
       "Arn": "arn:aws:iam::123456789012:role/my-iot-role"
     }
   }
   ```

2. Save the following JSON into a file named `my-iot-policy.json`.

   ```json
   {
     "Version": "2012-10-17",
     "Statement": [ {
       "Effect": "Allow",
       "Action": "dynamodb:*",
       "Resource": "*
     } ]
   }
   ```

   This JSON is an example policy document that grants AWS IoT administrator access to DynamoDB.
Use the `create-policy` command to grant AWS IoT access to your AWS resources upon assuming the role, passing in the `my-iot-policy.json` file:

```bash
aws iam create-policy --policy-name my-iot-policy --policy-document file://my-iot-policy.json
```

For more information about how to grant access to AWS services in policies for AWS IoT, see Creating an AWS IoT rule (p. 497).

The output of the `create-policy` command contains the ARN of the policy. Attach the policy to a role.

```json
{
   "Policy": {
      "PolicyName": "my-iot-policy",
      "CreateDate": "2015-09-30T19:31:18.620Z",
      "AttachmentCount": 0,
      "IsAttachable": true,
      "PolicyId": "ZXR6A36LTYANPAI7NJ5UV",
      "DefaultVersionId": "v1",
      "Path": "/",
      "Arn": "arn:aws:iam::123456789012:policy/my-iot-policy",
      "UpdateDate": "2015-09-30T19:31:18.620Z"
   }
}
```

3. Use the `attach-role-policy` command to attach your policy to your role:

```bash
aws iam attach-role-policy --role-name my-iot-role --policy-arn "arn:aws:iam::123456789012:policy/my-iot-policy"
```

Pass role permissions

Part of a rule definition is an IAM role that grants permission to access resources specified in the rule's action. The rules engine assumes that role when the rule's action is invoked. The role must be defined in the same AWS account as the rule.

When creating or replacing a rule you are, in effect, passing a role to the rules engine. The `iam:PassRole` permission is required to perform this operation. To verify that you have this permission, create a policy that grants the `iam:PassRole` permission and attach it to your IAM user. The following policy shows how to allow `iam:PassRole` permission for a role.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Sid": "Stmt1",
         "Effect": "Allow",
         "Action": [
            "iam:PassRole"
         ],
         "Resource": [
            "arn:aws:iam::123456789012:role/myRole"
         ]
      }
   ]
}
```
In this policy example, the `iam:PassRole` permission is granted for the role `myRole`. The role is specified using the role's ARN. Attach this policy to your IAM user or role that your user belongs to. For more information, see Working with Managed Policies.

**Note**
Lambda functions use resource-based policy, where the policy is attached directly to the Lambda function itself. When you create a rule that invokes a Lambda function, you don't pass a role, so the user creating the rule doesn't need the `iam:PassRole` permission. For more information about Lambda function authorization, see Granting Permissions Using a Resource Policy.

Creating an AWS IoT rule

You configure rules to route data from your connected things. Rules consist of the following:

**Rule name**
The name of the rule.

**Note**
We do not recommend the use of personally identifiable information in your rule names.

**Optional description**
A textual description of the rule.

**Note**
We do not recommend the use of personally identifiable information in your rule descriptions.

**SQL statement**
A simplified SQL syntax to filter messages received on an MQTT topic and push the data elsewhere. For more information, see AWS IoT SQL reference (p. 586).

**SQL version**
The version of the SQL rules engine to use when evaluating the rule. Although this property is optional, we strongly recommend that you specify the SQL version. The AWS IoT Core console sets this property to `2016-03-23` by default. If this property is not set, such as in an AWS CLI command or an AWS CloudFormation template, `2015-10-08` is used. For more information, see SQL versions (p. 655).

**One or more actions**
The actions AWS IoT performs when enacting the rule. For example, you can insert data into a DynamoDB table, write data to an Amazon S3 bucket, publish to an Amazon SNS topic, or invoke a Lambda function.

**An error action**
The action AWS IoT performs when it's unable to perform a rule's action.

When you create a rule, be aware of how much data you're publishing on topics. If you create rules that include a wildcard topic pattern, they might match a large percentage of your messages. If this is the case, you might need to increase the capacity of the AWS resources used by the target actions. Also, if you create a republish rule that includes a wildcard topic pattern, you can end up with a circular rule that causes an infinite loop.

**Note**
Creating and updating rules are administrator-level actions. Any user who has permission to create or update rules is able to access data processed by the rules.

**To create a rule (AWS CLI)**
Use the `create-topic-rule` command to create a rule:

```
aws iot create-topic-rule --rule-name myrule --topic-rule-payload file://myrule.json
```

The following is an example payload file with a rule that inserts all messages sent to the `iot/test` topic into the specified DynamoDB table. The SQL statement filters the messages and the role ARN grants AWS IoT permission to write to the DynamoDB table.

```
{
  "sql": "SELECT * FROM 'iot/test'",
  "ruleDisabled": false,
  "awsIoTSqlVersion": "2016-03-23",
  "actions": [
    {
      "dynamodb": {
        "tableName": "my-dynamodb-table",
        "roleArn": "arn:aws:iam::123456789012:role/my-iot-role",
        "hashKeyField": "topic",
        "hashKeyValue": "${topic(2)}",
        "rangeKeyField": "timestamp",
        "rangeKeyValue": "${timestamp()}
      }
    }
  ]
}
```

The following is an example payload file with a rule that inserts all messages sent to the `iot/test` topic into the specified S3 bucket. The SQL statement filters the messages, and the role ARN grants AWS IoT permission to write to the Amazon S3 bucket.

```
{
  "awsIoTSqlVersion": "2016-03-23",
  "sql": "SELECT * FROM 'iot/test'",
  "ruleDisabled": false,
  "actions": [
    {
      "s3": {
        "roleArn": "arn:aws:iam::123456789012:role/aws_iot_s3",
        "bucketName": "my-bucket",
        "key": "myS3Key"
      }
    }
  ]
}
```

The following is an example payload file with a rule that pushes data to Amazon OpenSearch Service:

```
{
  "sql": "SELECT *, timestamp() as timestamp FROM 'iot/test'",
  "ruleDisabled": false,
  "awsIoTSqlVersion": "2016-03-23",
  "actions": [
    {
      "OpenSearch": {
        "roleArn": "arn:aws:iam::123456789012:role/aws_iot_es",
        "endpoint": "https://my-endpoint",
        "index": "my-index",
        "type": "my-type",
        "id": "${newuid()}
      }
    }
  ]
}
```
The following is an example payload file with a rule that invokes a Lambda function:

```json
{
  "sql": "expression",
  "ruleDisabled": false,
  "awsIotSqlVersion": "2016-03-23",
  "actions": [{
    "lambda": {
      "functionArn": "arn:aws:lambda:us-west-2:123456789012:function:my-lambda-function"
    }
  }]
}
```

The following is an example payload file with a rule that publishes to an Amazon SNS topic:

```json
{
  "sql": "expression",
  "ruleDisabled": false,
  "awsIotSqlVersion": "2016-03-23",
  "actions": [{
    "sns": {
      "roleArn": "arn:aws:iam::123456789012:role/my-iot-role"
    }
  }]
}
```

The following is an example payload file with a rule that republishes on a different MQTT topic:

```json
{
  "sql": "expression",
  "ruleDisabled": false,
  "awsIotSqlVersion": "2016-03-23",
  "actions": [{
    "republish": {
      "topic": "my-mqtt-topic",
      "roleArn": "arn:aws:iam::123456789012:role/my-iot-role"
    }
  }]
}
```

The following is an example payload file with a rule that pushes data to an Amazon Kinesis Data Firehose stream:

```json
{
  "sql": "SELECT * FROM 'my-topic'",
  "ruleDisabled": false,
  "awsIotSqlVersion": "2016-03-23",
  "actions": [{
    "firehose": {
      "roleArn": "arn:aws:iam::123456789012:role/my-iot-role",
      "deliveryStreamName": "my-stream-name"
    }
  }]
}
```

The following is an example payload file with a rule that uses the Amazon SageMaker machinelearning_predict function to republish to a topic if the data in the MQTT payload is classified as a 1.
Tagging your rules

To add another layer of specificity to your new or existing rules, you can apply tagging. Tagging leverages key-value pairs in your rules to provide you with greater control over how and where your rules are applied to your AWS IoT resources and services. For example, you can limit the scope of your rule to only apply in your beta environment for pre release testing (Key=environment, Value=beta) or capturing all messages sent to the `iot/test` topic from a specific endpoint only and storing them in an Amazon S3 bucket.

IAM policy example

For an example that shows how to grant tagging permissions for a rule, consider a user that runs the following command to create a rule and tag it to apply only to their beta environment.

In the example, replace:
• *MyTopicRuleName* with the name of the rule.
• *myrule.json* with the name of the policy document.

```bash
aws iot create-topic-rule
  --rule-name MyTopicRuleName
  --topic-rule-payload file://myrule.json
  --tags "environment=beta"
```

For this example, you must use the following IAM policy:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [ "iot:CreateTopicRule", "iot:TagResource" ],
      "Effect": "Allow",
      "Resource": [ "arn:aws:iot:us-east-1:123456789012:rule/MyTopicRuleName" ]
    }
  ]
}
```

The above example shows a newly created rule called *MyTopicRuleName* that applies only to your beta environment. The `iot:TagResource` in the policy statement with *MyTopicRuleName* specifically called out allows tagging when creating or updating *MyTopicRuleName*. The parameter `--tags "environment=beta"` used when creating the rule limits the scope of *MyTopicRuleName* to only your beta environment. If you remove the parameter `--tags "environment=beta"`, then *MyTopicRuleName* will apply to all environments.

For more information on creating IAM roles and policies specific to an AWS IoT rule, see [Granting an AWS IoT rule the access it requires](p. 495)

For general information about tagging your resources, see [Tagging your AWS IoT resources](p. 291).

### Viewing your rules

Use the `list-topic-rules` command to list your rules:

```bash
aws iot list-topic-rules
```

Use the `get-topic-rule` command to get information about a rule:

```bash
aws iot get-topic-rule --rule-name myrule
```

### Deleting a rule

When you are finished with a rule, you can delete it.

**To delete a rule (AWS CLI)**

Use the `delete-topic-rule` command to delete a rule:

```bash
aws iot delete-topic-rule --rule-name myrule
```
**AWS IoT rule actions**

AWS IoT rule actions specify what to do when a rule is invoked. You can define actions to send data to an Amazon DynamoDB database, send data to Amazon Kinesis Data Streams, invoke an AWS Lambda function, and so on. AWS IoT supports the following actions in AWS Regions where the action’s service is available.

<table>
<thead>
<tr>
<th>Rule action</th>
<th>Description</th>
<th>Name in API</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Apache Kafka (p. 503)</strong></td>
<td>Sends a message to an Apache Kafka cluster.</td>
<td>kafka</td>
</tr>
<tr>
<td><strong>CloudWatch alarms (p. 511)</strong></td>
<td>Changes the state of an Amazon CloudWatch alarm.</td>
<td>cloudwatchAlarm</td>
</tr>
<tr>
<td><strong>CloudWatch Logs (p. 513)</strong></td>
<td>Sends a message to Amazon CloudWatch Logs.</td>
<td>cloudwatchLogs</td>
</tr>
<tr>
<td><strong>CloudWatch metrics (p. 514)</strong></td>
<td>Sends a message to a CloudWatch metric.</td>
<td>cloudwatchMetric</td>
</tr>
<tr>
<td><strong>DynamoDB (p. 516)</strong></td>
<td>Sends a message to a DynamoDB table.</td>
<td>dynamoDB</td>
</tr>
<tr>
<td><strong>DynamoDBv2 (p. 518)</strong></td>
<td>Sends message data to multiple columns in a DynamoDB table.</td>
<td>dynamoDBv2</td>
</tr>
<tr>
<td><strong>Elasticsearch (p. 519)</strong></td>
<td>Sends a message to an OpenSearch endpoint.</td>
<td>OpenSearch</td>
</tr>
<tr>
<td><strong>HTTP (p. 521)</strong></td>
<td>Posts a message to an HTTPS endpoint.</td>
<td>http</td>
</tr>
<tr>
<td><strong>IoT Analytics (p. 548)</strong></td>
<td>Sends a message to an AWS IoT Analytics channel.</td>
<td>iotAnalytics</td>
</tr>
<tr>
<td><strong>AWS IoT Events (p. 550)</strong></td>
<td>Sends a message to an AWS IoT Events input.</td>
<td>iotEvents</td>
</tr>
<tr>
<td><strong>AWS IoT SiteWise (p. 551)</strong></td>
<td>Sends message data to AWS IoT SiteWise asset properties.</td>
<td>iotSiteWise</td>
</tr>
<tr>
<td><strong>Kinesis Data Firehose (p. 555)</strong></td>
<td>Sends a message to a Kinesis Data Firehose delivery stream.</td>
<td>firehose</td>
</tr>
<tr>
<td><strong>Kinesis Data Streams (p. 557)</strong></td>
<td>Sends a message to a Kinesis data stream.</td>
<td>kinesis</td>
</tr>
<tr>
<td><strong>Lambda (p. 558)</strong></td>
<td>Invokes a Lambda function with message data as input.</td>
<td>lambda</td>
</tr>
<tr>
<td><strong>Location (p. 560)</strong></td>
<td>Sends location data to Amazon Location Service.</td>
<td>location</td>
</tr>
<tr>
<td><strong>OpenSearch (p. 563)</strong></td>
<td>Sends a message to an Amazon OpenSearch Service endpoint.</td>
<td>OpenSearch</td>
</tr>
<tr>
<td><strong>Republish (p. 564)</strong></td>
<td>Republishes a message to another MQTT topic.</td>
<td>republish</td>
</tr>
</tbody>
</table>
### Rule action

<table>
<thead>
<tr>
<th>Rule action</th>
<th>Description</th>
<th>Name in API</th>
</tr>
</thead>
<tbody>
<tr>
<td>S3 (p. 566)</td>
<td>Stores a message in an Amazon Simple Storage Service (Amazon S3) bucket.</td>
<td>s3</td>
</tr>
<tr>
<td><strong>Salesforce IoT (p. 568)</strong></td>
<td>Sends a message to a Salesforce IoT input stream.</td>
<td>salesforce</td>
</tr>
<tr>
<td>SNS (p. 569)</td>
<td>Publishes a message as an Amazon Simple Notification Service (Amazon SNS) push notification.</td>
<td>sns</td>
</tr>
<tr>
<td>SQS (p. 570)</td>
<td>Sends a message to an Amazon Simple Queue Service (Amazon SQS) queue.</td>
<td>sqs</td>
</tr>
<tr>
<td><strong>Step Functions (p. 572)</strong></td>
<td>Starts an AWS Step Functions state machine.</td>
<td>stepFunctions</td>
</tr>
<tr>
<td>the section called “Timestream” (p. 573)</td>
<td>Sends a message to an Amazon Timestream database table.</td>
<td>timestream</td>
</tr>
</tbody>
</table>

### Notes

- Define the rule in the same AWS Region as another service's resource so that the rule action can interact with that resource.
- The AWS IoT rules engine might make multiple attempts to perform an action if intermittent errors occur. If all attempts fail, the message is discarded and the error is available in your CloudWatch Logs. You can specify an error action for each rule that is invoked after a failure occurs. For more information, see Error handling (error action) (p. 583).
- Some rule actions activate actions in services that integrate with AWS Key Management Service (AWS KMS) to support data encryption at rest. If you use a customer-managed AWS KMS key (KMS key) to encrypt data at rest, the service must have permission to use the KMS key on the caller's behalf. To learn how to manage permissions for your customer managed KMS key, see the data encryption topics in the appropriate service guide. For more information about customer managed KMS keys, see AWS Key Management Service concepts in the AWS Key Management Service Developer Guide.

### Apache Kafka

The Apache Kafka (Kafka) action sends messages directly to your Amazon Managed Streaming for Apache Kafka (Amazon MSK) or self-managed Apache Kafka clusters for data analysis and visualization.

#### Note

This topic assumes familiarity with the Apache Kafka platform and related concepts. For more information about Apache Kafka, see Apache Kafka. You can't invoke an Apache Kafka action in an Error action (p. 583).

### Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the ec2:CreateNetworkInterface, ec2:DescribeNetworkInterfaces, ec2:CreateNetworkInterfacePermission,
ec2:DeleteNetworkInterface, ec2:DescribeSubnets, ec2:DescribeVpcs, ec2:DescribeVpcAttribute, and ec2:DescribeSecurityGroups operations. This role creates and manages elastic network interfaces to your Amazon Virtual Private Cloud to reach your Kafka broker. For more information, seeGranting an AWS IoT rule the access it requires (p. 495).

In the AWS IoT console, you can choose or create a role to allow AWS IoT Core to perform this rule action.

For more information about network interfaces, see Elastic network interfaces in the Amazon EC2 User Guide.

The policy attached to the role that you specify should look like the following example.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "ec2:CreateNetworkInterface",
                "ec2:DescribeNetworkInterfaces",
                "ec2:CreateNetworkInterfacePermission",
                "ec2:DeleteNetworkInterface",
                "ec2:DescribeSubnets",
                "ec2:DescribeVpcs",
                "ec2:DescribeVpcAttribute",
                "ec2:DescribeSecurityGroups"
            ],
            "Resource": "*
        }
    ]
}
```

- If you use AWS Secrets Manager to store the credentials required to connect to your Kafka broker, you must create an IAM role that AWS IoT Core can assume to perform the secretsmanager:GetSecretValue and secretsmanager:DescribeSecret operations.

  The policy attached to the role that you specify should look like the following example.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "secretsmanager:GetSecretValue",
                "secretsmanager:DescribeSecret"
            ],
            "Resource": [
            ]
        }
    ]
}
```

- You can run your Apache Kafka clusters inside Amazon Virtual Private Cloud (Amazon VPC). You must create an Amazon VPC destination and use an NAT gateway in your subnets to forward messages from AWS IoT to a public Kafka cluster. The AWS IoT rules engine creates a network interface in each of the subnets listed in the VPC destination to route traffic directly to the VPC. When you create a VPC...
destination, the AWS IoT rules engine automatically creates a VPC rule action. For more information about VPC rule actions, see Virtual private cloud (VPC) destinations (p. 509).

- If you use a customer managed AWS KMS key (KMS key) to encrypt data at rest, the service must have permission to use the KMS key on the caller's behalf. For more information, see Amazon MSK encryption in the Amazon Managed Streaming for Apache Kafka Developer Guide.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

destinationArn

The Amazon Resource Name (ARN) of the VPC destination. For information about creating a VPC destination, see Virtual private cloud (VPC) destinations (p. 509).

topic

The Kafka topic for messages to be sent to the Kafka broker.

You can substitute this field using a substitution template. For more information, see the section called “Substitution templates” (p. 648).

key (optional)

The Kafka message key.

You can substitute this field using a substitution template. For more information, see the section called “Substitution templates” (p. 648).

headers (optional)

The list of Kafka headers that you specify. Each header is a key-value pair that you can specify when you create a Kafka action. You can use these headers to route data from IoT clients to downstream Kafka clusters without modifying your message payload.

You can substitute this field using a substitution template. To understand how to pass an inline Rule's function as a substitution template in Kafka Action's header, see Examples (p. 508). For more information, see the section called “Substitution templates” (p. 648).

Note

Headers in binary format are not supported.

partition (optional)

The Kafka message partition.

You can substitute this field using a substitution template. For more information, see the section called “Substitution templates” (p. 648).

clientProperties

An object that defines the properties of the Apache Kafka producer client.

acks (optional)

The number of acknowledgments the producer requires the server to have received before considering a request complete.

If you specify 0 as the value, the producer won't wait for any acknowledgment from the server. If the server doesn't receive the message, the producer won't retry to send the message.
Valid values: -1, 0, 1, all. The default value is 1.

**bootstrap.servers**

A list of host and port pairs (for example, host1:port1, host2:port2) used to establish the initial connection to your Kafka cluster.

**compression.type (optional)**

The compression type for all data generated by the producer.

Valid values: none, gzip, snappy, lz4, zstd. The default value is none.

**security.protocol**

The security protocol used to attach to your Kafka broker.

Valid values: SSL, SASL_SSL. The default value is SSL.

**key.serializer**

Specifies how to turn the key objects that you provide with the `ProducerRecord` into bytes.

Valid value: `StringSerializer`.

**value.serializer**

Specifies how to turn value objects that you provide with the `ProducerRecord` into bytes.

Valid value: `ByteBufferSerializer`.

**ssl.truststore**

The truststore file in base64 format or the location of the truststore file in AWS Secrets Manager. This value isn't required if your truststore is trusted by Amazon certificate authorities (CA).

This field supports substitution templates. If you use Secrets Manager to store the credentials required to connect to your Kafka broker, you can use the `get_secret` SQL function to retrieve the value for this field. For more information about substitution templates, see the section called “Substitution templates” (p. 648). For more information about the `get_secret` SQL function, see the section called “get_secret(secretId, secretType, key, roleArn)” (p. 616). If the truststore is in the form of a file, use the `SecretBinary` parameter. If the truststore is in the form of a string, use the `SecretString` parameter.

The maximum size of this value is 65 KB.

**ssl.truststore.password**

The password for the truststore. This value is required only if you've created a password for the truststore.

**ssl.keystore**

The keystore file. This value is required when you specify SSL as the value for `security.protocol`.

This field supports substitution templates. Use Secrets Manager to store the credentials required to connect to your Kafka broker. To retrieve the value for this field, use the `get_secret` SQL function. For more information about substitution templates, see the section called “Substitution templates” (p. 648). For more information about the `get_secret` SQL function, see the section called “get_secret(secretId, secretType, key, roleArn)” (p. 616). Use the `SecretBinary` parameter.
ssl.keystore.password

The store password for the keystore file. This value is required if you specify a value for ssl.keystore.

The value of this field can be plaintext. This field also supports substitution templates. Use Secrets Manager to store the credentials required to connect to your Kafka broker. To retrieve the value for this field, use the get_secret SQL function. For more information about substitution templates, see the section called “Substitution templates” (p. 648). For more information about the get_secret SQL function, see the section called "get_secret(secretId, secretType, key, roleArn)" (p. 616). Use the SecretString parameter.

ssl.key.password

The password of the private key in your keystore file.

This field supports substitution templates. Use Secrets Manager to store the credentials required to connect to your Kafka broker. To retrieve the value for this field, use the get_secret SQL function. For more information about substitution templates, see the section called “Substitution templates” (p. 648). For more information about the get_secret SQL function, see the section called "get_secret(secretId, secretType, key, roleArn)" (p. 616). Use the SecretString parameter.

sasl.mechanism

The security mechanism used to connect to your Kafka broker. This value is required when you specify SASL_SSL for security.protocol.

Valid values: PLAIN, SCRAM-SHA-512, GSSAPI.

Note

SCRAM-SHA-512 is the only supported security mechanism in the cn-north-1, cn-northwest-1, us-gov-east-1, and us-gov-west-1 Regions.

sasl.plain.username

The username used to retrieve the secret string from Secrets Manager. This value is required when you specify SASL_SSL for security.protocol and PLAIN for sasl.mechanism.

sasl.plain.password

The password used to retrieve the secret string from Secrets Manager. This value is required when you specify SASL_SSL for security.protocol and PLAIN for sasl.mechanism.

sasl.scram.username

The username used to retrieve the secret string from Secrets Manager. This value is required when you specify SASL_SSL for security.protocol and SCRAM-SHA-512 for sasl.mechanism.

sasl.scram.password

The password used to retrieve the secret string from Secrets Manager. This value is required when you specify SASL_SSL for security.protocol and SCRAM-SHA-512 for sasl.mechanism.

sasl.kerberos.keytab

The keytab file for Kerberos authentication in Secrets Manager. This value is required when you specify SASL_SSL for security.protocol and GSSAPI for sasl.mechanism.

This field supports substitution templates. Use Secrets Manager to store the credentials required to connect to your Kafka broker. To retrieve the value for this field, use the get_secret SQL function. For more information about substitution templates, see the section called “Substitution templates” (p. 648). For more information about the get_secret SQL function, see the section called "get_secret(secretId, secretType, key, roleArn)" (p. 616). Use the SecretString parameter.
For more information about the `get_secret` SQL function, see the section called "get_secret(secretId, secretType, key, roleArn)" (p. 616).

Use the `SecretBinary` parameter.

**sasl.kerberos.service.name**

The Kerberos principal name under which Apache Kafka runs. This value is required when you specify SASL_SSL for `security.protocol` and GSSAPI for `sasl.mechanism`.

**sasl.kerberos.krb5.kdc**

The hostname of the key distribution center (KDC) to which your Apache Kafka producer client connects. This value is required when you specify SASL_SSL for `security.protocol` and GSSAPI for `sasl.mechanism`.

**sasl.kerberos.krb5.realm**

The realm to which your Apache Kafka producer client connects. This value is required when you specify SASL_SSL for `security.protocol` and GSSAPI for `sasl.mechanism`.

**sasl.kerberos.principal**

The unique Kerberos identity to which Kerberos can assign tickets to access Kerberos-aware services. This value is required when you specify SASL_SSL for `security.protocol` and GSSAPI for `sasl.mechanism`.

### Examples

The following JSON example defines an Apache Kafka action in an AWS IoT rule. The following example passes the `sourceIp()` (p. 635) inline function as a substitution template in the Kafka Action header.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "kafka": {
                    "destinationArn": "arn:aws:iot:region:123456789012:ruledestination/vpc/VPCDestinationARN",
                    "topic": "TopicName",
                    "clientProperties": {
                        "bootstrap.servers": "kafka.com:9092",
                        "security.protocol": "SASL_SSL",
                        "ssl.truststore": "${get_secret('kafka_client_truststore', 'SecretBinary', 'arn:aws:iam::123456789012:role/kafka-get-secret-role-name')}",
                        "ssl.truststore.password": "kafka password",
                        "sasl.mechanism": "GSSAPI",
                        "sasl.kerberos.service.name": "kafka",
                        "sasl.kerberos.krb5.kdc": "kerberosdns.com",
                        "sasl.kerberos.keytab": "${get_secret('kafka_keytab', 'SecretBinary', 'arn:aws:iam::123456789012:role/kafka-get-secret-role-name')}",
                        "sasl.kerberos.krb5.realm": "KERBEROSREALM",
                        "sasl.kerberos.principal": "kafka-keytab/kafka-keytab.com"
                    },
                    "headers": [
                        {
                            "key": "static_header_key",
                            "value": "static_header_value"
                        },
                        {
                            "key": "substitutable_header_key",
                            "value": "${value_from_payload}"
                        }
                    ]
                }
            }
        ]
    }
}
```
Important notes about your Kerberos setup

- Your key distribution center (KDC) must be resolvable through private Domain Name System (DNS) within your target VPC. One possible approach is to add the KDC DNS entry to a private hosted zone. For more information about this approach, see Working with private hosted zones.
- Each VPC must have DNS resolution enabled. For more information, see Using DNS with your VPC.
- Network interface security groups and instance-level security groups in the VPC destination must allow traffic from within your VPC on the following ports.
  - TCP traffic on the bootstrap broker listener port (often 9092, but must be within the 9000–9100 range)
  - TCP and UDP traffic on port 88 for the KDC
  - SCRAM-SHA-512 is the only supported security mechanism in the cn-north-1, cn-northwest-1, us-gov-east-1, and us-gov-west-1 Regions.

Virtual private cloud (VPC) destinations

The Apache Kafka rule action routes data to an Apache Kafka cluster in an Amazon Virtual Private Cloud (Amazon VPC). The VPC configuration used by the Apache Kafka rule action is automatically enabled when you specify the VPC destination for your rule action.

A VPC destination contains a list of subnets inside the VPC. The rules engine creates an elastic network interface in each subnet that you specify in this list. For more information about network interfaces, see Elastic network interfaces in the Amazon EC2 User Guide.

Requirements and considerations

- If you’re using a self-managed Apache Kafka cluster that will be accessed using a public endpoint across the internet:
  - Create a NAT gateway for instances in your subnets. The NAT gateway has a public IP address that can connect to the internet, which allows the rules engine to forward your messages to the public Kafka cluster.
  - Allocate an Elastic IP address with the elastic network interfaces (ENIs) that are created by the VPC destination. The security groups that you use must be configured to block incoming traffic.
    
    **Note**
    
    If the VPC destination is disabled and then re-enabled, you must re-associate the elastic IPs with the new ENIs.

- If a VPC topic rule destination doesn't receive any traffic for 30 days in a row, it will be disabled.
- If any resources used by the VPC destination change, the destination will be disabled and unable to be used.
- Some changes that can disable a VPC destination include: deleting the VPC, subnets, security groups, or the role used; modifying the role to no longer have the necessary permissions; and disabling the destination.
Pricing

For pricing purposes, a VPC rule action is metered in addition to the action that sends a message to a resource when the resource is in your VPC. For pricing information, see AWS IoT Core pricing.

Creating virtual private cloud (VPC) topic rule destinations

You create a virtual private cloud (VPC) destination by using the CreateTopicRuleDestination API or the AWS IoT Core console.

When you create a VPC destination, you must specify the following information.

vpcId

The unique ID of the VPC destination.

subnetIds

A list of subnets in which the rules engine creates elastic network interfaces. The rules engine allocates a single network interface for each subnet in the list.

securityGroups (optional)

A list of security groups to apply to the network interfaces.

roleArn

The Amazon Resource Name (ARN) of a role that has permission to create network interfaces on your behalf.

This ARN should have a policy attached to it that looks like the following example.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "ec2:CreateNetworkInterface",
                "ec2:DescribeNetworkInterfaces",
                "ec2:DescribeVpcs",
                "ec2:DeleteNetworkInterface",
                "ec2:DescribeSubnets",
                "ec2:DescribeVpcAttribute",
                "ec2:DescribeSecurityGroups"
            ],
            "Resource": "**"
        },
        {
            "Effect": "Allow",
            "Action": "ec2:CreateNetworkInterfacePermission",
            "Resource": "**",
            "Condition": {
                "StringEquals": {
                    "ec2:ResourceTag/VPCDestinationENI": "true"
                }
            }
        },
        {
            "Effect": "Allow",
            "Action": [
                "ec2:CreateTags"
            ],
            "Resource": "**"
        }
    ]
}
```
"Resource": "*",
"Condition": {
  "StringEquals": {
    "ec2:CreateAction": "CreateNetworkInterface",
    "aws:RequestTag/VPCDestinationENI": "true"
  }
}
]

Creating a VPC destination by using AWS CLI

The following example shows how to create a VPC destination by using AWS CLI.

```
aws --region regions iot create-topic-rule-destination --destination-configuration 'vpcConfiguration={subnetIds=["subnet-123456789101230456"],securityGroups=[],vpcId="vpc-123456789101230456",roleArn="arn:aws:iam::123456789012:role/role-name"}'
```

After you run this command, the VPC destination status will be IN_PROGRESS. After a few minutes, its status will change to either ERROR (if the command isn't successful) or ENABLED. When the destination status is ENABLED, it's ready to use.

You can use the following command to get the status of your VPC destination.

```
aws --region region iot get-topic-rule-destination --arn "VPCDestinationARN"
```

Creating a VPC destination by using the AWS IoT Core console

The following steps describe how to create a VPC destination by using the AWS IoT Core console.

1. Navigate to the AWS IoT Core console. In the left pane, on the Act tab, choose Destinations.
2. Enter values for the following fields.
   - VPC ID
   - Subnet IDs
   - Security Group
3. Select a role that has the permissions required to create network interfaces. The preceding example policy contains these permissions.

When the VPC destination status is ENABLED, it's ready to use.

CloudWatch alarms

The CloudWatch alarm (c.loudWatchAlarm) action changes the state of an Amazon CloudWatch alarm. You can specify the state change reason and value in this call.

Requirements

This rule action has the following requirements:
- An IAM role that AWS IoT can assume to perform the cloudwatch:SetAlarmState operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

- **alarmName**
  The CloudWatch alarm name.
  Supports [substitution templates (p. 648)](https://docs.aws.amazon.com/iot/latest/developerguide/cloudwatch-alarm-action.html): API and AWS CLI only

- **stateReason**
  Reason for the alarm change.

- **stateValue**
  The value of the alarm state. Valid values: OK, ALARM, INSUFFICIENT_DATA.

- **roleArn**
  The IAM role that allows access to the CloudWatch alarm. For more information, see [Requirements (p. 511)](https://docs.aws.amazon.com/iot/latest/developerguide/requirements.html).

**Examples**

The following JSON example defines a CloudWatch alarm action in an AWS IoT rule.

```
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIoTSqlVersion": "2016-03-23",
    "actions": [
      { "cloudwatchAlarm": {
          "alarmName": "IotAlarm",
          "stateReason": "Temperature stabilized.",
          "stateValue": "OK",
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_cw"
        }
      }
    ]
  }
}
```

**See also**

- [What is Amazon CloudWatch?](https://docs.aws.amazon.com/iot/latest/developerguide/what-is-cloudwatch.html) in the [Amazon CloudWatch User Guide](https://docs.aws.amazon.com/AmazonCloudWatch/latest/monitoring/)
- [Using Amazon CloudWatch alarms](https://docs.aws.amazon.com/iot/latest/developerguide/cloudwatch-alarms.html) in the [Amazon CloudWatch User Guide](https://docs.aws.amazon.com/AmazonCloudWatch/latest/monitoring/)
CloudWatch Logs

The CloudWatch Logs (cloudwatchLogs) action sends data to Amazon CloudWatch Logs. You can use batchMode to upload and timestamp multiple device log records in one message. You can also specify the log group where the action sends data.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the logs:CreateLogStream, logs:DescribeLogStreams, and logs:PutLogEvents operations. For more information, see Granting an AWS IoT rule the access it requires (p. 495). In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.
- If you use a customer managed AWS KMS key (KMS key) to encrypt log data in CloudWatch Logs, the service must have permission to use the KMS key on the caller's behalf. For more information, see Encrypt log data in CloudWatch Logs using AWS KMS in the Amazon CloudWatch Logs User Guide.

MQTT message format requirements for batchMode

If you use the CloudWatch Logs rule action with batchMode turned off, there are no MQTT message formatting requirements. (Note: the batchMode parameter's default value is false.) However, if you use the CloudWatch Logs rule action with batchMode turned on (the parameter value is true), MQTT messages containing device-side logs must be formatted to contain a timestamp and a message payload. **Note:** timestamp represents the time that the event occurred and is expressed as a number of milliseconds after January 1, 1970 00:00:00 UTC.

The following is an example of the publish format:

```json
[
  {"timestamp": 1673520691093, "message": "Test message 1"},
  {"timestamp": 1673520692879, "message": "Test message 2"},
  {"timestamp": 1673520693442, "message": "Test message 3"}
]
```

Depending on how the device-side logs are generated, they might need to be filtered and reformatted before they're sent to comply with this requirement. For more information, see MQTT Message payload.

Independent of the batchMode parameter, message contents must comply with AWS IoT message size limitations. For more information, see AWS IoT Core endpoints and quotas.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

logGroupName

The CloudWatch log group where the action sends data.

- Supports substitution templates (p. 648): API and AWS CLI only

roleArn

The IAM role that allows access to the CloudWatch log group. For more information, see Requirements (p. 513).

513
BatchMode

Indicates whether batches of log records will be extracted and uploaded into CloudWatch. Values include `true` or `false` (default). For more information, see Requirements (p. 513).

Supports substitution templates (p. 648): No

Examples

The following JSON example defines a CloudWatch Logs action in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "cloudwatchLogs": {
                    "logGroupName": "IotLogs",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_cw",
                    "batchMode": false
                }
            }
        ]
    }
}
```

See also

- What is Amazon CloudWatch Logs? in the Amazon CloudWatch Logs User Guide

CloudWatch metrics

The CloudWatch metric (cloudwatchMetric) action captures an Amazon CloudWatch metric. You can specify the metric namespace, name, value, unit, and timestamp.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the `cloudwatch:PutMetricData` operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

**metricName**

The CloudWatch metric name.

Supports substitution templates (p. 648): Yes
metricNamespace

The CloudWatch metric namespace name.

Supports substitution templates (p. 648): Yes

metricUnit

The metric unit supported by CloudWatch.

Supports substitution templates (p. 648): Yes

metricValue

A string that contains the CloudWatch metric value.

Supports substitution templates (p. 648): Yes

metricTimestamp

(Optional) A string that contains the timestamp, expressed in seconds in Unix epoch time. Defaults to the current Unix epoch time.

Supports substitution templates (p. 648): Yes

roleArn

The IAM role that allows access to the CloudWatch metric. For more information, see Requirements (p. 514).

Supports substitution templates (p. 648): No

Examples

The following JSON example defines a CloudWatch metric action in an AWS IoT rule.

```
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "cloudwatchMetric": {
          "metricName": "IotMetric",
          "metricNamespace": "IotNamespace",
          "metricUnit": "Count",
          "metricValue": "1",
          "metricTimestamp": "1456821314",
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_cw"
        }
      }
    ]
  }
}
```

The following JSON example defines a CloudWatch metric action with substitution templates in an AWS IoT rule.

```
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",

    "actions": [
      {
        "cloudwatchMetric": {
          "metricName": "IotMetric",
          "metricNamespace": "IotNamespace",
          "metricUnit": "Count",
          "metricValue": "1",
          "metricTimestamp": "1456821314",
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_cw"
        }
      }
    ]
  }
}
```
"actions": [
  {
    "cloudwatchMetric": {
      "metricName": "${topic()}",
      "metricNamespace": "${namespace}",
      "metricUnit": "${unit}",
      "metricValue": "${value}",
      "roleArn": "arn:aws:iam::123456789012:role/aws_iot_cw"
    }
  }
]

See also

- What is Amazon CloudWatch? in the Amazon CloudWatch User Guide
- Using Amazon CloudWatch metrics in the Amazon CloudWatch User Guide

DynamoDB

The DynamoDB (dynamoDB) action writes all or part of an MQTT message to an Amazon DynamoDB table.

You can follow a tutorial that shows you how to create and test a rule with a DynamoDB action. For more information, see Tutorial: Storing device data in a DynamoDB table (p. 214).

**Note**
This rule writes non-JSON data to DynamoDB as binary data. The DynamoDB console displays the data as base64-encoded text.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the dynamodb:PutItem operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

- If you use a customer managed AWS KMS key (KMS key) to encrypt data at rest in DynamoDB, the service must have permission to use the KMS key on the caller's behalf. For more information, see Customer Managed KMS key in the Amazon DynamoDB Getting Started Guide.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

**tableName**

The name of the DynamoDB table.

Supports substitution templates (p. 648): API and AWS CLI only

**hashKeyField**

The name of the hash key (also called the partition key).

Supports substitution templates (p. 648): API and AWS CLI only
hashKeyType  
(Optional) The data type of the hash key (also called the partition key). Valid values: STRING, NUMBER.
Supports substitution templates (p. 648): API and AWS CLI only

hashKeyValue  
The value of the hash key. Consider using a substitution template such as ${topic()} or ${timestamp()}.
Supports substitution templates (p. 648): Yes

rangeKeyField  
(Optional) The name of the range key (also called the sort key).
Supports substitution templates (p. 648): API and AWS CLI only

rangeKeyType  
(Optional) The data type of the range key (also called the sort key). Valid values: STRING, NUMBER.
Supports substitution templates (p. 648): API and AWS CLI only

rangeKeyValue  
(Optional) The value of the range key. Consider using a substitution template such as ${topic()} or ${timestamp()}.
Supports substitution templates (p. 648): Yes

payloadField  
(Optional) The name of the column where the payload is written. If you omit this value, the payload is written to the column named payload.
Supports substitution templates (p. 648): Yes

operation  
(Optional) The type of operation to be performed. Valid values: INSERT, UPDATE, DELETE.
Supports substitution templates (p. 648): Yes

roleARN  
The IAM role that allows access to the DynamoDB table. For more information, see Requirements (p. 516).
Supports substitution templates (p. 648): No

The data written to the DynamoDB table is the result from the SQL statement of the rule.

Examples

The following JSON example defines a DynamoDB action in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * AS message FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIoTSqVersion": "2016-03-23",
        "actions": [
            {
                "dynamoDB": {
```
DynamoDBv2

The DynamoDBv2 (dynamoDBv2) action writes all or part of an MQTT message to an Amazon DynamoDB table. Each attribute in the payload is written to a separate column in the DynamoDB database.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the dynamodb:PutItem operation. For more information, see [Granting an AWS IoT rule the access it requires](p. 495).
  
  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.
- The MQTT message payload must contain a root-level key that matches the table's primary partition key and a root-level key that matches the table's primary sort key, if one is defined.
- If you use a customer managed AWS KMS key (KMS key) to encrypt data at rest in DynamoDB, the service must have permission to use the KMS key on the caller's behalf. For more information, see [Customer Managed KMS key](p. 304).

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

putItem

An object that specifies the DynamoDB table to which the message data will be written. This object must contain the following information:

tableName

The name of the DynamoDB table.

Supports [substitution templates](p. 648): API and AWS CLI only

roleARN

The IAM role that allows access to the DynamoDB table. For more information, see [Requirements](p. 518).

Supports [substitution templates](p. 648): No

See also

- [What is Amazon DynamoDB?](p. 648) in the *Amazon DynamoDB Developer Guide*
- [Getting started with DynamoDB](p. 648) in the *Amazon DynamoDB Developer Guide*
- [Tutorial: Storing device data in a DynamoDB table](p. 214)
The data written to the DynamoDB table is the result from the SQL statement of the rule.

Examples

The following JSON example defines a DynamoDBv2 action in an AWS IoT rule.

```
{
    "topicRulePayload": {
        "sql": "SELECT * AS message FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "dynamoDBv2": {
                    "putItem": {
                        "tableName": "my_ddb_table"
                    },
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_dynamoDBv2"
                }
            }
        ]
    }
}
```

The following JSON example defines a DynamoDB action with substitution templates in an AWS IoT rule.

```
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2015-10-08",
        "actions": [
            {
                "dynamoDBv2": {
                    "putItem": {
                        "tableName": "${topic()}
                    },
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_dynamoDBv2"
                }
            }
        ]
    }
}
```

See also

- [What is Amazon DynamoDB?](#) in the *Amazon DynamoDB Developer Guide*
- [Getting started with DynamoDB](#) in the *Amazon DynamoDB Developer Guide*

Elasticsearch

The Elasticsearch (elasticsearch) action writes data from MQTT messages to an Amazon OpenSearch Service domain. You can then use tools like OpenSearch Dashboards to query and visualize data in OpenSearch Service.

Warning

The Elasticsearch action can only be used by existing rule actions. To create a new rule action or to update an existing rule action, use the OpenSearch rule action instead. For more information, see [OpenSearch](p. 563).
Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the es:ESHttpPut operation. For more information, see [Granting an AWS IoT rule the access it requires](p. 495).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

- If you use a customer managed AWS KMS key (KMS key) to encrypt data at rest in OpenSearch, the service must have permission to use the KMS key on the caller’s behalf. For more information, see [Encryption of data at rest for Amazon OpenSearch Service](p. 495) in the Amazon OpenSearch Service Developer Guide.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

endpoint

The endpoint of your service domain.

- Supports [substitution templates](p. 648): API and AWS CLI only

index

The index where you want to store your data.

- Supports [substitution templates](p. 648): Yes

type

The type of document you are storing.

- Supports [substitution templates](p. 648): Yes

id

The unique identifier for each document.

- Supports [substitution templates](p. 648): Yes

roleARN

The IAM role that allows access to the OpenSearch Service domain. For more information, see [Requirements](p. 520).

- Supports [substitution templates](p. 648): No

Examples

The following JSON example defines an Elasticsearch action in an AWS IoT rule and how you can specify the fields for the Elasticsearch action. For more information, see [ElasticsearchAction](p. 520).

```json
{
    "topicRulePayload": {
        "sql": "SELECT *, timestamp() as timestamp FROM 'iot/test'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "elasticsearch": {
                    "endpoint": "https://my-endpoint",
                    "index": "my-index",
                    "type": "my-type",
                    "id": "my-id",
                    "roleArn": "arn:aws:iam::1234567890:role/my-role"
                }
            }
        ]
    }
}
```
The following JSON example defines an Elasticsearch action with substitution templates in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "elasticsearch": {
                    "endpoint": "https://my-endpoint",
                    "index": "${topic()}",
                    "type": "${type}",
                    "id": "${newuuid()}",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_es"
                }
            }
        ]
    }
}
```

See also
- OpenSearch (p. 563)
- What is Amazon OpenSearch Service?

**HTTP**

The HTTPS (http) action sends data from an MQTT message to a web application or service.

**Requirements**

This rule action has the following requirements:

- You must confirm and enable HTTPS endpoints before the rules engine can use them. For more information, see Working with HTTP topic rule destinations (p. 523).

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

**url**

The HTTPS endpoint where the message is sent using the HTTP POST method. If you use an IP address in place of a hostname, it must be an IPv4 address. IPv6 addresses are not supported.

Supports substitution templates (p. 648): Yes
confirmationUrl

(Optional) If specified, AWS IoT uses the confirmation URL to create a matching topic rule destination. You must enable the topic rule destination before using it in an HTTP action. For more information, see Working with HTTP topic rule destinations (p. 523). If you use substitution templates, you must manually create topic rule destinations before the http action can be used. confirmationUrl must be a prefix of url.

The relationship between url and confirmationUrl is described by the following:

- If url is hardcoded and confirmationUrl is not provided, we implicitly treat the url field as the confirmationUrl. AWS IoT creates a topic rule destination for url.
- If url and confirmationUrl are hardcoded, url must begin with confirmationUrl. AWS IoT creates a topic rule destination for confirmationUrl.
- If url contains a substitution template, you must specify confirmationUrl and url must begin with confirmationUrl. If confirmationUrl contains substitution templates, you must manually create topic rule destinations before the http action can be used. If confirmationUrl does not contain substitution templates, AWS IoT creates a topic rule destination for confirmationUrl.

Supports substitution templates (p. 648): Yes

headers

(Optional) The list of headers to include in HTTP requests to the endpoint. Each header must contain the following information:

- key
  - The key of the header.
  - Supports substitution templates (p. 648): No
  - value
  - The value of the header.
  - Supports substitution templates (p. 648): Yes

Note

The default content type is application/json when the payload is in JSON format. Otherwise, it is application/octet-stream. You can overwrite it by specifying the exact content type in the header with the key content-type (case insensitive).

auth

(Optional) The authentication used by the rules engine to connect to the endpoint URL specified in the url argument. Currently, Signature Version 4 is the only supported authentication type. For more information, see HTTP Authorization.

Supports substitution templates (p. 648): No

Examples

The following JSON example defines an AWS IoT rule with an HTTP action.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
```
HTTP action retry logic

The AWS IoT rules engine retries the HTTP action according to these rules:

- The rules engine tries to send a message at least once.
- The rules engine retries at most twice. The maximum number of tries is three.
- The rules engine does not attempt a retry if:
  - The previous try provided a response larger than 16,384 bytes.
  - The downstream web service or application closes the TCP connection after the try.
  - The total time to complete a request with retries exceeded the request timeout limit.
  - The request returns an HTTP status code other than 429, 500-599.

**Note**

Standard data transfer costs apply to retries.

See also

- Working with HTTP topic rule destinations (p. 523)
- Route data directly from AWS IoT Core to your web services in the *Internet of Things on AWS* blog

Working with HTTP topic rule destinations

An HTTP topic rule destination is a web service to which the rules engine can route data from a topic rule. An AWS IoT Core resource describes the web service for AWS IoT. Topic rule destination resources can be shared by different rules.

Before AWS IoT Core can send data to another web service, it must confirm that it can access the service's endpoint.

HTTP topic rule destination overview

An HTTP topic rule destination refers to a web service that supports a confirmation URL and one or more data collection URLs. The HTTP topic rule destination resource contains the confirmation URL of your web service. When you configure an HTTP topic rule action, you specify the actual URL of the endpoint that should receive the data along with the web service's confirmation URL. After your destination is confirmed, the topic rule sends the result of the SQL statement to the HTTPS endpoint (and not to the confirmation URL).
An HTTP topic rule destination can be in one of the following states:

**ENABLED**

The destination has been confirmed and can be used by a rule action. A destination must be in the ENABLED state for it to be used in a rule. You can only enable a destination that's in DISABLED status.

**DISABLED**

The destination has been confirmed but it can't be used by a rule action. This is useful if you want to temporarily prevent traffic to your endpoint without having to go through the confirmation process again. You can only disable a destination that's in ENABLED status.

**IN_PROGRESS**

Confirmation of the destination is in progress.

**ERROR**

Destination confirmation timed out.

After an HTTP topic rule destination has been confirmed and enabled, it can be used with any rule in your account.

The following sections describe common actions on HTTP topic rule destinations.

### Creating and confirming HTTP topic rule destinations

You create an HTTP topic rule destination by calling the `CreateTopicRuleDestination` operation or by using the AWS IoT console.

After you create a destination, AWS IoT sends a confirmation request to the confirmation URL. The confirmation request has the following format:

```
HTTP POST {confirmationUrl}/?confirmationToken={confirmationToken}

Headers:
- x-amz-rules-engine-message-type: DestinationConfirmation
- x-amz-rules-engine-destination-arn:"arn:aws:iot:us-east-1:123456789012:ruledestination/http/7a280e37-b9c6-47a2-a751-0703693f46e4"
- Content-Type: application/json

Body:
{
    "arn":"arn:aws:iot:us-east-1:123456789012:ruledestination/http/7a280e37-b9c6-47a2-a751-0703693f46e4",
    "confirmationToken": "AYADeMXLrPzNY2wq3AKsFNNn-...NBJndA",
    "enableUrl": "https://iot.us-east-1.amazonaws.com/confirmdestination/AYADeMXLrPzNY2wq3AKsFNNn-...NBJndA",
    "messageType": "DestinationConfirmation"
}
```

The content of the confirmation request includes the following information:

- **arn**
  - The Amazon Resource Name (ARN) for the topic rule destination to confirm.
- **confirmationToken**
  - The confirmation token sent by AWS IoT Core. The token in the example is truncated. Your token will be longer. You'll need this token to confirm your destination with AWS IoT Core.
- **enableUrl**
  - The URL to which you browse to confirm a topic rule destination.
messageType

The type of message.

To complete the endpoint confirmation process, you must do one of the following after your confirmation URL receives the confirmation request.

- Call the `enableUrl` in the confirmation request, and then call `UpdateTopicRuleDestination` to set the topic rule's status to `ENABLED`.
- Call the `ConfirmTopicRuleDestination` operation and passing the `confirmationToken` from the confirmation request.
- Copy the `confirmationToken` and paste it into the destination's confirmation dialog in the AWS IoT console.

Sending a new confirmation request

To activate a new confirmation message for a destination, call `UpdateTopicRuleDestination` and set the topic rule destination's status to `IN_PROGRESS`.

Repeat the confirmation process after you send a new confirmation request.

Disabling and deleting a topic rule destination

To disable a destination, call `UpdateTopicRuleDestination` and set the topic rule destination's status to `DISABLED`. A topic rule in the DISABLED state can be enabled again without the need to send a new confirmation request.

To delete a topic rule destination, call `DeleteTopicRuleDestination`.

Certificate authorities supported by HTTPS endpoints in topic rule destinations

The following certificate authorities are supported by HTTPS endpoints in topic rule destinations. You can choose one of these supported certificate authorities. The signatures are for reference. Note that you can't use self-signed certificates because they won't work.

<table>
<thead>
<tr>
<th>Alias name</th>
<th>Certificate fingerprints</th>
</tr>
</thead>
</table>
| swisssignplatinumg2ca | MD5: C9:98:27:77:28:1E:3D:0E:15:3C:84:00:B8:85:03:E6  

Help us improve this topic
Let us know what you think.
Certificate fingerprints:
  SHA256:

Alias name: trustisfpzrootca
Certificate fingerprints:
  SHA256:

Alias name: quovadisrootca3g3
Certificate fingerprints:
  SHA256:

Alias name: secureglobalca
Certificate fingerprints:
  SHA256:

Alias name: chunghwaepkirootca
Certificate fingerprints:
  SHA256:

Alias name: verisignclass2g2ca
Certificate fingerprints:
  SHA256:

Alias name: szafirrootca2
Certificate fingerprints:
  SHA256:

Alias name: verisignclass2g2ca
Certificate fingerprints:
  SHA256:

Alias name: quovadisrootca1g3
Certificate fingerprints:
  SHA256:

Alias name: utndatacorpsgcca
Certificate fingerprints:
HTTP

Certificate fingerprints:

- Alias name: autoridaddecertificacionfirmaprofesionalcifa62634068

Certificate fingerprints:

- Alias name: securesignrootca11

Certificate fingerprints:

- Alias name: amazon-ca-g4-acm1

Certificate fingerprints:

- Alias name: isrgrootx1

Certificate fingerprints:

- Alias name: geotrustuniversalca2

Certificate fingerprints:

- Alias name: digicertglobalrootca

Certificate fingerprints:

- Alias name: staatderederlandenevrootca
Alias name: utnuserfirstclientauthemailca
Certificate fingerprints:

Alias name: actalisauthenticationrootca
Certificate fingerprints:

Alias name: amazonrootca4
Certificate fingerprints:

Alias name: amazonrootca3
Certificate fingerprints:

Alias name: amazonrootca2
Certificate fingerprints:

Alias name: amazonrootca1
Certificate fingerprints:

Alias name: affirmtrustpremium
Certificate fingerprints:

Alias name: keynectisrootca
Certificate fingerprints:

Alias name: equifaxsecureglobalebusinessca1
Certificate fingerprints:

Alias name: affirmtrustpreimumca
Certificate fingerprints:
Alias name: baltimorecodesigningca
Certificate fingerprints:
Alias name: gdcatrustauthr5root
Certificate fingerprints:
Alias name: certinomisrootca
Certificate fingerprints:
Alias name: verisignclass3publicprimarycertificationauthorityg5
Certificate fingerprints:
Alias name: verisignclass3publicprimarycertificationauthorityg4
Certificate fingerprints:
Alias name: verisignclass3publicprimarycertificationauthorityg3
Certificate fingerprints:
Alias name: swisssignsilver2ca
Certificate fingerprints:
Alias name: swisssignsilvercag2
Certificate fingerprints:
Alias name: atotrustedroot2011
Certificate fingerprints:
Alias name: comodoecccertificationauthority
Certificate fingerprints:

Alias name: securetrustca
Certificate fingerprints:

Alias name: soneraclass1ca
Certificate fingerprints:

Alias name: cadisigroot2
Certificate fingerprints:

Alias name: cadisigroot1
Certificate fingerprints:

Alias name: verisignclass3g5ca
Certificate fingerprints:

Alias name: utnuserfirsthardwareca
Certificate fingerprints:

Alias name: addtrustqualifiedca
Certificate fingerprints:

Alias name: verisignclass3g3ca
Certificate fingerprints:

Alias name: thawtepersonalfreemailca
Certificate fingerprints:

530
SHA256:

Alias name: buypassclass2rootca
Certificate fingerprints:
SHA256:

Alias name: opentrustrootca1
Certificate fingerprints:
SHA256:

Alias name: globalsignr2ca
Certificate fingerprints:
SHA256:

Alias name: buypassclass3rootca
Certificate fingerprints:
SHA256:

Alias name: ecacc
Certificate fingerprints:
SHA256:

Alias name: epkrootcertificationauthority
Certificate fingerprints:
SHA256:

Alias name: verisignclass1g2ca
Certificate fingerprints:
SHA256:

Alias name: certigna
Certificate fingerprints:
SHA256:

Alias name: camerfirmaglobalchambersignroot
Certificate fingerprints:
SHA256:

532
Alias name: cfcaevroot
Certificate fingerprints:

Alias name: soneraclass2rootca
Certificate fingerprints:

Alias name: certumtrustednetworkca
Certificate fingerprints:

Alias name: securitycommunicationrootca2
Certificate fingerprints:

Alias name: globalsignecrootcar5
Certificate fingerprints:

Alias name: globalsignecrootcar4
Certificate fingerprints:

Alias name: chambersofcommericeroot2008
Certificate fingerprints:

Alias name: pscprocert
Certificate fingerprints:

Alias name: thawteprimaryrootcag3
Certificate fingerprints:

Alias name: quovadisrootca
Certificate fingerprints:
  MD5:  27:DE:36:FE:72:B7:00:03:00:9D:F4:F0:1E:6C:04:24
SHA256:

Alias name: thawteprimaryrootcag2
Certificate fingerprints:
  SHA256:

Alias name: deprecateditsecca
Certificate fingerprints:
  SHA256:

Alias name: usertrustsacertificateauthority
Certificate fingerprints:
  SHA256:

Alias name: entrustrootcag2
Certificate fingerprints:
  SHA256:

Alias name: networksolutionscertificateauthority
Certificate fingerprints:
  SHA256:

Alias name: trustcenterclass4cail
Certificate fingerprints:
  SHA256:

Alias name: oistewisekeyglobalrootgaca
Certificate fingerprints:
  SHA256:

Alias name: verisignuniversalrootcertificateauthority
Certificate fingerprints:
  MD5: 8E:AD:B5:01:AA:4D:81:E4:8C:1D:D1:0E:14:00:95:19
  SHA256:

Alias name: ttelesecglobalrootclass3ca
Certificate fingerprints:
  SHA256:
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<tr>
<th>Alias name: starfieldservicesrootg2ca</th>
<th>Certificate fingerprints:</th>
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<tr>
<th>Alias name: addtrustexternalroot</th>
<th>Certificate fingerprints:</th>
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<tr>
<th>Alias name: turktrustelektroniksertifikahizmetsaglayicisih5</th>
<th>Certificate fingerprints:</th>
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<tr>
<th>Alias name: camerfirmachambersca</th>
<th>Certificate fingerprints:</th>
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<tr>
<th>Alias name: certsignrootca</th>
<th>Certificate fingerprints:</th>
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<tr>
<th>Alias name: verisignuniversalrootca</th>
<th>Certificate fingerprints:</th>
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<th>Alias name: geotrustuniversalca</th>
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<th>Alias name: luxtrustglobalroot2</th>
<th>Certificate fingerprints:</th>
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<th>Alias name: twcaglobalrootca</th>
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</table>
SHA256:

Alias name: tubitakkamusmslikcertifikatisurum1
Certificate fingerprints:
  SHA256:

Alias name: affirmtrustnetworkingca
Certificate fingerprints:
  SHA256:

Alias name: affirmtrustcommercialca
Certificate fingerprints:
  SHA256:

Alias name: godaddyrootcertificateauthorityg2
Certificate fingerprints:
  SHA256:

Alias name: starfieldrootg2ca
Certificate fingerprints:
  SHA256:

Alias name: dtrustrootclass3ca2ev2009
Certificate fingerprints:
  SHA256:

Alias name: buypassclass3ca
Certificate fingerprints:
  SHA256:

Alias name: verisignclass2g3ca
Certificate fingerprints:
  SHA256:
Alias name: quovadisrootca2g3
Certificate fingerprints:

Alias name: geotrustprimarycertificationauthorityg3
Certificate fingerprints:

Alias name: geotrustprimarycertificationauthorityg2
Certificate fingerprints:

Alias name: godaddyclass2ca
Certificate fingerprints:

Alias name: trustcoreca1
Certificate fingerprints:

Alias name: hellenicacademicandresearchinstitutionsseccrootca2015
Certificate fingerprints:

Alias name: utnuserfirstobjectca
Certificate fingerprints:

Alias name: ttelesecglobalrootclass3
Certificate fingerprints:

Alias name: ttelesecglobalrootclass2
Certificate fingerprints:

Alias name: addtrustclass1ca
Certificate fingerprints:

Alias name: amzninternalrootca
Certificate fingerprints:

Alias name: starfieldrootcertificateauthorityg2
Certificate fingerprints:

Alias name: camerfirmachambersignca
Certificate fingerprints:

Alias name: secomscrootca2
Certificate fingerprints:

Alias name: secomscrootca1
Certificate fingerprints:
  MD5: D6:A5:C3:ED:5D:DD:3E:00:C1:3D:87:92:1F:ID:3F:E4

Alias name: affirmtrustcommercial
Certificate fingerprints:

Alias name: affirmtrustnetworking
Certificate fingerprints:
Alias name: izenpecom
Certificate fingerprints:
  SHA256:

Alias name: amazon-ca-g4-legacy
Certificate fingerprints:
  SHA256:

Alias name: digicertassuredidrootg2
Certificate fingerprints:
  SHA256:

Alias name: comodoaaservicesroot
Certificate fingerprints:
  SHA256:

Alias name: entrustnetpremium2048secureserverca
Certificate fingerprints:
  SHA256:

Alias name: trustcorrootcertca2
Certificate fingerprints:
  SHA256:

Alias name: entrust2048ca
Certificate fingerprints:
  SHA256:

Alias name: trustcorrootcertc1al
Certificate fingerprints:
  SHA256:

Alias name: baltimorecybertrustroot
Certificate fingerprints:
  SHA256:

Alias name: eecertificationcentrerootca
Certificate fingerprints:

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<th>Alias name: dstacescax6</th>
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<th>Alias name: comodocertificationauthority</th>
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<tr>
<th>Alias name: equifaxsecurebusinessca1</th>
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<th>Alias name: sarcastic</th>
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<th>Alias name: globalchambersignroot2008</th>
<th>Certificate fingerprints:</th>
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<tr>
<th>Alias name: quovadisrootca3</th>
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<tr>
<th>Alias name: usertrustecccertificationauthority</th>
<th>Certificate fingerprints:</th>
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<tbody>
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<td>----------------------------------------------------------------------------------------------</td>
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Alias name: camerfirmachamberscommerceca
Certificate fingerprints:

Alias name: verisignclass3g2ca
Certificate fingerprints:

Alias name: deutschetelekomrootca2
Certificate fingerprints:

Alias name: certumca
Certificate fingerprints:

Alias name: cybertrustglobalroot
Certificate fingerprints:

Alias name: secomevrootca1
Certificate fingerprints:

Alias name: staatderhollandenrootcag3
Certificate fingerprints:

Alias name: staatderhollandenrootcag2
Certificate fingerprints:
Alien name: aolrootca2
Certificate fingerprints:
SHA256:

HTTP
Alias name: addtrustexterna1ca
Certificate fingerprints:
  MD5:  1D:35:54:04:85:78:00:3F:42:4D:BF:20:73:0A:3F
  SHA256:

Alias name: entrustrootcertificationauthority
Certificate fingerprints:
  MD5:  D6:A5:C3:ED:5D:DD:3E:00:C1:3D:87:92:1F:3:F4
  SHA256:

Alias name: verisignclass3ca
Certificate fingerprints:
  SHA256:

Alias name: globalsignrootcar3
Certificate fingerprints:
  SHA256:

Alias name: globalsignrootcar2
Certificate fingerprints:
  SHA256:

Alias name: verisignclass1ca
Certificate fingerprints:

Alias name: thawtepremiumserverca
Certificate fingerprints:
  SHA256:

Alias name: verisignstsca
Certificate fingerprints:
  SHA256:

Alias name: thawteprimaryrootca
Certificate fingerprints:
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<tr>
<th>Alias name: visaecommerceroot</th>
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<table>
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<tr>
<th>Alias name: digicertglobalroot3</th>
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<tr>
<th>Alias name: x rampglobalca</th>
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<th>Alias name: valicertclass2ca</th>
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<tr>
<th>Alias name: geotrustprimaryca</th>
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<tr>
<th>Alias name: netlockaranyclassgoldfotanusitvany</th>
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<tr>
<th>Alias name: geotrustglobalca</th>
<th>Certificate fingerprints:</th>
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<thead>
<tr>
<th>Alias name: oistewisekeyglobalrootgbc</th>
<th>Certificate fingerprints:</th>
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</thead>
<tbody>
<tr>
<td>-------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Alias name:</strong> certumtrustednetworkca2</td>
<td></td>
</tr>
<tr>
<td><strong>Certificate fingerprints:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Alias name:</strong> starfieldservicesrootcertificateauthorityg2</td>
<td></td>
</tr>
<tr>
<td><strong>Certificate fingerprints:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Alias name:</strong> comodorsacertificationauthority</td>
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<tr>
<td><strong>Certificate fingerprints:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Alias name:</strong> identrustpublicsectorrootca1</td>
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<tr>
<td><strong>Certificate fingerprints:</strong></td>
<td></td>
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<tr>
<td><strong>Alias name:</strong> certplusclass2primaryca</td>
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<tr>
<td><strong>Certificate fingerprints:</strong></td>
<td></td>
</tr>
<tr>
<td>MDS: 2B:9B:8E:E4:78:6C:1F:00:72:1A:CC:C1:77:79:DF:6A</td>
<td></td>
</tr>
<tr>
<td><strong>Alias name:</strong> accvraiz1</td>
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<tr>
<td><strong>Certificate fingerprints:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Alias name:</strong> digicerthighassuranceevrootca</td>
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</tr>
<tr>
<td><strong>Certificate fingerprints:</strong></td>
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</table>
Alias name: amzninternalinfoseccag3
Certificate fingerprints:
  SHA256:

Alias name: cia-crt-g3-02-ca
Certificate fingerprints:
  SHA256:

Alias name: entrustrooteccag2
Certificate fingerprints:
  SHA256:

Alias name: globalsignca
Certificate fingerprints:
  SHA256:

Alias name: trustcenterclass2caii
Certificate fingerprints:
  SHA256:

Alias name: camerfirmachambersofcommerceroot
Certificate fingerprints:
  SHA256:

Alias name: geotrustprimarycag3
Certificate fingerprints:
  SHA256:

Alias name: geotrustprimarycag2
Certificate fingerprints:
  SHA256:

Alias name: hongkongpostrootca1
Certificate fingerprints:
IoT Analytics

The AWS IoT Analytics (iotAnalytics) action sends data from an MQTT message to an AWS IoT Analytics channel.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the iotanalytics:BatchPutMessage operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

The policy attached to the role you specify should look like the following example.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iotanalytics:BatchPutMessage",
      "Resource": [
        "arn:aws:iotanalytics:us-west-2:account-id:channel/mychannel"
      ]
    }
  ]
}
```

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

batchMode

(Optional) Whether to process the action as a batch. The default value is false.

When batchMode is true and the rule SQL statement evaluates to an Array, each Array element is delivered as a separate message when passed by `BatchPutMessage` to the AWS IoT Analytics channel. The resulting array can't have more than 100 messages.

Supports substitution templates (p. 648): No
channelName

The name of the AWS IoT Analytics channel to which to write the data.

Supports substitution templates (p. 648): API and AWS CLI only

roleArn

The IAM role that allows access to the AWS IoT Analytics channel. For more information, see Requirements (p. 548).

Supports substitution templates (p. 648): No

Examples

The following JSON example defines an AWS IoT Analytics action in an AWS IoT rule.

```
{
   "topicRulePayload": {
      "sql": "SELECT * FROM 'some/topic'",
      "ruleDisabled": false,
      "awsIotSqlVersion": "2016-03-23",
      "actions": [
      {
         "iotAnalytics": {
            "channelName": "mychannel",
            "roleArn": "arn:aws:iam::123456789012:role/analyticsRole",
         }
      }]
   }
}
```

See also

- What is AWS IoT Analytics? in the AWS IoT Analytics User Guide
- The AWS IoT Analytics console also has a Quick start feature that lets you create a channel, data store, pipeline, and data store with one click. For more information, see AWS IoT Analytics console quickstart guide in the AWS IoT Analytics User Guide.
AWS IoT Events

The AWS IoT Events (iotEvents) action sends data from an MQTT message to an AWS IoT Events input.

**Important**
If the payload is sent to AWS IoT Core without the Input attribute Key, or if the key isn't in the same JSON path specified in the key, it will cause the IoT rule to fail with the error Failed to send message to Iot Events.

**Requirements**

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the iotevents:BatchPutMessage operation. For more information, see [Granting an AWS IoT rule the access it requires](p. 495).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

- **batchMode**
  - (Optional) Whether to process the event actions as a batch. The default value is false.
    - When batchMode is true and the rule SQL statement evaluates to an Array, each Array element is treated as a separate message when it's sent to AWS IoT Events by calling `BatchPutMessage`. The resulting array can't have more than 10 messages.
    - When batchMode is true, you can't specify a messageId.
  - Supports [substitution templates (p. 648)]: No

- **inputName**
  - The name of the AWS IoT Events input.
  - Supports [substitution templates (p. 648)]: API and AWS CLI only

- **messageId**
  - (Optional) Use this to verify that only one input (message) with a given messageId is processed by an AWS IoT Events detector. You can use the `${newuuid()}` substitution template to generate a unique ID for each request.
    - When batchMode is true, you can't specify a messageId--a new UUID value will be assigned.
  - Supports [substitution templates (p. 648)]: Yes

- **roleArn**
  - The IAM role that allows AWS IoT to send an input to an AWS IoT Events detector. For more information, see [Requirements (p. 550)].
  - Supports [substitution templates (p. 648)]: No

**Examples**

The following JSON example defines an IoT Events action in an AWS IoT rule.
See also

- What is AWS IoT Events? in the AWS IoT Events Developer Guide

AWS IoT SiteWise

The AWS IoT SiteWise (iotsiteWise) action sends data from an MQTT message to asset properties in AWS IoT SiteWise.

You can follow a tutorial that shows you how to ingest data from AWS IoT things. For more information, see the Ingesting data to AWS IoT SiteWise from AWS IoT things tutorial or the Ingesting data using AWS IoT Core rules section in the AWS IoT SiteWise User Guide.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the iotsiteWise:BatchPutAssetPropertySetValue operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

You can attach the following example trust policy to the role.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": "iotsiteWise:BatchPutAssetPropertySetValue",
         "Resource": "*"
      }
   ]
}
```

To improve security, you can specify an AWS IoT SiteWise asset hierarchy path in the Condition property. The following example is a trust policy that specifies an asset hierarchy path.

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": "iotsiteWise:BatchPutAssetPropertySetValue",
         "Resource": "*",
         "Condition": {
            "StringMatch": {
               "Field": "aws_iot_device_name",
               "Value": "my_device"
            }
         }
      }
   ]
}
```
When you send data to AWS IoT SiteWise with this action, your data must meet the requirements of the BatchPutAssetPropertyValue operation. For more information, see BatchPutAssetPropertyValue in the AWS IoT SiteWise API Reference.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

**putAssetPropertyValueEntries**

A list of asset property value entries that each contain the following information:

**propertyAlias**

(Optional) The property alias associated with your asset property. Specify either a propertyAlias or both an assetId and a propertyId. For more information about property aliases, see Mapping industrial data streams to asset properties in the AWS IoT SiteWise User Guide.

Supports substitution templates (p. 648): Yes

**assetId**

(Optional) The ID of the AWS IoT SiteWise asset. Specify either a propertyAlias or both an assetId and a propertyId.

Supports substitution templates (p. 648): Yes

**propertyId**

(Optional) The ID of the asset's property. Specify either a propertyAlias or both an assetId and a propertyId.

Supports substitution templates (p. 648): Yes

**entryId**

(Optional) A unique identifier for this entry. Define the entryId to better track which message caused an error if failure occurs. Defaults to a new UUID.

Supports substitution templates (p. 648): Yes

**propertyValues**

A list of property values to insert that each contain timestamp, quality, and value (TQV) in the following format:
timestamp

A timestamp structure that contains the following information:

- **timeInSeconds**
  A string that contains the time in seconds in Unix epoch time. If your message payload doesn't have a timestamp, you can use `timestamp()` (p. 640), which returns the current time in milliseconds. To convert that time to seconds, you can use the following substitution template: `floor(timestamp() / 1E3)`.

  Supports [substitution templates](p. 648): Yes

- **offsetInNanos** (Optional)
  A string that contains the nanosecond time offset from the time in seconds. If your message payload doesn't have a timestamp, you can use `timestamp()` (p. 640), which returns the current time in milliseconds. To calculate the nanosecond offset from that time, you can use the following substitution template: `floor(timestamp() / 1E3)`.

  Supports [substitution templates](p. 648): Yes

Regarding Unix epoch time, AWS IoT SiteWise accepts only entries that have a timestamp of up to 7 days in the past up to 5 minutes in the future.

quality

(Optional) A string that describes the quality of the value. Valid values: GOOD, BAD, UNCERTAIN.

Supports [substitution templates](p. 648): Yes

value

A value structure that contains one of the following value fields, depending on the asset property's data type:

- **booleanValue** (Optional)
  A string that contains the Boolean value of the value entry.

  Supports [substitution templates](p. 648): Yes

- **doubleValue** (Optional)
  A string that contains the double value of the value entry.

  Supports [substitution templates](p. 648): Yes

- **integerValue** (Optional)
  A string that contains the integer value of the value entry.

  Supports [substitution templates](p. 648): Yes

- **stringValue** (Optional)
  The string value of the value entry.

  Supports [substitution templates](p. 648): Yes

roleArn

The ARN of the IAM role that grants AWS IoT permission to send an asset property value to AWS IoT SiteWise. For more information, see [Requirements](p. 551).
Supports substitution templates (p. 648): No

Examples

The following JSON example defines a basic IoT SiteWise action in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "iotSiteWise": {
                    "putAssetPropertyValueEntries": [
                        {
                            "propertyAlias": "/some/property/alias",
                            "propertyValues": [
                                {
                                    "timestamp": {
                                        "timeInSeconds": "${my.payload.timeInSeconds}"},
                                    "value": {
                                        "integerValue": "${my.payload.value}"}
                                }
                            ]
                        },
                        "roleArn": "arn:aws:iam::123456789012:role/aws_iot_sitewise"
                    }
                }
            }
        ]
    }
}
```

The following JSON example defines an IoT SiteWise action in an AWS IoT rule. This example uses the topic as the property alias and the `timestamp()` function. For example, if you publish data to `/company/windfarm/3/turbine/7/rpm`, this action sends the data to the asset property with a property alias that's the same as the topic that you specified.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM '/company/windfarm/+/turbine/+/+'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "iotSiteWise": {
                    "putAssetPropertyValueEntries": [
                        {
                            "propertyAlias": "${topic()}",
                            "propertyValues": [
                                {
                                    "timestamp": {
                                        "timeInSeconds": "${floor(timestamp() / 1E3)}",
                                        "offsetInNanos": "${(timestamp() % 1E3) * 1E6}"
                                    },
                                    "value": {
                                        "doubleValue": "${my.payload.value}"}
                                }
                            ]
                        }
                    ]
                }
            }
        ]
    }
}
```
The Kinesis Data Firehose (firehose) action sends data from an MQTT message to an Amazon Kinesis Data Firehose stream.

**Requirements**

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the firehose:PutRecord operation. For more information, see [Granting an AWS IoT rule the access it requires (p. 495)](#).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

- If you use Kinesis Data Firehose to send data to an Amazon S3 bucket, and you use an AWS KMS customer managed AWS KMS key to encrypt data at rest in Amazon S3, Kinesis Data Firehose must have access to your bucket and permission to use the AWS KMS key on the caller's behalf. For more information, see [Grant Kinesis Data Firehose access to an Amazon S3 destination](#) in the *Amazon Kinesis Data Firehose Developer Guide*.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

**batchMode**

(Optional) Whether to deliver the Kinesis Data Firehose stream as a batch by using PutRecordBatch. The default value is false.

When batchMode is true and the rule's SQL statement evaluates to an Array, each Array element forms one record in the PutRecordBatch request. The resulting array can't have more than 500 records.

Supports [substitution templates (p. 648)](#): No

**deliveryStreamName**

The Kinesis Data Firehose stream to which to write the message data.

---

### See also

- [What is AWS IoT SiteWise?](#) in the *AWS IoT SiteWise User Guide*
- [Ingesting data using AWS IoT Core rules](#) in the *AWS IoT SiteWise User Guide*
- [Ingesting data to AWS IoT SiteWise from AWS IoT things](#) in the *AWS IoT SiteWise User Guide*
- [Troubleshooting an AWS IoT SiteWise rule action](#) in the *AWS IoT SiteWise User Guide*
Supports substitution templates (p. 648): API and AWS CLI only

separators

(Optional) A character separator that is used to separate records written to the Kinesis Data Firehose stream. If you omit this parameter, the stream uses no separator. Valid values: , (comma), \t (tab), \n (newline), \r\n (Windows newline).

Supports substitution templates (p. 648): No

roleArn

The IAM role that allows access to the Kinesis Data Firehose stream. For more information, see Requirements (p. 555).

Supports substitution templates (p. 648): No

Examples

The following JSON example defines a Kinesis Data Firehose action in an AWS IoT rule.

```
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "firehose": {
                    "deliveryStreamName": "my_firehose_stream",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_firehose"
                }
            }
        ]
    }
}
```

The following JSON example defines a Kinesis Data Firehose action with substitution templates in an AWS IoT rule.

```
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "firehose": {
                    "deliveryStreamName": "${topic()}",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_firehose"
                }
            }
        ]
    }
}
```

See also

- What is Amazon Kinesis Data Firehose? in the Amazon Kinesis Data Firehose Developer Guide
Kinesis Data Streams

The Kinesis Data Streams (`kinesis`) action writes data from an MQTT message to Amazon Kinesis Data Streams.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the `kinesis:PutRecord` operation. For more information, see [Granting an AWS IoT rule the access it requires (p. 495)](https://docs.aws.amazon.com/iot/latest/developerguide/security-configure-iot-rule-access.html).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

- If you use an AWS KMS customer-managed AWS KMS key (KMS key) to encrypt data at rest in Kinesis Data Streams, the service must have permission to use the AWS KMS key on the caller's behalf. For more information, see [Permissions to use user-generated AWS KMS keys](https://docs.aws.amazon.com/AmazonKinesis/latest/dev/amazon-kinesis-data-streams-developerguide.html) in the Amazon Kinesis Data Streams Developer Guide.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

stream

The Kinesis data stream to which to write data.

Supports [substitution templates (p. 648)](https://docs.aws.amazon.com/iot/latest/developerguide/security-configure-iot-rule-access.html): API and AWS CLI only

partitionKey

The partition key used to determine to which shard the data is written. The partition key is usually composed of an expression (for example, `${topic()}` or `${timestamp()}`).

Supports [substitution templates (p. 648)](https://docs.aws.amazon.com/iot/latest/developerguide/security-configure-iot-rule-access.html): Yes

roleArn

The ARN of the IAM role that grants AWS IoT permission to access the Kinesis data stream. For more information, see [Requirements (p. 557)](https://docs.aws.amazon.com/iot/latest/developerguide/security-configure-iot-rule-access.html).

Supports [substitution templates (p. 648)](https://docs.aws.amazon.com/iot/latest/developerguide/security-configure-iot-rule-access.html): No

Examples

The following JSON example defines a Kinesis Data Streams action in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIoSqlServerVersion": "2016-03-23",
    "actions": [
      {
        "kinesis": {
          "streamName": "my_kinesis_stream",
          "partitionKey": "${topic()}",
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_kinesis"
        }
      }
    ]
  }
}
```
The following JSON example defines a Kinesis action with substitution templates in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "kinesis": {
                    "streamName": "${topic()}",
                    "partitionKey": "${timestamp()}",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_kinesis"
                }
            }
        ]
    }
}
```

See also

- [What is Amazon Kinesis Data Streams?](#) in the [Amazon Kinesis Data Streams Developer Guide](#)

**Lambda**

A Lambda (lambda) action invokes an AWS Lambda function, passing in an MQTT message. AWS IoT invokes Lambda functions asynchronously.

You can follow a tutorial that shows you how to create and test a rule with a Lambda action. For more information, see [Tutorial: Formatting a notification by using an AWS Lambda function](#) (p. 220).

**Requirements**

This rule action has the following requirements:

- For AWS IoT to invoke a Lambda function, you must configure a policy that grants the `lambda:InvokeFunction` permission to AWS IoT. You can only invoke a Lambda function defined in the same AWS Region where your Lambda policy exists. Lambda functions use resource-based policies, so you must attach the policy to the Lambda function itself.

Use the following AWS CLI command to attach a policy that grants the `lambda:InvokeFunction` permission.

```bash
aws lambda add-permission --function-name function_name --region region --principal iot.amazonaws.com --source-arn arn:aws:iot:region:account-id:rule/rule_name --source-account account-id --statement-id unique_id --action "lambda:InvokeFunction"
```

The `add-permission` command expects the following parameters:

- **--function-name**
  Name of the Lambda function. You add a new permission to update the function's resource policy.
- **--region**
  The AWS Region of the function.
--principal
The principal that gets the permission. This should be iot.amazonaws.com to allow AWS IoT permission to call the Lambda function.

--source-arn
The ARN of the rule. You can use the get-topic-rule AWS CLI command to get the ARN of a rule.

--source-account
The AWS account where the rule is defined.

--statement-id
A unique statement identifier.

--action
The Lambda action that you want to allow in this statement. To allow AWS IoT to invoke a Lambda function, specify lambda:InvokeFunction.

Important
If you add a permission for an AWS IoT principal without providing the source-arn or source-account, any AWS account that creates a rule with your Lambda action can activate rules to invoke your Lambda function from AWS IoT.

For more information, see AWS Lambda permissions.

• If you use an AWS KMS customer managed AWS KMS key to encrypt data at rest in Lambda, the service must have permission to use the AWS KMS key on the caller’s behalf. For more information, see Encryption at rest in the AWS Lambda Developer Guide.

Parameters
When you create an AWS IoT rule with this action, you must specify the following information:

functionArn
The ARN of the Lambda function to invoke. AWS IoT must have permission to invoke the function. For more information, see Requirements (p. 558).

If you don’t specify a version or alias for your Lambda function, the most recent version of the function is shut down. You can specify a version or alias if you want to shut down a specific version of your Lambda function. To specify a version or alias, append the version or alias to the ARN of the Lambda function.

```
```

For more information about versioning and aliases, and see AWS Lambda function versioning and aliases.

Supports substitution templates (p. 648): API and AWS CLI only

Examples
The following JSON example defines a Lambda action in an AWS IoT rule.

```json
{
    "topicRulePayload": {
```
The following JSON example defines a Lambda action with substitution templates in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "lambda": {
                    "functionArn": "arn:aws:lambda:us-east-2:123456789012:function:myLambdaFunction"
                }
            }
        ]
    }
}
```

See also

- What is AWS Lambda? in the AWS Lambda Developer Guide
- Tutorial: Formatting a notification by using an AWS Lambda function (p. 220)

**Location**

The Location (location) action sends your geographical location data to Amazon Location Service.

**Requirements**

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the `geo:BatchUpdateDevicePosition` operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

**deviceId**

The unique ID of the device providing the location data. For more information, see DeviceId from the Amazon Location Service API Reference.
Supports substitution templates (p. 648): Yes

**latitude**

A string that evaluates to a double value that represents the latitude of the device's location.

Supports substitution templates (p. 648): Yes

**longitude**

A string that evaluates to a double value that represents the longitude of the device's location.

Supports substitution templates (p. 648): Yes

**roleArn**

The IAM role that allows access to the Amazon Location Service domain. For more information, see Requirements (p. 560).

**timestamp**

The time that the location data was sampled. The default value is the time that the MQTT message was processed.

The timestamp value consists of the following two values:

- **value**: An expression that returns a long epoch time value. You can use the the section called “time_to_epoch(String, String)” (p. 639) function to create a valid timestamp from a date or time value passed in the message payload. Supports substitution templates (p. 648): Yes.

- **unit**: (Optional) The precision of the timestamp value that results from the expression described in value. Valid values: SECONDS | MILLISECONDS | MICROSECONDS | NANOSECONDS. The default is MILLISECONDS. Supports substitution templates (p. 648): API and AWS CLI only.

**trackerName**

The name of the tracker resource in Amazon Location in which the location is updated. For more information, see Tracker from the Amazon Location Service Developer Guide.

Supports substitution templates (p. 648): API and AWS CLI only

### Examples

The following JSON example defines a Location action in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIoTSqlVersion": "2016-03-23",
        "actions": [
            {
                "location": {
                    "roleArn": "arn:aws:iam::123454962127:role/service-role/ExampleRole",
                    "trackerName": "MyTracker",
                    "deviceId": "001",
                    "sampleTime": {
                        "value": "${timestamp()}",
                        "unit": "MILLISECONDS"
                    },
                    "latitude": "-12.3456",
                    "longitude": "65.4321"
                }
            }
        ]
    }
}
```
The following JSON example defines a Location action with substitution templates in an AWS IoT rule.

```
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "location": {
          "roleArn": "arn:aws:iam::123456789012:role/service-role/ExampleRole",
          "trackerName": "${TrackerName}",
          "deviceId": "${DeviceID}",
          "timestamp": {
            "value": "${timestamp()}",
            "unit": "MILLISECONDS"
          },
          "latitude": "${get(position, 0)}",
          "longitude": "${get(position, 1)}"
        }
      }
    ]
  }
}
```

The following MQTT payload example shows how substitution templates in the preceding example accesses data. You can use the `get-device-position-history` CLI command to verify that the MQTT payload data is delivered in your location tracker.

```
{
  "TrackerName": "mytracker",
  "DeviceID": "001",
  "position": [
    -12.3456,
    65.4321
  ]
}
```

```
aws location get-device-position-history --device-id 001 --tracker-name mytracker
```

```
{
  "DevicePositions": [
    {
      "DeviceId": "001",
      "Position": [
        -12.3456,
        65.4321
      ],
      "ReceivedTime": "2022-11-11T01:31:54.464000+00:00",
      "SampleTime": "2022-11-11T01:31:54.308000+00:00"
    }
  ]
}
```

See also

- [What is Amazon Location Service?](https://aws.amazon.com/location) in the Amazon Location Service Developer Guide.
OpenSearch

The OpenSearch (openSearch) action writes data from MQTT messages to an Amazon OpenSearch Service domain. You can then use tools like OpenSearch Dashboards to query and visualize data in OpenSearch Service.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the es:ESHttpPut operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).
  - In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.
- If you use a customer managed AWS KMS key to encrypt data at rest in OpenSearch Service, the service must have permission to use the KMS key on the caller’s behalf. For more information, see Encryption of data at rest for Amazon OpenSearch Service in the Amazon OpenSearch Service Developer Guide.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

- endpoint
  
  The endpoint of your Amazon OpenSearch Service domain.
  
  Supports substitution templates (p. 648): API and AWS CLI only

- index
  
  The OpenSearch index where you want to store your data.
  
  Supports substitution templates (p. 648): Yes

- type
  
  The type of document you are storing.
  
  Supports substitution templates (p. 648): Yes

- id
  
  The unique identifier for each document.
  
  Supports substitution templates (p. 648): Yes

- roleARN
  
  The IAM role that allows access to the OpenSearch Service domain. For more information, see Requirements (p. 563).
  
  Supports substitution templates (p. 648): No

Limitations

The OpenSearch (openSearch) action cannot be used to deliver data to VPC Elasticsearch clusters.
Examples

The following JSON example defines an OpenSearch action in an AWS IoT rule and how you can specify the fields for the OpenSearch action. For more information, see OpenSearchAction.

```json
{
    "topicRulePayload": {
        "sql": "SELECT *, timestamp() as timestamp FROM 'iot/test'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "openSearch": {
                    "endpoint": "https://my-endpoint",
                    "index": "my-index",
                    "type": "my-type",
                    "id": "${newuuid()}",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_os"
                }
            }
        ]
    }
}
```

The following JSON example defines an OpenSearch action with substitution templates in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "openSearch": {
                    "endpoint": "https://my-endpoint",
                    "index": "${topic()}",
                    "type": "${type}",
                    "id": "${newuuid()}",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_os"
                }
            }
        ]
    }
}
```

See also

What is Amazon OpenSearch Service? in the Amazon OpenSearch Service Developer Guide

Republish

The republish (republish) action republishes an MQTT message to another MQTT topic.

Requirements

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the iot:Publish operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).
In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

- **headers**
  MQTT Version 5.0 headers information.
  For more information, see [RepublishAction](#) and [MqttHeaders](#) in the [AWS API Reference](#).

- **topic**
  The MQTT topic to which to republish the message.
  To republish to a reserved topic, which begins with $, use $$ instead. For example, to republish to the device shadow topic $aws/things/MyThing/shadow/update, specify the topic as $$aws/things/MyThing/shadow/update.

  **Note**
  Republishing to [reserved job topics](#) is not supported.
  AWS IoT Device Defender reserve topics don't support HTTP publish.

  Supports [substitution templates](#): Yes

- **qos**
  (Optional) The Quality of Service (QoS) level to use when republishing messages. Valid values: 0, 1. The default value is 0. For more information about MQTT QoS, see [MQTT](#).

  Supports [substitution templates](#): No

- **roleArn**
  The IAM role that allows AWS IoT to publish to the MQTT topic. For more information, see [Restrictions](#).

  Supports [substitution templates](#): No

**Examples**

The following JSON example defines a republish action in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "republish": {
          "topic": "another/topic",
          "qos": 1,
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_republish"
        }
      }
    ]
  }
}
```
The following JSON example defines a republish action with substitution templates in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "republish": {
                    "topic": "${topic()}/republish",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_republish"
                }
            }
        ]
    }
}
```

The following JSON example defines a republish action with headers in an AWS IoT rule.

```json
{
    "topicRulePayload": {
        "sql": "SELECT * FROM 'some/topic'",
        "ruleDisabled": false,
        "awsIotSqlVersion": "2016-03-23",
        "actions": [
            {
                "republish": {
                    "topic": "${topic()}/republish",
                    "roleArn": "arn:aws:iam::123456789012:role/aws_iot_republish",
                    "headers": {
                        "payloadFormatIndicator": "UTF8_DATA",
                        "contentType": "rule/contentType",
                        "correlationData": "cnVsZSBjb3JyZWxhdGlvdG9yaW8gY2FsaXR5",
                        "userProperties": [
                            {
                                "key": "ruleKey1",
                                "value": "ruleValue1"
                            },
                            {
                                "key": "ruleKey2",
                                "value": "ruleValue2"
                            }
                        ]
                    }
                }
            }
        ]
    }
}
```

**Note**
The original source IP won't be passed through [Republish action](p. 564).

---

**S3**

The S3 (s3) action writes the data from an MQTT message to an Amazon Simple Storage Service (Amazon S3) bucket.

**Requirements**

This rule action has the following requirements:
• An IAM role that AWS IoT can assume to perform the s3:PutObject operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.
• If you use an AWS KMS customermanaged AWS KMS key to encrypt data at rest in Amazon S3, the service must have permission to use the AWS KMS key on the caller's behalf. For more information, see AWS managed AWS KMS keys and customer managed AWS KMS keys in the Amazon Simple Storage Service Developer Guide.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

bucket

The Amazon S3 bucket to which to write data.

Supports substitution templates (p. 648): API and AWS CLI only
cannedacl

(Optional) The Amazon S3 canned ACL that controls access to the object identified by the object key. For more information, including allowed values, see Canned ACL.

Supports substitution templates (p. 648): No
cannedacl

key

The path to the file where the data is written.

Consider an example where this parameter is ${topic()}/${timestamp()} and the rule receives a message where the topic is some/topic. If the current timestamp is 1460685389, then this action writes the data to a file called 1460685389 in the some/topic folder of the S3 bucket.

Note

If you use a static key, AWS IoT overwrites a single file each time the rule invokes. We recommend that you use the message timestamp or another unique message identifier so that a new file is saved in Amazon S3 for each message received.

Supports substitution templates (p. 648): Yes
roleArn

The IAM role that allows access to the Amazon S3 bucket. For more information, see Requirements (p. 566).

Supports substitution templates (p. 648): No

Examples

The following JSON example defines an S3 action in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIoTSqlVersion": "2016-03-23",
    "actions": [
      {
        "s3": {
```

See also

- [What is Amazon S3?](#) in the [Amazon Simple Storage Service User Guide](#)

**Salesforce IoT**

The Salesforce IoT ([salesforce](#)) action sends data from the MQTT message that triggered the rule to a Salesforce IoT input stream.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

- `url`

  The URL exposed by the Salesforce IoT input stream. The URL is available from the Salesforce IoT platform when you create an input stream. For more information, see the Salesforce IoT documentation.

  Supports substitution templates ([p. 648](#)):

- `token`

  The token used to authenticate access to the specified Salesforce IoT input stream. The token is available from the Salesforce IoT platform when you create an input stream. For more information, see the Salesforce IoT documentation.

  Supports substitution templates ([p. 648](#)):

**Examples**

The following JSON example defines a Salesforce IoT action in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      { "salesforce": {
        "token": "ABCDEF123456789abcdefghi123456789",
        "url": "https://ingestion-cluster-id.my-env.sfdcnow.com/streams/stream-id/connection-id/my-event"
      } }
    ]
  }
}
```
The SNS (sns) action sends the data from an MQTT message as an Amazon Simple Notification Service (Amazon SNS) push notification.

You can follow a tutorial that shows you how to create and test a rule with an SNS action. For more information, see Tutorial: Sending an Amazon SNS notification (p. 207).

**Note**
The SNS action doesn't support Amazon SNS FIFO (First-In-First-Out) topics. Because the rules engine is a fully distributed service, there is no guarantee of message order when the SNS action is invoked.

**Requirements**
This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the sns:Publish operation. For more information, see Granting an AWS IoT rule the access it requires (p. 495).
  
  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

- If you use an AWS KMS customer managed-managed AWS KMS key to encrypt data at rest in Amazon SNS, the service must have permission to use the AWS KMS key on the caller's behalf. For more information, see Key management in the Amazon Simple Notification Service Developer Guide.

**Parameters**
When you create an AWS IoT rule with this action, you must specify the following information:

- **targetArn**
  
  The SNS topic or individual device to which the push notification is sent.

  Supports substitution templates (p. 648): API and AWS CLI only

- **messageFormat**
  
  (Optional) The message format. Amazon SNS uses this setting to determine if the payload should be parsed and if relevant platform-specific parts of the payload should be extracted. Valid values: JSON, RAW. Defaults to RAW.

  Supports substitution templates (p. 648): No

- **roleArn**
  
  The IAM role that allows access to SNS. For more information, see Requirements (p. 569).

  Supports substitution templates (p. 648): No

**Examples**
The following JSON example defines an SNS action in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
```
The following JSON example defines an SNS action with substitution templates in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "sns": {
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_sns"
        }
      }
    ]
  }
}
```

See also

- [Tutorial: Sending an Amazon SNS notification](https://docs.aws.amazon.com/iot/latest/developerguide/awsiot-sns-mqtt.html) (p. 207)

**SQS**

The SQS (sqs) action sends data from an MQTT message to an Amazon Simple Queue Service (Amazon SQS) queue.

**Note**
The SQS action doesn't support Amazon SQS FIFO (First-In-First-Out) queues. Because the rules engine is a fully distributed service, there is no guarantee of message order when the SQS action is triggered.

**Requirements**

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the sqs:SendMessage operation. For more information, see [Granting an AWS IoT rule the access it requires](https://docs.aws.amazon.com/iot/latest/developerguide/awsiot-sqs-mqtt.html) (p. 495).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

- If you use an AWS KMS customer managed AWS KMS key to encrypt data at rest in Amazon SQS, the service must have permission to use the AWS KMS key on the caller's behalf. For more information, see [Key management](https://docs.aws.amazon.com/iot/latest/developerguide/awsiot-sqs-mqtt.html) in the *Amazon Simple Queue Service Developer Guide*.
Parameters

When you create an AWS IoT rule with this action, you must specify the following information:

queueUrl

The URL of the Amazon SQS queue to which to write the data.

Supports substitution templates (p. 648): API and AWS CLI only

useBase64

Set this parameter to true to configure the rule action to base64-encode the message data before it writes the data to the Amazon SQS queue. Defaults to false.

Supports substitution templates (p. 648): No

roleArn

The IAM role that allows access to the Amazon SQS queue. For more information, see Requirements (p. 570).

Supports substitution templates (p. 648): No

Examples

The following JSON example defines an SQS action in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "sqs": {
          "queueUrl": "https://sqs.us-east-2.amazonaws.com/123456789012/my_sqs_queue",
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_sqs"
        }
      }
    ]
  }
}
```

The following JSON example defines an SQS action with substitution templates in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "sqs": {
          "queueUrl": "https://sqs.us-east-2.amazonaws.com/123456789012/${topic()}",
          "useBase64": true,
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_sqs"
        }
      }
    ]
  }
}
```
See also

- [What is Amazon Simple Queue Service?](#) in the *Amazon Simple Queue Service Developer Guide*

**Step Functions**

The Step Functions (`stepFunctions`) action starts an AWS Step Functions state machine.

**Requirements**

This rule action has the following requirements:

- An IAM role that AWS IoT can assume to perform the `states:StartExecution` operation. For more information, see [Granting an AWS IoT rule the access it requires](#).

  In the AWS IoT console, you can choose or create a role to allow AWS IoT to perform this rule action.

**Parameters**

When you create an AWS IoT rule with this action, you must specify the following information:

- **stateMachineName**

  The name of the Step Functions state machine to start.

  Supports [substitution templates](#): API and AWS CLI only

- **executionNamePrefix**

  (Optional) The name given to the state machine execution consists of this prefix followed by a UUID. Step Functions creates a unique name for each state machine execution if one is not provided.

  Supports [substitution templates](#): Yes

- **roleArn**

  The ARN of the role that grants AWS IoT permission to start the state machine. For more information, see [Requirements](#).

  Supports [substitution templates](#): No

**Examples**

The following JSON example defines a Step Functions action in an AWS IoT rule.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIoTSqlVersion": "2016-03-23",
    "actions": [
      {
        "stepFunctions": {
          "stateMachineName": "myStateMachine",
```
"executionNamePrefix": "myExecution",
"roleArn": "arn:aws:iam::123456789012:role/aws_iot_step_functions"

See also

• What is AWS Step Functions? in the AWS Step Functions Developer Guide

Timestream

The Timestream rule action writes attributes (measures) from an MQTT message into an Amazon Timestream table. For more information about Amazon Timestream, see What Is Amazon Timestream?

Note

Amazon Timestream is not available in all AWS Regions. If Amazon Timestream is not available in your Region, it won't appear in the list of rule actions.

The attributes that this rule stores in the Timestream database are those that result from the rule's query statement. The value of each attribute in the query statement's result is parsed to infer its data type (as in a the section called "DynamoDBv2" (p. 518) action). Each attribute's value is written to its own record in the Timestream table. To specify or change an attribute's data type, use the cast() (p. 604) function in the query statement. For more information about the contents of each Timestream record, see the section called “Timestream record content” (p. 574).

Note

With SQL V2 (2016-03-23), numeric values that are whole numbers, such as 10.0, are converted their Integer representation (10). Explicitly casting them to a Decimal value, such as by using the cast() (p. 604) function, does not prevent this behavior—the result is still an Integer value. This can cause type mismatch errors that prevent data from being recorded in the Timestream database. To process whole number numeric values as Decimal values, use SQL V1 (2015-10-08) for the rule query statement.

Note

The maximum number of values that a Timestream rule action can write into an Amazon Timestream table is 100. For more information, see Amazon Timestream Quota's Reference.

Requirements

This rule action has the following requirements:

• An IAM role that AWS IoT can assume to perform the timestream:DescribeEndpoints and timestream:WriteRecords operations. For more information, see Granting an AWS IoT rule the access it requires (p. 495).

In the AWS IoT console, you can choose, update, or create a role to allow AWS IoT to perform this rule action.

• If you use a customer- AWS KMS to encrypt data at rest in Timestream, the service must have permission to use the AWS KMS key on the caller's behalf. For more information, see How AWS services use AWS KMS.

Parameters

When you create an AWS IoT rule with this action, you must specify the following information:
databaseName

The name of an Amazon Timestream database that has the table to receive the records this action creates. See also tableName.

Supports substitution templates (p. 648): API and AWS CLI only

dimensions

Metadata attributes of the time series that are written in each measure record. For example, the name and Availability Zone of an EC2 instance or the name of the manufacturer of a wind turbine are dimensions.

name

The metadata dimension name. This is the name of the column in the database table record.

Dimensions can't be named: measure_name, measure_value, or time. These names are reserved. Dimension names can't start with ts_ or measure_value and they can't contain the colon (:) character.

Supports substitution templates (p. 648): No

value

The value to write in this column of the database record.

Supports substitution templates (p. 648): Yes

roleArn

The Amazon Resource Name (ARN) of the role that grants AWS IoT permission to write to the Timestream database table. For more information, see Requirements (p. 573).

Supports substitution templates (p. 648): No

tableName

The name of the database table into which to write the measure records. See also databaseName.

Supports substitution templates (p. 648): API and AWS CLI only

timestamp

The value to use for the entry's timestamp. If blank, the time that the entry was processed is used.

unit

The precision of the timestamp value that results from the expression described in value.

Valid values: SECONDS | MILLISECONDS | MICROSECONDS | NANOSECONDS. The default is MILLISECONDS.

value

An expression that returns a long epoch time value.

You can use the the section called “time_to_epoch(String, String)” (p. 639) function to create a valid timestamp from a date or time value passed in the message payload.

Timestream record content

The data written to the Amazon Timestream table by this action include a timestamp, metadata from the Timestream rule action, and the result of the rule's query statement.

For each attribute (measure) in the result of the query statement, this rule action writes a record to the specified Timestream table with these columns.
<table>
<thead>
<tr>
<th>Column name</th>
<th>Attribute type</th>
<th>Value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>dimension-name</td>
<td>DIMENSION</td>
<td>The value specified in the Timestream rule action entry.</td>
<td>Each Dimension specified in the rule action entry creates a column in the Timestream database with the dimension's name.</td>
</tr>
<tr>
<td>measure_name</td>
<td>MEASURE_NAME</td>
<td>The attribute's name</td>
<td>The name of the attribute in the result of the query statement whose value is specified in the measure_value::datatype column.</td>
</tr>
<tr>
<td>measure_value::datatype</td>
<td>MEASURE_VALUE</td>
<td>The value of the attribute in the result of the query statement. The attribute's name is in the measure_name column.</td>
<td>The value is interpreted* and cast as the most suitable match of: bigint, boolean, double, or varchar. Amazon Timestream creates a separate column for each data type. The value in the message can be cast to another data type by using the cast() function in the rule's query statement.</td>
</tr>
<tr>
<td>time</td>
<td>TIMESTAMP</td>
<td>The date and time of the record in the database.</td>
<td>This value is assigned by rules engine or the timestamp property, if it is defined.</td>
</tr>
</tbody>
</table>

* The attribute value read from the message payload is interpreted as follows. See the *the section called "Examples" (p. 575)* for an illustration of each of these cases.

- An unquoted value of true or false is interpreted as a boolean type.
- A decimal numeric is interpreted as a double type.
- A numeric value without a decimal point is interpreted as a bigint type.
- A quoted string is interpreted as a varchar type.
- Objects and array values are converted to JSON strings and stored as a varchar type.

**Examples**

The following JSON example defines a Timestream rule action with a substitution template in an AWS IoT rule.

```json
{
```
"topicRulePayload": {
  "sql": "SELECT * FROM 'iot/topic'",
  "ruleDisabled": false,
  "awsIotSqlVersion": "2016-03-23",
  "actions": [
    {
      "timestream": {
        "roleArn": "arn:aws:iam::123456789012:role/aws_iot_timestream",
        "tableName": "devices_metrics",
        "dimensions": [
          {
            "name": "device_id",
            "value": "${clientId()}"
          },
          {
            "name": "device_firmware_sku",
            "value": "My Static Metadata"
          }
        ],
        "databaseName": "record_devices"
      }
    }
  ]
}

Using the Timestream topic rule action defined in the previous example with the following message payload results in the Amazon Timestream records written in the table that follows.

```
{
  "boolean_value": true,
  "integer_value": 123456789012,
  "double_value": 123.456789012,
  "string_value": "String value",
  "boolean_value_as_string": "true",
  "integer_value_as_string": "123456789012",
  "double_value_as_string": "123.456789012",
  "array_of_integers": [23,36,56,72],
  "array of strings": ["red", "green","blue"],
  "complex_value": {
    "simple_element": 42,
    "array_of_integers": [23,36,56,72],
    "array of strings": ["red","green","blue"]
  }
}
```

The following table displays the database columns and records that using the specified topic rule action to process the previous message payload creates. The device_firmware_sku and device_id columns are the DIMENSIONS defined in the topic rule action. The Timestream topic rule action creates the time column and the measure_name and measure_value: * columns, which it fills with the values from the result of the topic rule action’s query statement.

<table>
<thead>
<tr>
<th>device_firmware_sku</th>
<th>device_id</th>
<th>measure_name</th>
<th>measure_value</th>
<th>measure_value</th>
<th>measure_value</th>
<th>measure_value</th>
<th>measure_value</th>
<th>time</th>
</tr>
</thead>
</table>
Troubleshooting a rule

If you have an issue with your rules, we recommend that you activate CloudWatch Logs. You can analyze your logs to determine whether the issue is authorization or whether, for example, a WHERE clause condition didn't match. For more information, see Setting Up CloudWatch Logs.

Accessing cross-account resources using AWS IoT rules

You can configure AWS IoT rules for cross-account access so that data ingested on MQTT topics of one account can be routed into the AWS services, such as Amazon SQS and Lambda, of another account. The following explains how to set up AWS IoT rules for cross-account data ingestion, from an MQTT topic in one account, to a destination in another account.

Cross-account rules can be configured using resource-based permissions on the destination resource. Therefore, only destinations that support resource-based permissions can be enabled for the cross-account access with AWS IoT rules. The supported destinations include Amazon SQS, Amazon SNS, Amazon S3, and AWS Lambda.

Note
You must define the rule in the same AWS Region as another service's resource so that the rule action can interact with that resource. For more information about AWS IoT rule actions, see AWS IoT rule actions (p. 502).

Prerequisites

- Familiarity with AWS IoT rules
• An understanding of IAM users, roles, and resource-based permission
• Having AWS CLI installed

Cross-account setup for Amazon SQS

Scenario: Account A sends data from an MQTT message to account B's Amazon SQS queue.

<table>
<thead>
<tr>
<th>AWS account</th>
<th>Account referred to as</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111-1111-1111</td>
<td>Account A</td>
<td>Rule action: sqs:SendMessage</td>
</tr>
<tr>
<td>2222-2222-2222</td>
<td>Account B</td>
<td>Amazon SQS queue</td>
</tr>
</tbody>
</table>

- ARN: arn:aws:sqs:region:2222-2222-2222:ExampleQueue
- URL: https://sqs.region.amazonaws.com/2222-2222-2222/ExampleQueue

Do the Account A tasks

**Note**
To run the following commands, your IAM user should have permissions to
iot:CreateTopicRule with the rule's Amazon Resource Name (ARN) as a resource, and permissions to iam:PassRole action with a resource as the role's ARN.

1. **Configure AWS CLI** using account A's IAM user.
2. Create an IAM role that trusts AWS IoT rules engine, and attaches a policy that allows access to account B's Amazon SQS queue. See example commands and policy documents in [Granting AWS IoT the required access](#).
3. To create a rule that is attached to a topic, run the `create-topic-rule` command.

```
aws iot create-topic-rule --rule-name myRule --topic-rule-payload file://./my-rule.json
```

The following is an example payload file with a rule that inserts all messages sent to the iot/test topic into the specified Amazon SQS queue. The SQL statement filters the messages and the role ARN grants AWS IoT permissions to add the message to the Amazon SQS queue.

```json
{
    "sql": "SELECT * FROM 'iot/test'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [  
        {  
            "sqs": {  
                "queueUrl": "https://sqs.region.amazonaws.com/2222-2222-2222/ExampleQueue",
                "roleArn": "arn:aws:iam::1111-1111-1111:role/my-iot-role",
                "useBase64": false
            }  
        }  
    ]
}
```

For more information about how to define an Amazon SQS action in an AWS IoT rule, see [AWS IoT rule actions - Amazon SQS](#).
Do the Account B tasks

1. Configure AWS CLI using account B's IAM user.
2. To give permissions for the Amazon SQS queue resource to account A, run the `add-permission` command.

```
aws sqs add-permission --queue-url https://sqs.region.amazonaws.com/2222-2222-2222/ExampleQueue --label SendMessagesToMyQueue --aws-account-ids 1111-1111-1111 --actions SendMessage
```

Cross-account setup for Amazon SNS

Scenario: Account A sends data from an MQTT message to an Amazon SNS topic of account B.

<table>
<thead>
<tr>
<th>AWS account</th>
<th>Account referred to as</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111-1111-1111</td>
<td>Account A</td>
<td>Rule action: sns:Publish</td>
</tr>
<tr>
<td>2222-2222-2222</td>
<td>Account B</td>
<td>Amazon SNS topic ARN: arn:aws:sns:region:2222-2222-2222:ExampleTopic</td>
</tr>
</tbody>
</table>

Do the Account A tasks

Notes
To run the following commands, your IAM user should have permissions to
`iot:CreateTopicRule` with rule ARN as a resource and permissions to the `iam:PassRole` action with a resource as role ARN.

1. Configure AWS CLI using account A's IAM user.
2. Create an IAM role that trusts AWS IoT rules engine, and attaches a policy that allows access to account B's Amazon SNS topic. For example commands and policy documents, see [Granting AWS IoT the required access](#).
3. To create a rule that is attached to a topic, run the `create-topic-rule command`.

```
aws iot create-topic-rule --rule-name myRule --topic-rule-payload file://./my-rule.json
```

The following is an example payload file with a rule that inserts all messages sent to the `iot/test` topic into the specified Amazon SNS topic. The SQL statement filters the messages, and the role ARN grants AWS IoT permissions to send the message to the Amazon SNS topic.

```json
{
  "sql": "SELECT * FROM 'iot/test'",
  "ruleDisabled": false,
  "awsIotSqlVersion": "2016-03-23",
  "actions": [
    {
      "sns": {
        "targetArn": "arn:aws:sns:region:2222-2222-2222:ExampleTopic",
        "roleArn": "arn:aws:iam::1111-1111-1111:role/my-iot-role"
      }
    }
  ]
}
```
For more information about how to define an Amazon SNS action in an AWS IoT rule, see AWS IoT rule actions - Amazon SNS.

Do the Account B tasks

1. Configure AWS CLI using account B's IAM user.
2. To give permission on the Amazon SNS topic resource to account A, run the add-permission command.

   ```bash
   ```

Cross-account setup for Amazon S3

Scenario: Account A sends data from an MQTT message to an Amazon S3 bucket of account B.

<table>
<thead>
<tr>
<th>AWS account</th>
<th>Account referred to as</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111-1111-1111</td>
<td>Account A</td>
<td>Rule action: s3:PutObject</td>
</tr>
<tr>
<td>2222-2222-2222</td>
<td>Account B</td>
<td>Amazon S3 bucket ARN: arn:aws:s3:::ExampleBucket</td>
</tr>
</tbody>
</table>

Do the Account A tasks

**Note**
To run the following commands, your IAM user should have permissions to iot:CreateTopicRule with the rule ARN as a resource and permissions to iam:PassRole action with a resource as role ARN.

1. Configure AWS CLI using account A's IAM user.
2. Create an IAM role that trusts AWS IoT rules engine and attaches a policy that allows access to account B's Amazon S3 bucket. For example commands and policy documents, see Granting AWS IoT the required access.
3. To create a rule that is attached to your target S3 bucket, run the create-topic-rule command.

   ```bash
   aws iot create-topic-rule --rule-name my-rule --topic-rule-payload file://./my-rule.json
   ```

The following is an example payload file with a rule that inserts all messages sent to the iot/test topic into the specified Amazon S3 bucket. The SQL statement filters the messages, and the role ARN grants AWS IoT permissions to add the message to the Amazon S3 bucket.

```json
{
    "sql": "SELECT * FROM 'iot/test',
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
        {
            "s3": {
                "bucketName": "ExampleBucket",
                "key": "${topic()}/${timestamp()}"
            }
        }
    ]
}
```
For more information about how to define an Amazon S3 action in an AWS IoT rule, see AWS IoT rule actions - Amazon S3.

Do the Account B tasks

1. Configure AWS CLI using account B’s IAM user.
2. Create a bucket policy that trusts account A’s principal.

   The following is an example payload file that defines a bucket policy that trusts the principal of another account.

   ```json
   {
   "Version": "2012-10-17",
   "Statement": [
   {
   "Sid": "AddCannedAcl",
   "Effect": "Allow",
   "Principal": {
   "AWS": [
   "arn:aws:iam::1111-1111-1111:root"
   ],
   "Action": "s3:PutObject",
   "Resource": "arn:aws:s3:::ExampleBucket/*"
   }
   }
   ]
   }
   ```

   For more information, see bucket policy examples.

3. To attach the bucket policy to the specified bucket, run the put-bucket-policy command.

   ```bash
   aws s3api put-bucket-policy --bucket ExampleBucket --policy file://./my-bucket-policy.json
   ```

4. To make the cross-account access work, make sure you have the correct Block all public access settings. For more information, see Security Best Practices for Amazon S3.

Cross-account setup for AWS Lambda

Scenario: Account A invokes an AWS Lambda function of account B, passing in an MQTT message.

<table>
<thead>
<tr>
<th>AWS account</th>
<th>Account referred to as</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1111-1111-1111</td>
<td>Account A</td>
<td>Rule action: lambda:InvokeFunction</td>
</tr>
<tr>
<td>2222-2222-2222</td>
<td>Account B</td>
<td>Lambda function ARN:</td>
</tr>
<tr>
<td></td>
<td></td>
<td><code>arn:aws:lambda:region:2222-2222-2222:function:example_function</code></td>
</tr>
</tbody>
</table>
Do the Account A tasks

Notes
To run the following commands, your IAM user should have permissions to
iot:CreateTopicRule with rule ARN as a resource, and permissions to iam:PassRole action
with resource as role ARN.

1. Configure AWS CLI using account A's IAM user.
2. Run the create-topic-rule command to create a rule that defines cross-account access to account B's Lambda function.

```
aws iot create-topic-rule --rule-name my-rule --topic-rule-payload file://./my-rule.json
```

The following is an example payload file with a rule that inserts all messages sent to the iot/test topic into the specified Lambda function. The SQL statement filters the messages and the role ARN grants AWS IoT permission to pass in the data to the Lambda function.

```json
{
    "sql": "SELECT * FROM 'iot/test'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
        {
            "lambda": {
                "functionArn": "arn:aws:lambda:region:2222-2222-2222:function:example-function"
            }
        }
    ]
}
```

For more information about how to define an AWS Lambda action in an AWS IoT rule, read AWS IoT rule actions - Lambda.

Do the Account B tasks

1. Configure AWS CLI using account B's IAM user.
2. Run Lambda's add-permission command to give AWS IoT rules permission to activate the Lambda function. To run the following command, your IAM user should have permission to lambda:AddPermission action.

```
```

Options:

--principal
This field gives permission to AWS IoT (represented by iot.amazonaws.com) to call the Lambda function.

--source-arn
This field confirms that only arn:aws:iot:region:1111-1111-1111:rule/example-rule in AWS IoT triggers this Lambda function and no other rule in the same or different account can activate this Lambda function.

--source-account

This field confirms that AWS IoT activates this Lambda function only on behalf of the 1111-1111-1111 account.

Notes
If you see an error message "The rule could not be found" from your AWS Lambda function's console under Configuration, ignore the error message and proceed to test the connection.

**Error handling (error action)**

When AWS IoT receives a message from a device, the rules engine checks to see if the message matches a rule. If so, the rule's query statement is evaluated and the rule's actions are activated, passing the query statement's result.

If a problem occurs when activating an action, the rules engine activates an error action, if one is specified for the rule. This might happen when:

- A rule doesn't have permission to access an Amazon S3 bucket.
- A user error causes DynamoDB provisioned throughput to be exceeded.

Note
The error handling covered in this topic is for rule actions (p. 502). To debug SQL issues, including external functions, you can set up AWS IoT logging. For more information, see ??? (p. 439).

**Error action message format**

A single message is generated per rule and message. For example, if two rule actions in the same rule fail, the error action receives one message that contains both errors.

The error action message looks like the following example.

```
{
  "ruleName": "TestAction",
  "topic": "testme/action",
  "cloudwatchTraceId": "7e1e46a2c-95b5-6caf-98b9-50e3969734c7",
  "clientId": "iotconsole-1511213971966-0",
  "base64OriginalPayload": "ewogICJtZXNzYWdlIjogIkhlbGxvIHZyb20gQVdTIElvVCBjb25zb2xlIgp9",
  "failures": [
    {
      "failedAction": "S3Action",
      "failedResource": "us-east-1-s3-verify-user",
      "errorMessage": "Failed to put S3 object. The error received was The specified bucket does not exist (Service: Amazon S3; Status Code: 404; Error Code: NoSuchBucket; Request ID: 9DF5416B9B4789AF; S3 Extended Request ID: yMah1cwPpqTH267QLPhTKevPKJ88B05ndBH2OmWxtLTM6uAvwYYuqieAKyb6gRPTxP1tHXCoR4Y=). Message arrived on: error/action, Action: s3, Bucket: us-east-1-s3-verify-user, Key: "aaa". Value of x-amz-id-2: yMah1cwPpqTH267QLPhTKevPKJ88B05ndBH2OmWxtLTM6uAvwYYuqieAKyb6gRPTxP1tHXCoR4Y="
    }
  ]
}
```
Error action example

Here is an example of a rule with an added error action. The following rule has an action that writes message data to a DynamoDB table and an error action that writes data to an Amazon S3 bucket:

```json
{
  "sql": "SELECT * FROM ...",
  "actions": [{
    "dynamoDB": {
      "table": "PoorlyConfiguredTable",
      "hashKeyField": "AConstantString",
      "hashKeyValue": "AHashKey"
    }
  },
  "errorAction": {
    "s3": {
      "roleArn": "arn:aws:iam::123456789012:role/aws_iot_s3",
      "bucketName": "message-processing-errors",
      "key": "${replace(topic(), '/', '-') + '-' + timestamp() + '-' + newuuid()}"
    }
  }
}
```

You can use any function or substitution in an error action's SQL statement, except for external functions (for example, `get_thing_shadow`, `aws_lambda`, and `machinelearning_predict`).

For more information about rules and how to specify an error action, see [Creating an AWS IoT Rule](#).
Reducing messaging costs with Basic Ingest

You can use Basic Ingest, to securely send device data to the AWS services supported by AWS IoT rule actions (p. 502), without incurring messaging costs. Basic Ingest optimizes data flow by removing the publish/subscribe message broker from the ingestion path.

Basic Ingest can send messages from your devices or applications. The messages have topic names that start with $aws/rules/rule_name for their first three levels, where rule_name is the name of the AWS IoT rule that you want to invoke.

You can use an existing rule with Basic Ingest by adding the Basic Ingest prefix ($aws/rules/rule_name) to the message topic that you'd use to invoke the rule. For example, if you have a rule named BuildingManager that's invoked by messages like Buildings/Building5/Floor2/Room201/Lights ("sql": "SELECT * FROM 'Buildings/#'"), you can invoke the same rule with Basic Ingest by sending a message with topic $aws/rules/BuildingManager/Buildings/Building5/Floor2/Room201/Lights.

Note:
- Your devices and rules can't subscribe to Basic Ingest reserved topics. For more information, see Reserved topics (p. 111).
- If you need a publish/subscribe broker to distribute messages to multiple subscribers (for example, to deliver messages to other devices and the rules engine), you should continue to use the AWS IoT message broker to handle the message distribution. However, make sure that you publish your messages on topics other than Basic Ingest topics.

Using Basic Ingest

Before you use Basic Ingest, verify that your device or application is using a policy (p. 336) that has publish permissions on $aws/rules/*. Alternatively, you can specify permission for individual rules with $aws/rules/rule_name/* in the policy. Otherwise, your devices and applications can continue to use their existing connections with AWS IoT Core.

When the message reaches the rules engine, there's no difference in implementation or error handling between rules invoked from Basic Ingest and those invoked through message broker subscriptions.

You can create rules for use with Basic Ingest. Keep in mind the following:
- The initial prefix of a Basic Ingest topic ($aws/rules/rule_name) isn't available to the topic(Decimal) (p. 640) function.
- If you define a rule that's invoked only with Basic Ingest, the FROM clause is optional in the sql field of the rule definition. It's still required if the rule is also invoked by other messages that must be sent through the message broker (for example, because those other messages must be distributed to multiple subscribers). For more information, see AWS IoT SQL reference (p. 586).
- The first three levels of the Basic Ingest topic ($aws/rules/rule_name) aren't counted toward the 8-segment length limit or toward the 256-total character limit for a topic. Otherwise, the same restrictions apply as documented in AWS IoT Limits.
- If a message is received with a Basic Ingest topic that specifies an inactive rule or a rule that doesn't exist, an error log is created in an Amazon CloudWatch log to help you with debugging. For more information, see Rules engine log entries (p. 472). A RuleNotFound metric is indicated and you can create alarms on this metric. For more information, see Rule Metrics in Rule metrics (p. 451).
You can still publish with QoS 1 on Basic Ingest topics. You receive a PUBACK after the message is successfully delivered to the rules engine. Receiving a PUBACK doesn't mean that your rule actions were completed successfully. You can configure an error action to handle errors when an action is run. For more information, see Error handling (error action) (p. 583).

AWS IoT SQL reference

In AWS IoT, rules are defined using an SQL-like syntax. SQL statements are composed of three types of clauses:

**SELECT**

(Required) Extracts information from the payload of an incoming message and performs transformations on the information. The messages to use are identified by the topic filter specified in the FROM clause.

The SELECT clause supports Data types (p. 589), Operators (p. 593), Functions (p. 598), Literals (p. 645), Case statements (p. 646), JSON extensions (p. 646), Substitution templates (p. 648), Nested object queries (p. 649), and Binary payloads (p. 650).

**FROM**

The MQTT message topic filter that identifies the messages to extract data from. The rule is activated for each message sent to an MQTT topic that matches the topic filter specified here. Required for rules that are activated by messages that pass through the message broker. Optional for rules that are only activated using the Basic Ingest (p. 585) feature.

**WHERE**

(Optional) Adds conditional logic that determines whether the actions specified by a rule are carried out.

The WHERE clause supports Data types (p. 589), Operators (p. 593), Functions (p. 598), Literals (p. 645), Case statements (p. 646), JSON extensions (p. 646), Substitution templates (p. 648), and Nested object queries (p. 649).

An example SQL statement looks like this:

```
SELECT color AS rgb FROM 'topic/subtopic' WHERE temperature > 50
```

An example MQTT message (also called an incoming payload) looks like this:

```json
{
  "color":"red",
  "temperature":100
}
```

If this message is published on the 'topic/subtopic' topic, the rule is triggered and the SQL statement is evaluated. The SQL statement extracts the value of the color property if the "temperature" property is greater than 50. The WHERE clause specifies the condition temperature > 50. The AS keyword renames the "color" property to "rgb". The result (also called an outgoing payload) looks like this:

```json
{
  "rgb":"red"
}
```
This data is then forwarded to the rule's action, which sends the data for more processing. For more information about rule actions, see AWS IoT rule actions (p. 502).

Note
Comments are not currently supported in AWS IoT SQL syntax. Attribute names with spaces in them can't be used as field names in the SQL statement. While the incoming payload can have attribute names with spaces in them, such names can't be used in the SQL statement. They will, however, be passed through to the outgoing payload if you use a wildcard (*) field name specification.

SELECT clause

The AWS IoT SELECT clause is essentially the same as the ANSI SQL SELECT clause, with some minor differences.

The SELECT clause supports Data types (p. 589), Operators (p. 593), Functions (p. 598), Literals (p. 645), Case statements (p. 646), JSON extensions (p. 646), Substitution templates (p. 648), Nested object queries (p. 649), and Binary payloads (p. 650).

You can use the SELECT clause to extract information from incoming MQTT messages. You can also use SELECT * to retrieve the entire incoming message payload. For example:

Incoming payload published on topic 'topic/subtopic': {"color":"red", "temperature":50}
SQL statement: SELECT * FROM 'topic/subtopic'
Outgoing payload: {"color":"red", "temperature":50}

If the payload is a JSON object, you can reference keys in the object. Your outgoing payload contains the key-value pair. For example:

Incoming payload published on topic 'topic/subtopic': {"color":"red", "temperature":50}
SQL statement: SELECT color FROM 'topic/subtopic'
Outgoing payload: {"color":"red"}

You can use the AS keyword to rename keys. For example:

Incoming payload published on topic 'topic/subtopic': {"color":"red", "temperature":50}
SQL: SELECT color AS my_color FROM 'topic/subtopic'
Outgoing payload: {"my_color":"red"}

You can select multiple items by separating them with a comma. For example:

Incoming payload published on topic 'topic/subtopic': {"color":"red", "temperature":50}
SQL: SELECT color as my_color, temperature as fahrenheit FROM 'topic/subtopic'
Outgoing payload: {"my_color":"red","fahrenheit":50}

You can select multiple items including '*' to add items to the incoming payload. For example:

Incoming payload published on topic 'topic/subtopic': {"color":"red", "temperature":50}
SQL: SELECT *, 15 as speed FROM 'topic/subtopic'
Outgoing payload: {"color":"red", "temperature":50, "speed":15}

You can use the "VALUE" keyword to produce outgoing payloads that are not JSON objects. With SQL version 2015-10-08, you can select only one item. With SQL version 2016-03-23 or later, you can also select an array to output as a top-level object.
Example

Incoming payload published on topic 'topic/subtopic': {"color":"red", "temperature":50}
SQL: SELECT VALUE color FROM 'topic/subtopic'
Outgoing payload: "red"

You can use '.' syntax to drill into nested JSON objects in the incoming payload. For example:

Incoming payload published on topic 'topic/subtopic': {"color":{"red":255,"green":0,"blue":0}, "temperature":50}
SQL: SELECT color.red as red_value FROM 'topic/subtopic'
Outgoing payload: {"red_value":255}

For information about how to use JSON object and property names that include reserved characters, such as numbers or the hyphen (minus) character, see JSON extensions (p. 646)

You can use functions (see Functions (p. 598)) to transform the incoming payload. You can use parentheses for grouping. For example:

Incoming payload published on topic 'topic/subtopic': {"color":"red", "temperature":50}
SQL: SELECT (temperature - 32) * 5 / 9 AS celsius, upper(color) as my_color FROM 'topic/subtopic'
Outgoing payload: {"celsius":10,"my_color":"RED"}

FROM clause

The FROM clause subscribes your rule to a topic (p. 109) or topic filter (p. 110). Enclose the topic or topic filter in single quotes ('). The rule is triggered for each message sent to an MQTT topic that matches the topic filter specified here. You can subscribe to a group of similar topics using a topic filter.

Example:

Incoming payload published on topic 'topic/subtopic':{temperature: 50}
Incoming payload published on topic 'topic/subtopic-2':{temperature: 50}
SQL: "SELECT temperature AS t FROM 'topic/subtopic-2'".

The rule is subscribed to 'topic/subtopic', so the incoming payload is passed to the rule. The outgoing payload, passed to the rule actions, is: {t: 50}. The rule is not subscribed to 'topic/subtopic-2', so the rule is not triggered for the message published on 'topic/subtopic-2'.

# Wildcard Example:

You can use the '#' (multi-level) wildcard character to match one or more particular path elements:

Incoming payload published on topic 'topic/subtopic':{temperature: 50}.
Incoming payload published on topic 'topic/subtopic-2':{temperature: 60}.
Incoming payload published on topic 'topic/subtopic-3/details':{temperature: 70}.
Incoming payload published on topic 'topic/2/subtopic-x':{temperature: 80}.
SQL: "SELECT temperature AS t FROM 'topic/#'".

The rule is subscribed to any topic that begins with 'topic', so it's executed three times, sending outgoing payloads of {t: 50} (for topic/subtopic), {t: 60} (for topic/subtopic-2), and {t: 70} (for...
WHERE clause

The WHERE clause determines if the actions specified by a rule are carried out. If the WHERE clause evaluates to true, the rule actions are performed. Otherwise, the rule actions are not performed.

The WHERE clause supports Data types (p. 589), Operators (p. 593), Functions (p. 598), Literals (p. 645), Case statements (p. 646), JSON extensions (p. 646), Substitution templates (p. 648), and Nested object queries (p. 649).

Example:

Incoming payload published on topic/subtopic: {"color":"red", "temperature":40}.

SQL: SELECT color AS my_color FROM 'topic/subtopic' WHERE temperature > 50 AND color <> 'red'.

In this case, the rule will be triggered, but the actions specified by the rule will not be performed. There will be no outgoing payload.

You can use functions and operators in the WHERE clause. However, you cannot reference any aliases created with the AS keyword in the SELECT. The WHERE clause is evaluated first, to determine if SELECT is evaluated.

Example with non-JSON payload:

Incoming non-JSON payload published on `topic/subtopic`: `80`

SQL: `SELECT decode(encode(*, 'base64'), 'base64') AS value FROM 'topic/subtopic' WHERE decode(encode(*, 'base64'), 'base64') > 50`

In this case, the rule will be triggered, and the actions specified by the rule will be performed. The outgoing payload will be transformed by the SELECT clause as a JSON payload {"value":80}.

Data types

The AWS IoT rules engine supports all JSON data types.
### Supported data types

<table>
<thead>
<tr>
<th>Type</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>A discrete Int. 34 digits maximum.</td>
</tr>
<tr>
<td>Decimal</td>
<td>A Decimal with a precision of 34 digits, with a minimum non-zero magnitude of 1E-999 and a maximum magnitude 9.999...E999. <strong>Note</strong> Some functions return Decimal values with double precision rather than 34-digit precision. With SQL V2 (2016-03-23), numeric values that are whole numbers, such as 10.0, are processed as an Int value (10) instead of the expected Decimal value (10.0). To reliably process whole number numeric values as Decimal values, use SQL V1 (2015-10-08) for the rule query statement.</td>
</tr>
<tr>
<td>Boolean</td>
<td>True or False.</td>
</tr>
<tr>
<td>String</td>
<td>A UTF-8 string.</td>
</tr>
<tr>
<td>Array</td>
<td>A series of values that don’t have to have the same type.</td>
</tr>
<tr>
<td>Object</td>
<td>A JSON value consisting of a key and a value. Keys must be strings. Values can be any type.</td>
</tr>
<tr>
<td>Null</td>
<td>Null as defined by JSON. It’s an actual value that represents the absence of a value. You can explicitly create a Null value by using the Null keyword in your SQL statement. For example: “SELECT NULL AS n FROM ‘topic/subtopic’”</td>
</tr>
<tr>
<td>Undefined</td>
<td>Not a value. This isn’t explicitly representable in JSON except by omitting the value. For example, in the object {“foo”: null}, the key “foo” returns NULL, but the key “bar” returns Undefined. Internally, the SQL language treats Undefined as a value, but it isn’t representable in JSON, so when serialized to JSON, the results are Undefined.</td>
</tr>
</tbody>
</table>

```json
{"foo":null, "bar":undefined}
```

is serialized to JSON as:

```json
{"foo":null}
```

Similarly, Undefined is converted to an empty string when serialized by itself. Functions called with invalid arguments (for example, wrong types,
### Conversions

The following table lists the results when a value of one type is converted to another type (when a value of the incorrect type is given to a function). For example, if the absolute value function "abs" (which expects an Int or Decimal) is given a String, it attempts to convert the String to a Decimal, following these rules. In this case, 'abs("-5.123")' is treated as 'abs(-5.123).

**Note**

There are no attempted conversions to Array, Object, Null, or Undefined.

#### To decimal

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>A Decimal with no decimal point.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The source value.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined. (You can explicitly use the cast function to transform true = 1.0, false = 0.0.)</td>
</tr>
<tr>
<td>String</td>
<td>The SQL engine tries to parse the string as a Decimal. AWS IoT attempts to parse strings matching the regular expression:^-?\d+(. \d+)?((?i)E-?\d+)?.$, &quot;0&quot;, &quot;-1.2&quot;, &quot;5E-12&quot; are all examples of strings that are converted automatically to Decimals.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Null.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

#### To int

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The source value.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The source value rounded to the nearest Int.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined. (You can explicitly use the cast function to transform true = 1.0, false = 0.0.)</td>
</tr>
<tr>
<td>String</td>
<td>The SQL engine tries to parse the string as a Decimal. AWS IoT attempts to parse strings matching the regular expression:^-?\d+(. \d+)?((?i)E-?\d+)?.$, &quot;0&quot;, &quot;-1.2&quot;, &quot;5E-12&quot; are all examples of strings that are converted automatically to Decimals. AWS IoT attempts</td>
</tr>
</tbody>
</table>
### Data types

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>to convert the String to a Decimal, and then truncates the decimal places of that Decimal to make an Int.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Null.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

#### To Boolean

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Undefined. (You can explicitly use the cast function to transform 0 = False, any_nonzero_value = True.)</td>
</tr>
<tr>
<td>Decimal</td>
<td>Undefined. (You can explicitly use the cast function to transform 0 = False, any_nonzero_value = True.)</td>
</tr>
<tr>
<td>Boolean</td>
<td>The original value.</td>
</tr>
<tr>
<td>String</td>
<td>&quot;true&quot;=True and &quot;false&quot;=False (case insensitive). Other string values are Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

#### To string

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>A string representation of the Int in standard notation.</td>
</tr>
<tr>
<td>Decimal</td>
<td>A string representing the Decimal value, possibly in scientific notation.</td>
</tr>
<tr>
<td>Boolean</td>
<td>&quot;true&quot; or &quot;false&quot;. All lowercase.</td>
</tr>
<tr>
<td>String</td>
<td>The original value.</td>
</tr>
<tr>
<td>Array</td>
<td>The Array serialized to JSON. The resultant string is a comma-separated list, enclosed in square brackets. A String is quoted. A Decimal, Int, Boolean, and Null is not.</td>
</tr>
</tbody>
</table>
Operators

The following operators can be used in SELECT and WHERE clauses.

**AND operator**

Returns a Boolean result. Performs a logical AND operation. Returns true if left and right operands are true. Otherwise, returns false. Boolean operands or case insensitive "true" or "false" string operands are required.

*Syntax:* `expression AND expression`.

**AND operator**

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boolean</td>
<td>Boolean</td>
<td>Boolean. True if both operands are true. Otherwise, false.</td>
</tr>
<tr>
<td>String/Boolean</td>
<td>String/Boolean</td>
<td>If all strings are &quot;true&quot; or &quot;false&quot; (case insensitive), they are converted to Boolean and processed normally as <code>boolean AND boolean</code>.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**OR operator**

Returns a Boolean result. Performs a logical OR operation. Returns true if either the left or the right operands are true. Otherwise, returns false. Boolean operands or case insensitive "true" or "false" string operands are required.

*Syntax:* `expression OR expression`.

**OR operator**

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boolean</td>
<td>Boolean</td>
<td>Boolean. True if either operand is true. Otherwise, false.</td>
</tr>
<tr>
<td>String/Boolean</td>
<td>String/Boolean</td>
<td>If all strings are &quot;true&quot; or &quot;false&quot; (case insensitive), they are converted to Booleans and processed normally as <code>boolean OR boolean</code>.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>
**NOT operator**

Returns a Boolean result. Performs a logical NOT operation. Returns true if the operand is false. Otherwise, returns true. A Boolean operand or case insensitive "true" or "false" string operand is required.

Syntax: `NOT expression`.

<table>
<thead>
<tr>
<th>NOT operator</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operand</strong></td>
<td><strong>Boolean</strong></td>
</tr>
<tr>
<td>Boolean</td>
<td>True if operand is false. Otherwise, true.</td>
</tr>
<tr>
<td>String</td>
<td>If string is &quot;true&quot; or &quot;false&quot; (case insensitive), it is converted to the corresponding Boolean value, and the opposite value is returned.</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**> operator**

Returns a Boolean result. Returns true if the left operand is greater than the right operand. Both operands are converted to a Decimal, and then compared.

Syntax: `expression > expression`.

<table>
<thead>
<tr>
<th>&gt; operator</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left operand</strong></td>
<td><strong>Right operand</strong></td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
</tr>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**>= operator**

Returns a Boolean result. Returns true if the left operand is greater than or equal to the right operand. Both operands are converted to a Decimal, and then compared.

Syntax: `expression >= expression`.

<table>
<thead>
<tr>
<th>&gt;= operator</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Left operand</strong></td>
<td><strong>Right operand</strong></td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
</tr>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
</tr>
<tr>
<td>Left operand</td>
<td>Right operand</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**< operator**

Returns a Boolean result. Returns true if the left operand is less than the right operand. Both operands are converted to a Decimal, and then compared.

*Syntax:* `expression < expression`.

**<= operator**

Returns a Boolean result. Returns true if the left operand is less than or equal to the right operand. Both operands are converted to a Decimal, and then compared.

*Syntax:* `expression <= expression`.

**<> operator**

Returns a Boolean result. Returns true if both left and right operands are not equal. Otherwise, returns false.

*Syntax:* `expression <> expression`.
<> operator

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>True if left operand is not equal to right operand. Otherwise, false.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal</td>
<td>True if left operand is not equal to right operand. Otherwise, false.</td>
</tr>
<tr>
<td>String</td>
<td>String</td>
<td>True if left operand is not equal to right operand. Otherwise, false.</td>
</tr>
<tr>
<td>Array</td>
<td>Array</td>
<td>True if the items in each operand are not equal and not in the same order. Otherwise, false.</td>
</tr>
<tr>
<td>Object</td>
<td>Object</td>
<td>True if the keys and values of each operand are not equal. Otherwise, false. The order of keys/values is unimportant.</td>
</tr>
<tr>
<td>Null</td>
<td>Null</td>
<td>False.</td>
</tr>
<tr>
<td>Any value</td>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Any value</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Mismatched type</td>
<td>Mismatched type</td>
<td>True.</td>
</tr>
</tbody>
</table>

= operator

Returns a Boolean result. Returns true if both left and right operands are equal. Otherwise, returns false.

Syntax: `expression = expression`.

= operator

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>True if left operand is equal to right operand. Otherwise, false.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal</td>
<td>True if left operand is equal to right operand. Otherwise, false.</td>
</tr>
<tr>
<td>String</td>
<td>String</td>
<td>True if left operand is equal to right operand. Otherwise, false.</td>
</tr>
<tr>
<td>Array</td>
<td>Array</td>
<td>True if the items in each operand are equal and in the same order.</td>
</tr>
<tr>
<td>Object</td>
<td>Object</td>
<td>True if the keys and values of each operand are equal. Otherwise, false. The order of keys/values is unimportant.</td>
</tr>
<tr>
<td>Any value</td>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Any value</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Mismatched type</td>
<td>Mismatched type</td>
<td>False.</td>
</tr>
</tbody>
</table>
+ operator

The "+" is an overloaded operator. It can be used for string concatenation or addition.

Syntax: \textit{expression} + \textit{expression}.

+ operator

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>Any value</td>
<td>Converts the right operand to a string and concatenates it to the end of the left operand.</td>
</tr>
<tr>
<td>Any value</td>
<td>String</td>
<td>Converts the left operand to a string and concatenates the right operand to the end of the converted left operand.</td>
</tr>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int value. Adds operands together.</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Decimal value. Adds operands together.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

- operator

Subtracts the right operand from the left operand.

Syntax: \textit{expression} - \textit{expression}.

- operator

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int value. Subtracts right operand from left operand.</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Decimal value. Subtracts right operand from left operand.</td>
</tr>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
<td>If all strings convert to decimals correctly, a Decimal value is returned. Subtracts right operand from left operand. Otherwise, returns Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

* operator

Multiplies the left operand by the right operand.

Syntax: \textit{expression} * \textit{expression}.

* operator

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int value. Multiplies the left operand by the right operand.</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Decimal value. Multiplies the left operand by the right operand.</td>
</tr>
</tbody>
</table>
### Functions

You can use the following built-in functions in the SELECT or WHERE clauses of your SQL expressions.

#### abs(Decimal)

Returns the absolute value of a number. Supported by SQL version 2015-10-08 and later.

---

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
<td>If all strings convert to decimals correctly, a Decimal value is returned. Multiplies the left operand by the right operand. Otherwise, returns Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

### / operator

Divides the left operand by the right operand.

**Syntax:** `expression / expression`.

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int value. Divides the left operand by the right operand.</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Decimal value. Divides the left operand by the right operand.</td>
</tr>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
<td>If all strings convert to decimals correctly, a Decimal value is returned. Divides the left operand by the right operand. Otherwise, returns Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

### % operator

Returns the remainder from dividing the left operand by the right operand.

**Syntax:** `expression % expression`.

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int value. Returns the remainder from dividing the left operand by the right operand.</td>
</tr>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
<td>If all strings convert to decimals correctly, a Decimal value is returned. Returns the remainder from dividing the left operand by the right operand. Otherwise, Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>
Example: \( \text{abs}(-5) \) returns 5.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int, the absolute value of the argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal, the absolute value of the argument.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal. The result is the absolute value of the argument. If the string cannot be converted, the result is Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**accountid()**

Returns the ID of the account that owns this rule as a String. Supported by SQL version 2015-10-08 and later.

Example:

\( \text{accountid()} = "123456789012" \)

**acos(Decimal)**

Returns the inverse cosine of a number in radians. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: \( \text{acos}(0) = 1.5707963267948966 \)
### Argument type | Result
--- | ---
Null | Undefined.  
Undefined | Undefined.  

**asin(Decimal)**

Returns the inverse sine of a number in radians. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: `asin(0) = 0.0`

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
</table>
| Int | Decimal (with double precision), the inverse sine of the argument. Imaginary results are returned as Undefined.  
Decimal | Decimal (with double precision), the inverse sine of the argument. Imaginary results are returned as Undefined.  
Boolean | Undefined.  
String | Decimal (with double precision), the inverse sine of the argument. If the string cannot be converted, the result is Undefined. Imaginary results are returned as Undefined.  
Array | Undefined.  
Object | Undefined.  
Null | Undefined.  
Undefined | Undefined.  

**atan(Decimal)**

Returns the inverse tangent of a number in radians. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: `atan(0) = 0.0`

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
</table>
| Int | Decimal (with double precision), the inverse tangent of the argument. Imaginary results are returned as Undefined.  
Decimal | Decimal (with double precision), the inverse tangent of the argument. Imaginary results are returned as Undefined.  
Boolean | Undefined.  

---
<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>Decimal, the inverse tangent of the argument. If the string cannot be converted, the result is Undefined. Imaginary results are returned as Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**atan2(Decimal, Decimal)**

Returns the angle, in radians, between the positive x-axis and the (x, y) point defined in the two arguments. The angle is positive for counter-clockwise angles (upper half-plane, y > 0), and negative for clockwise angles (lower half-plane, y < 0). Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: atan2(1, 0) = 1.5707963267948966

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Decimal (with double x-axis and the specified y-coordinate)</td>
</tr>
<tr>
<td>Int/Decimal/String</td>
<td>Int/Decimal/String</td>
<td>Decimal, the inverse tangent of the specified point. If a string cannot be converted, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**aws_lambda(functionArn, inputJson)**

Calls the specified Lambda function passing inputJson to the Lambda function and returns the JSON generated by the Lambda function.

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>functionArn</td>
<td>The ARN of the Lambda function to call. The Lambda function must return JSON data.</td>
</tr>
<tr>
<td>inputJson</td>
<td>The JSON input passed to the Lambda function. To pass nested object queries and literals, you must use SQL version 2016-03-23.</td>
</tr>
</tbody>
</table>

You must grant AWS IoT lambda:InvokeFunction permissions to invoke the specified Lambda function. The following example shows how to grant the lambda:InvokeFunction permission using the AWS CLI:

```
aws lambda add-permission --function-name "function_name" --region "region" --principal iot.amazonaws.com
```
The following are the arguments for the `add-permission` command:

--function-name

Name of the Lambda function. You add a new permission to update the function's resource policy.

--region

The AWS Region of your account.

--principal

The principal who is getting the permission. This should be `iot.amazonaws.com` to allow AWS IoT permission to call a Lambda function.

--source-arn

The ARN of the rule. You can use the `get-topic-rule` AWS CLI command to get the ARN of a rule.

--source-account

The AWS account where the rule is defined.

--statement-id

A unique statement identifier.

--action

The Lambda action that you want to allow in this statement. To allow AWS IoT to invoke a Lambda function, specify `lambda:InvokeFunction`.

**Important**

If you add a permission for an AWS IoT principal without providing the `source-arn` or `source-account`, any AWS account that creates a rule with your Lambda action can trigger rules to invoke your Lambda function from AWS IoT. For more information, see [Lambda Permission Model](#).

Given a JSON message payload like:

```json
{
    "attribute1": 21,
    "attribute2": "value"
}
```

The `aws.lambda` function can be used to call Lambda function as follows.

```sql
SELECT aws.lambda("arn:aws:lambda:us-east-1:account_id:function:lambda_function",
{"payload":attribute1}) as output FROM 'topic-filter'
```

If you want to pass the full MQTT message payload, you can specify the JSON payload using `"*"`, such as the following example.

```sql
SELECT aws.lambda("arn:aws:lambda:us-east-1:account_id:function:lambda_function", *) as output FROM 'topic-filter'
```

`payload.inner.element` selects data from messages published on topic `topic/subtopic`.

---

602
some.value selects data from the output that's generated by the Lambda function.

**Note**
The rules engine limits the execution duration of Lambda functions. Lambda function calls from rules should be completed within 2000 milliseconds.

### bitand(Int, Int)

Performs a bitwise AND on the bit representations of the two Int(-converted) arguments. Supported by SQL version 2015-10-08 and later.

Example: `bitand(13, 5) = 5`

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int, a bitwise AND of Int.</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Int, a bitwise AND of Int/Decimal. If the arguments cannot be converted to Int, the result is Undefined.</td>
</tr>
<tr>
<td>Int/Decimal/String</td>
<td>Int/Decimal/String</td>
<td>Int, the bitwise OR of Int/Decimal/Strings converted to Int. If the conversion fails, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

### bitor(Int, Int)

Performs a bitwise OR of the bit representations of the two arguments. Supported by SQL version 2015-10-08 and later.

Example: `bitor(8, 5) = 13`

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int, the bitwise OR of Int.</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Int, the bitwise OR of Int/Decimal. If the arguments cannot be converted to Int, the result is Undefined.</td>
</tr>
<tr>
<td>Int/Decimal/String</td>
<td>Int/Decimal/String</td>
<td>Int, the bitwise OR of Int/Decimal/Strings converted to Int. If the conversion fails, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

### bitxor(Int, Int)

Performs a bitwise XOR on the bit representations of the two Int(-converted) arguments. Supported by SQL version 2015-10-08 and later.

Example: `bitxor(13, 5) = 8`
### Argument type | Argument type | Result
--- | --- | ---
Int | Int | Int, a bitwise XOR on the two arguments.
Int/Decimal | Int/Decimal | Int, a bitwise XOR on the two arguments. Non-Int numbers are rounded down to the nearest Int.
Int/Decimal/String | Int/Decimal/String | Int, a bitwise XOR on the two arguments. Strings are converted to decimals and rounded down to the nearest Int. If any conversion fails, the result is Undefined.
Other value | Other value | Undefined.

#### bitnot(Int)
Performs a bitwise NOT on the bit representations of the Int(-converted) argument. Supported by SQL version 2015-10-08 and later.

Example: `bitnot(13) = 2`

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int, a bitwise NOT of the argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Int, a bitwise NOT of the argument. The Decimal value is rounded down to the nearest Int.</td>
</tr>
<tr>
<td>String</td>
<td>Int, a bitwise NOT of the argument. Strings are converted to decimals and rounded down to the nearest Int. If any conversion fails, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value.</td>
</tr>
</tbody>
</table>

#### cast()
Converts a value from one data type to another. Cast behaves mostly like the standard conversions, with the addition of the ability to cast numbers to or from Booleans. If AWS IoT cannot determine how to cast one type to another, the result is Undefined. Supported by SQL version 2015-10-08 and later. Format: `cast(value as type)`.

Example:

`cast(true as Int) = 1`

The following keywords might appear after "as" when calling cast:

**For SQL version 2015-10-08 and 2016-03-23**

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>Casts value to String.</td>
</tr>
<tr>
<td>Nvarchar</td>
<td>Casts value to String.</td>
</tr>
<tr>
<td>Text</td>
<td>Casts value to String.</td>
</tr>
<tr>
<td>Ntext</td>
<td>Casts value to String.</td>
</tr>
<tr>
<td>Keyword</td>
<td>Result</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>varchar</td>
<td>Casts value to String.</td>
</tr>
<tr>
<td>Int</td>
<td>Casts value to Int.</td>
</tr>
<tr>
<td>Integer</td>
<td>Casts value to Int.</td>
</tr>
<tr>
<td>Double</td>
<td>Casts value to Decimal (with double precision).</td>
</tr>
</tbody>
</table>

**Additionally, for SQL version 2016-03-23**

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal</td>
<td>Casts value to Decimal.</td>
</tr>
<tr>
<td>Bool</td>
<td>Casts value to Boolean.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Casts value to Boolean.</td>
</tr>
</tbody>
</table>

**Casting rules:**

**Cast to decimal**

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>A Decimal with no decimal point.</td>
</tr>
</tbody>
</table>
| Decimal       | The source value.  
  **Note**  
  With SQL V2 (2016-03-23), numeric values that are whole numbers, such as 10.0, return an Int value (10) instead of the expected Decimal value (10.0). To reliably cast whole number numeric values as Decimal values, use SQL V1 (2015-10-08) for the rule query statement. |
| Boolean       | true = 1.0, false = 0.0. |
| String        | Tries to parse the string as a Decimal. AWS IoT attempts to parse strings matching the regex: ^-?\d+(\.\d+)?((?!E-?) \d+)?$"0","-.1.2","5E-12" are all examples of strings that are converted automatically to decimals. |
| Array         | Undefined. |
| Object        | Undefined. |
| Null          | Undefined. |
| Undefined     | Undefined. |

**Cast to int**

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The source value.</td>
</tr>
</tbody>
</table>
### Cast to Boolean

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>0 = False, any_nonzero_value = True.</td>
</tr>
<tr>
<td>Decimal</td>
<td>0 = False, any_nonzero_value = True.</td>
</tr>
<tr>
<td>Boolean</td>
<td>The source value.</td>
</tr>
<tr>
<td>String</td>
<td>&quot;true&quot; = True and &quot;false&quot; = False (case insensitive). Other string values = Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

### Cast to string

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>A string representation of the Int, in standard notation.</td>
</tr>
<tr>
<td>Decimal</td>
<td>A string representing the Decimal value, possibly in scientific notation.</td>
</tr>
<tr>
<td>Boolean</td>
<td>&quot;true&quot; or &quot;false&quot;, all lowercase.</td>
</tr>
<tr>
<td>String</td>
<td>&quot;true&quot;=True and &quot;false&quot;=False (case-insensitive). Other string values = Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>The array serialized to JSON. The result string is a comma-separated list enclosed in square brackets. String is quoted. Decimal, Int, and Boolean are not.</td>
</tr>
<tr>
<td>Argument type</td>
<td>Result</td>
</tr>
<tr>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Object</td>
<td>The object serialized to JSON. The JSON string is a comma-separated list of key-value pairs and begins and ends with curly braces. String is quoted. Decimal, Int, Boolean, and Null are not.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**ceil(Decimal)**

Rounds the given Decimal up to the nearest Int. Supported by SQL version 2015-10-08 and later.

Examples:

ceil(1.2) = 2

ceil(-1.2) = -1

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int, the argument value.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Int, the Decimal value rounded up to the nearest Int.</td>
</tr>
<tr>
<td>String</td>
<td>Int. The string is converted to Decimal and rounded up to the nearest Int. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**chr(String)**

Returns the ASCII character that corresponds to the given Int argument. Supported by SQL version 2015-10-08 and later.

Examples:

chr(65) = "A".

chr(49) = "1".

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The character corresponding to the specified ASCII value. If the argument is not a valid ASCII value, the result is Undefined.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The character corresponding to the specified ASCII value. The Decimal argument is rounded down to the nearest Int. If the argument is not a valid ASCII value, the result is Undefined.</td>
</tr>
<tr>
<td>Argument type</td>
<td>Result</td>
</tr>
<tr>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>If the String can be converted to a Decimal, it is rounded down to the nearest Int. If the argument is not a valid ASCII value, the result is Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**clientid()**

Returns the ID of the MQTT client sending the message, or n/a if the message wasn't sent over MQTT. Supported by SQL version 2015-10-08 and later.

Example:
```
clientid() = "123456789012"
```

**concat()**

Concatenates arrays or strings. This function accepts any number of arguments and returns a String or an Array. Supported by SQL version 2015-10-08 and later.

Examples:
```
concat() = Undefined.
concat(1) = "1".
concat([1, 2, 3], 4) = [1, 2, 3, 4].
concat([1, 2, 3], "hello") = [1, 2, 3,"hello"]
concat("con", "cat") = "concat"
concat(1, "hello") = "1hello"
concat("he","is","man") = "heisman"
concat([1, 2, 3], "hello", [4, 5, 6]) = [1, 2, 3,"hello", 4, 5, 6]
```

<table>
<thead>
<tr>
<th>Number of arguments</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Undefined.</td>
</tr>
<tr>
<td>1</td>
<td>The argument is returned unmodified.</td>
</tr>
<tr>
<td>2+</td>
<td>If any argument is an Array, the result is a single array containing all of the arguments. If no arguments are arrays, and at least one argument is a String, the result is the concatenation of the String representations of all</td>
</tr>
<tr>
<td>Number of arguments</td>
<td>Result</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>the arguments. Arguments are converted to strings using the standard conversions previously listed.</td>
</tr>
</tbody>
</table>

**cos(Decimal)**

Returns the cosine of a number in radians. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example:

\[
\cos(0) = 1.
\]

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Decimal (with double precision), the cosine of the argument. Imaginary results are returned as Undefined.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal (with double precision), the cosine of the argument. Imaginary results are returned as Undefined.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal (with double precision), the cosine of the argument. If the string cannot be converted to a Decimal, the result is Undefined. Imaginary results are returned as Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**cosh(Decimal)**

Returns the hyperbolic cosine of a number in radians. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: \[
cosh(2.3) = 5.037220649268761.
\]
<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>Decimal (with double precision), the hyperbolic cosine of the argument. If the string cannot be converted to a Decimal, the result is Undefined. Imaginary results are returned as Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**decode(value, decodingScheme)**

Use the `decode` function to decode an encoded value. If the decoded string is a JSON document, an addressable object is returned. Otherwise, the decoded string is returned as a string. The function returns NULL if the string cannot be decoded. This function supports decoding base64-encoded strings and Protocol Buffer (protobuf) message format.

Supported by SQL version 2016-03-23 and later.

- **value**
  A string value or any of the valid expressions, as defined in [AWS IoT SQL reference (p. 586)](https://aws.amazon.com), that return a string.

- **decodingScheme**
  A literal string representing the scheme used to decode the value. Currently, only 'base64' and 'proto' are supported.

**Decoding base64-encoded strings**

In this example, the message payload includes an encoded value.

```sql
{
    encoded_temp: "eyAidGVtcGVyYXR1cmUiOiAzMyB9Cg=="
}
```

The `decode` function in this SQL statement decodes the value in the message payload.

```sql
SELECT decode(encoded_temp,"base64").temperature AS temp from 'topic/subtopic'
```

Decoding the `encoded_temp` value results in the following valid JSON document, which allows the SELECT statement to read the temperature value.

```json
{ "temperature": 33 }
```

The result of the SELECT statement in this example is shown here.

```json
{ "temp": 33 }
```

If the decoded value was not a valid JSON document, the decoded value would be returned as a string.
Decoding protobuf message payload

You can use the decode SQL function to configure a Rule that can decode your protobuf message payload. For more information, see Decoding protobuf message payloads (p. 651).

The function signature looks like the following:

\[
\text{decode}(\text{ENCODED DATA}, \text{'proto'}, \text{'<S3 BUCKET NAME>'}, \text{'<S3 OBJECT KEY>'}, \text{'<PROTO NAME>'}, \text{'<MESSAGE TYPE>'})
\]

**ENCODED DATA**

Specifies the protobuf-encoded data to be decoded. If the entire message sent to the Rule is protobuf-encoded data, you can reference the raw binary incoming payload using *. Otherwise, this field must be a base-64 encoded JSON string and a reference to the string can be passed in directly.

1) To decode a raw binary protobuf incoming payload:

\[
\text{decode}(*, \text{'proto'}, \ldots)
\]

2) To decode a protobuf-encoded message represented by a base64-encoded string 'a.b':

\[
\text{decode}(a.b, \text{'proto'}, \ldots)
\]

**proto**

Specifies the data to be decoded in a protobuf message format. If you specify base64 instead of proto, this function will decode base64-encoded strings as JSON.

**S3 BUCKET NAME**

The name of the Amazon S3 bucket where you've uploaded your FileDescriptorSet file.

**S3 OBJECT KEY**

The object key that specifies the FileDescriptorSet file within the Amazon S3 bucket.

**PROTO NAME**

The name of the .proto file (excluding the extension) from which the FileDescriptorSet file was generated.

**MESSAGE TYPE**

The name of the protobuf message structure within the FileDescriptorSet file, to which the data to be decoded should conform.

An example SQL expression using the decode SQL function can look like the following:

\[
\text{SELECT VALUE decode}(*, \text{'proto'}, \text{'s3-bucket'}, \text{'messageformat.desc'}, \text{'myproto'}, \text{'messagetype'}) \text{ FROM 'some/topic'}
\]

- *

  Represents a binary incoming payload, which conforms to the protobuf message type called mymessagetype.

- messageformat.desc

  The FileDescriptorSet file stored in an Amazon S3 bucket named s3-bucket.
• myproto

  The original .proto file used to generate the FileDescriptorSet file named myproto.proto.

• messagetype

  The message type called messagetype (along with any imported dependencies) as defined in myproto.proto.

**encode(value, encodingScheme)**

Use the `encode` function to encode the payload, which potentially might be non-JSON data, into its string representation based on the encoding scheme. Supported by SQL version 2016-03-23 and later.

**value**

Any of the valid expressions, as defined in [AWS IoT SQL reference](https://docs.aws.amazon.com/iot/latest/developerguide/iot-sql-reference.html) (p. 586). You can specify `*` to encode the entire payload, regardless of whether it's in JSON format. If you supply an expression, the result of the evaluation is converted to a string before it is encoded.

**encodingScheme**

A literal string representing the encoding scheme you want to use. Currently, only 'base64' is supported.

**endwith(String, String)**

Returns a Boolean indicating whether the first String argument ends with the second String argument. If either argument is Null or Undefined, the result is Undefined. Supported by SQL version 2015-10-08 and later.

Example: `endwith("cat","at") = true`.

<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>String</td>
<td>True if the first argument ends in the second argument. Otherwise, false.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Both arguments are converted to strings using the standard conversion rules. Returns true if the first argument ends in the second argument. Otherwise, false. If either argument is Null or Undefined, the result is Undefined.</td>
</tr>
</tbody>
</table>

**exp(Decimal)**

Returns e raised to the Decimal argument. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: `exp(1) = e`.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Decimal (with double precision), e ^ argument.</td>
</tr>
<tr>
<td>Argument type</td>
<td>Result</td>
</tr>
<tr>
<td>---------------</td>
<td>--------</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal (with double precision), e^argument.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal (with double precision), e^argument. If the String cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**floor(Decimal)**

Rounds the given Decimal down to the nearest Int. Supported by SQL version 2015-10-08 and later.

Examples:

\[
\text{floor}(1.2) = 1 \\
\text{floor}(-1.2) = -2
\]

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int, the argument value.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Int, the Decimal value rounded down to the nearest Int.</td>
</tr>
<tr>
<td>String</td>
<td>Int. The string is converted to Decimal and rounded down to the nearest Int. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**get**

Extracts a value from a collection-like type (Array, String, Object). No conversion is applied to the first argument. Conversion applies as documented in the table to the second argument. Supported by SQL version 2015-10-08 and later.

Examples:

\[
\text{get(["a", "b", "c"], 1)} = "b" \\
\text{get({"a":"b"}, "a") = "b"} \\
\text{get("abc", 0)} = "a"
\]

<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Array</td>
<td>Any Type (converted to Int)</td>
<td>The item at the 0-based index of the Array provided by the second argument. If the conversion is unsuccessful, the result is Undefined. If the index is outside the bounds of the Array (negative or &gt;= array.length), the result is Undefined.</td>
</tr>
</tbody>
</table>
get_dynamodb(tableName, partitionKeyName, partitionKeyValue, sortKeyName, sortKeyValue, roleArn)

Retrieves data from a DynamoDB table. get_dynamodb() allows you to query a DynamoDB table while a rule is evaluated. You can filter or augment message payloads using data retrieved from DynamoDB. Supported by SQL version 2016-03-23 and later.

get_dynamodb() takes the following parameters:

tableName

The name of the DynamoDB table to query.

partitionKeyName

The name of the partition key. For more information, see DynamoDB Keys.

partitionKeyValue

The value of the partition key used to identify a record. For more information, see DynamoDB Keys.

sortKeyName

(Optional) The name of the sort key. This parameter is required only if the DynamoDB table queried uses a composite key. For more information, see DynamoDB Keys.

sortKeyValue

(Optional) The value of the sort key. This parameter is required only if the DynamoDB table queried uses a composite key. For more information, see DynamoDB Keys.

roleArn

The ARN of an IAM role that grants access to the DynamoDB table. The rules engine assumes this role to access the DynamoDB table on your behalf. Avoid using an overly permissive role. Grant the role only those permissions required by the rule. The following is an example policy that grants access to one DynamoDB table.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "dynamodb:GetItem",
        }
    ]
}
```
As an example of how to use `get_dynamodb()`, say you have a DynamoDB table that contains device ID and location information for all of your devices connected to AWS IoT. The following SELECT statement uses the `get_dynamodb()` function to retrieve the location for the specified device ID:

```sql
SELECT *, get_dynamodb("InServiceDevices", "deviceId", id, "arn:aws:iam::12345678910:role/getdynamo").location AS location FROM 'some/topic'
```

**Note**

- You can call `get_dynamodb()` a maximum of one time per SQL statement. Calling `get_dynamodb()` multiple times in a single SQL statement causes the rule to terminate without invoking any actions.
- If `get_dynamodb()` returns more than 8 KB of data, the rule's action may not be invoked.

### `get_mqtt_property(name)`

References any of the following MQTT5 headers: `contentType`, `payloadFormatIndicator`, `responseTopic`, and `correlationData`. This function takes any of the following literal strings as an argument: `content_type`, `format_indicator`, `response_topic`, and `correlation_data`. For more information, see the following **Function arguments** table.

**contentType**

String: A UTF-8 encoded string that describes the content of the publishing message.

**payloadFormatIndicator**

String: An Enum string value that indicates whether the payload is formatted as UTF-8. Valid values are `UNSPECIFIED_BYTES` and `UTF8_DATA`.

**responseTopic**

String: A UTF-8 encoded string that's used as the topic name for a response message. The response topic is used to describe the topic that the receiver should publish to as part of the request-response flow. The topic must not contain wildcard characters.

**correlationData**

String: The base64-encoded binary data used by the sender of the Request Message to identify which request the Response Message is for when it's received.

The following table shows the acceptable function arguments and their associated return types for the `get_mqtt_property` function:

<table>
<thead>
<tr>
<th>Function arguments</th>
<th>Returned data type (if present)</th>
<th>Returned data type (if not present)</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>get_mqtt_property(&quot;format_indicator&quot;)</code></td>
<td>String (UNSPECIFIED_BYTES or UTF8_DATA)</td>
<td>String (UNSPECIFIED_BYTES)</td>
</tr>
<tr>
<td><code>get_mqtt_property(&quot;content_type&quot;)</code></td>
<td>String</td>
<td>Undefined</td>
</tr>
</tbody>
</table>
### Functions

<table>
<thead>
<tr>
<th>SQL</th>
<th>Returned data type (if present)</th>
<th>Returned data type (if not present)</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>get_mqtt_property(&quot;response_topic&quot;)</code></td>
<td>String</td>
<td>Undefined</td>
</tr>
<tr>
<td><code>get_mqtt_property(&quot;correlation_data&quot;)</code></td>
<td>base64 encoded String</td>
<td>Undefined</td>
</tr>
<tr>
<td><code>get_mqtt_property(&quot;some_invalid_name&quot;)</code></td>
<td>Undefined</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

The following example Rules SQL references any of the following MQTT5 headers: contentType, payLoadFormatIndicator, responseTopic, and correlationData.

```sql
SELECT *, get_mqtt_property('content_type') as contentType,
       get_mqtt_property('format_indicator') as payloadFormatIndicator,
       get_mqtt_property('response_topic') as responseTopic,
       get_mqtt_property('correlation_data') as correlationData
FROM 'some/topic'
```

### get_secret(secretId, secretType, key, roleArn)

Retrieves the value of the encrypted SecretString or SecretBinary field of the current version of a secret in AWS Secrets Manager. For more information about creating and maintaining secrets, see CreateSecret, UpdateSecret, and PutSecretValue.

get_secret() takes the following parameters:

- **secretId**
  
  String: The Amazon Resource Name (ARN) or the friendly name of the secret to retrieve.

- **secretType**
  

  - **SecretString**
    
    - For secrets that you create as JSON objects by using the APIs, the AWS CLI, or the AWS Secrets Manager console:
      
      - If you specify a value for the key parameter, this function returns the value of the specified key.
      
      - If you don't specify a value for the key parameter, this function returns the entire JSON object.
    
    - For secrets that you create as non-JSON objects by using the APIs or the AWS CLI:
      
      - If you specify a value for the key parameter, this function fails with an exception.
      
      - If you don't specify a value for the key parameter, this function returns the contents of the secret.

  - **SecretBinary**
    
    - If you specify a value for the key parameter, this function fails with an exception.
    
    - If you don't specify a value for the key parameter, this function returns the secret value as a base64-encoded UTF-8 string.

- **key**
  
  (Optional) String: The key name inside a JSON object stored in the SecretString field of a secret. Use this value when you want to retrieve only the value of a key stored in a secret instead of the entire JSON object.
If you specify a value for this parameter and the secret doesn't contain a JSON object inside its `SecretString` field, this function fails with an exception.

**roleArn**

String: A role ARN with `secretsmanager:GetSecretValue` and `secretsmanager:DescribeSecret` permissions.

**Note**

This function always returns the current version of the secret (the version with the `AWSCURRENT` tag). The AWS IoT rules engine caches each secret for up to 15 minutes. As a result, the rules engine can take up to 15 minutes to update a secret. This means that if you retrieve a secret up to 15 minutes after an update with AWS Secrets Manager, this function might return the previous version.

This function is not metered, but AWS Secrets Manager charges apply. Because of the secret caching mechanism, the rules engine occasionally calls AWS Secrets Manager. Because the rules engine is a fully distributed service, you might see multiple Secrets Manager API calls from the rules engine during the 15-minute caching window.

**Examples:**

You can use the `get_secret` function in an authentication header in an HTTPS rule action, as in the following API key authentication example.

```
"API_KEY": "${get_secret('API_KEY', 'SecretString', 'API_KEY_VALUE', 'arn:aws:iam::12345678910:role/getsecret')}
```

For more information about the HTTPS rule action, see the section called "HTTP" (p. 521).

### get_thing_shadow(thingName, shadowName, roleARN)

Returns the specified shadow of the specified thing. Supported by SQL version 2016-03-23 and later.

**thingName**

String: The name of the thing whose shadow you want to retrieve.

**shadowName**

(Optional) String: The name of the shadow. This parameter is required only when referencing named shadows.

**roleArn**

String: A role ARN with `iot:GetThingShadow` permission.

**Examples:**

When used with a named shadow, provide the `shadowName` parameter.

```
SELECT * from 'topic/subtopic'
WHERE
  get_thing_shadow("MyThing","MyThingShadow","arn:aws:iam::123456789012:role
  AllowsThingShadowAccess")
  .state.reported.alarm = 'ON'
```

When used with an unnamed shadow, omit the `shadowName` parameter.
get_user_properties(userPropertyKey)

References User Properties, which is one type of property headers supported in MQTT5.

userProperty

String: A user property is a key-value pair. This function takes the key as an argument and returns an array of all values that match the associated key.

Function arguments

For the following User Properties in the message headers:

<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>some key</td>
<td>some value</td>
</tr>
<tr>
<td>a different key</td>
<td>a different value</td>
</tr>
<tr>
<td>some key</td>
<td>value with duplicate key</td>
</tr>
</tbody>
</table>

The following table shows the expected SQL behavior:

<table>
<thead>
<tr>
<th>SQL</th>
<th>Returned data type</th>
<th>Returned data value</th>
</tr>
</thead>
<tbody>
<tr>
<td>get_user_properties('some key')</td>
<td>Array of String</td>
<td>['some value', 'value with duplicate key']</td>
</tr>
<tr>
<td>get_user_properties('other key')</td>
<td>Array of String</td>
<td>['a different value']</td>
</tr>
<tr>
<td>get_user_properties()</td>
<td>Array of key-value</td>
<td>[{&quot;some key&quot;: &quot;some value&quot;}, {&quot;other key&quot;: &quot;a different value&quot;}, {&quot;some key&quot;: &quot;value with duplicate key&quot;}]</td>
</tr>
<tr>
<td></td>
<td>pair Objects</td>
<td></td>
</tr>
<tr>
<td>get_user_properties('non-existent key')</td>
<td>Undefined</td>
<td></td>
</tr>
</tbody>
</table>

The following example Rules SQL references User Properties (a type of MQTT5 property header) into the payload:

```
SELECT *, get_user_properties('user defined property key') as userProperty
FROM 'some/topic'
```

Hashing functions

AWS IoT provides the following hashing functions:
• md2
• md5
• sha1
• sha224
• sha256
• sha384
• sha512

All hash functions expect one string argument. The result is the hashed value of that string. Standard string conversions apply to non-string arguments. All hash functions are supported by SQL version 2015-10-08 and later.

Examples:
md2("hello") = "a9046c73e00331af68917d3804f70655"
md5("hello") = "5d41402abc4b2a76b9719d911017c592"

**indexOf(String, String)**

Returns the first index (0-based) of the second argument as a substring in the first argument. Both arguments are expected as strings. Arguments that are not strings are subjected to standard string conversion rules. This function does not apply to arrays, only to strings. Supported by SQL version 2016-03-23 and later.

Examples:
indexof("abcd", "bc") = 1

**isNull()**

Returns true if the argument is the Null value. Supported by SQL version 2015-10-08 and later.

Examples:
isNull(5) = false.
isNull(Null) = true.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>false</td>
</tr>
<tr>
<td>Decimal</td>
<td>false</td>
</tr>
<tr>
<td>Boolean</td>
<td>false</td>
</tr>
<tr>
<td>String</td>
<td>false</td>
</tr>
<tr>
<td>Array</td>
<td>false</td>
</tr>
<tr>
<td>Object</td>
<td>false</td>
</tr>
<tr>
<td>Null</td>
<td>true</td>
</tr>
</tbody>
</table>
### isUndefined()

Returns true if the argument is Undefined. Supported by SQL version 2016-03-23 and later.

Examples:

- `isUndefined(5) = false`
- `isUndefined(floor([1,2,3])) = true`

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>true</td>
</tr>
<tr>
<td>Int</td>
<td>false</td>
</tr>
<tr>
<td>Decimal</td>
<td>false</td>
</tr>
<tr>
<td>Boolean</td>
<td>false</td>
</tr>
<tr>
<td>String</td>
<td>false</td>
</tr>
<tr>
<td>Array</td>
<td>false</td>
</tr>
<tr>
<td>Object</td>
<td>false</td>
</tr>
<tr>
<td>Null</td>
<td>false</td>
</tr>
</tbody>
</table>

### length(String)

Returns the number of characters in the provided string. Standard conversion rules apply to non-String arguments. Supported by SQL version 2016-03-23 and later.

Examples:

- `length("hi") = 2`
- `length(false) = 5`

### ln(Decimal)

Returns the natural logarithm of the argument. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: `ln(e) = 1`
<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decimal</td>
<td>Decimal (with double precision), the natural log of the argument.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal (with double precision), the natural log of the argument. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**log(Decimal)**

Returns the base 10 logarithm of the argument. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: log(100) = 2.0.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Decimal (with double precision), the base 10 log of the argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal (with double precision), the base 10 log of the argument.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal (with double precision), the base 10 log of the argument. If the String cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**lower(String)**

Returns the lowercase version of the given String. Non-string arguments are converted to strings using the standard conversion rules. Supported by SQL version 2015-10-08 and later.

Examples:

lower("HELLO") = "hello".
lower(['"HELLO"']) = ["hello"].
**lpad(String, Int)**

Returns the String argument, padded on the left side with the number of spaces specified by the second argument. The Int argument must be between 0 and 1000. If the provided value is outside of this valid range, the argument is set to the nearest valid value (0 or 1000). Supported by SQL version 2015-10-08 and later.

Examples:

lpad("hello", 2) = " hello".
lpad(1, 3) = " 1"

<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>Int</td>
<td>String, the provided String with a number of spaces padded on the left side.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal</td>
<td>The Decimal argument is rounded down to the nearest Int and the String is padded on the left with the specified number of spaces.</td>
</tr>
<tr>
<td>String</td>
<td>String</td>
<td>The second argument is converted to a Decimal, which is rounded down to the nearest Int, and the String is padded with the specified number of spaces. If the second argument cannot be converted to an Int, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Int/Decimal/String</td>
<td>The first value is converted to a String using the standard conversions, and then the LPAD function is applied on that String. If it cannot be converted, the result is Undefined.</td>
</tr>
<tr>
<td>Any value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**ltrim(String)**

Removes all leading white space (tabs and spaces) from the provided String. Supported by SQL version 2015-10-08 and later.

Example:

ltrim(" h i ") = "hi".

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The String representation of the Int with all leading white space removed.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The String representation of the Decimal with all leading white space removed.</td>
</tr>
<tr>
<td>Boolean</td>
<td>The String representation of the Boolean (&quot;true&quot; or &quot;false&quot;) with all leading white space removed.</td>
</tr>
<tr>
<td>String</td>
<td>The argument with all leading white space removed.</td>
</tr>
</tbody>
</table>
### Functions

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Array</td>
<td>The String representation of the Array (using standard conversion rules) with all leading white space removed.</td>
</tr>
<tr>
<td>Object</td>
<td>The String representation of the Object (using standard conversion rules) with all leading white space removed.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

#### machinelearning_predict(modelId, roleArn, record)

Use the `machinelearning_predict` function to make predictions using the data from an MQTT message based on an Amazon SageMaker model. Supported by SQL version 2015-10-08 and later. The arguments for the `machinelearning_predict` function are:

- **modelId**
  - The ID of the model against which to run the prediction. The real-time endpoint of the model must be enabled.

- **roleArn**
  - The IAM role that has a policy with `machinelearning:Predict` and `machinelearning:GetMLModel` permissions and allows access to the model against which the prediction is run.

- **record**
  - The data to be passed into the SageMaker Predict API. This should be represented as a single layer JSON object. If the record is a multi-level JSON object, the record is flattened by serializing its values. For example, the following JSON:

```json
{ "key1": {"innerKey1": "value1"}, "key2": 0 }
```

would become:

```json
{ "key1": "{"innerKey1": "value1"}", "key2": 0 }
```

The function returns a JSON object with the following fields:

- **predictedLabel**
  - The classification of the input based on the model.

- **details**
  - Contains the following attributes:
    - **PredictiveModelType**
      - The model type. Valid values are REGRESSION, BINARY, MULTICLASS.
    - **Algorithm**
      - The algorithm used by SageMaker to make predictions. The value must be SGD.
  - **predictedScores**
    - Contains the raw classification score corresponding to each label.
predictedValue

The value predicted by SageMaker.

**mod(Decimal, Decimal)**

Returns the remainder of the division of the first argument by the second argument. Equivalent to `remainder(Decimal, Decimal)` (p. 629). You can also use "%" as an infix operator for the same modulo functionality. Supported by SQL version 2015-10-08 and later.

Example: \( \text{mod}(8, 3) = 2. \)

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int, the first argument</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Decimal, the first argument</td>
</tr>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
<td>If all strings convert to numbers, argument modulo the second operand. Otherwise, Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

**nanvl(AnyValue, AnyValue)**

Returns the first argument if it is a valid Decimal. Otherwise, the second argument is returned. Supported by SQL version 2015-10-08 and later.

Example: \( \text{nanvl}(8, 3) = 8. \)

<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undefined</td>
<td>Any value</td>
<td>The second argument</td>
</tr>
<tr>
<td>Null</td>
<td>Any value</td>
<td>The second argument</td>
</tr>
<tr>
<td>Decimal (NaN)</td>
<td>Any value</td>
<td>The second argument</td>
</tr>
<tr>
<td>Decimal (not NaN)</td>
<td>Any value</td>
<td>The first argument</td>
</tr>
<tr>
<td>Other value</td>
<td>Any value</td>
<td>The first argument</td>
</tr>
</tbody>
</table>

**newuuid()**

Returns a random 16-byte UUID. Supported by SQL version 2015-10-08 and later.

Example: \( \text{newuuid()} = 123a4567-b89c-12d3-e456-789012345000 \)

**numbytes(String)**

Returns the number of bytes in the UTF-8 encoding of the provided string. Standard conversion rules apply to non-String arguments. Supported by SQL version 2016-03-23 and later.

Examples:
numbytes("hi") = 2
numbytes("€") = 3

**parse_time(String, Long[, String])**

Use the `parse_time` function to format a timestamp into a human-readable date/time format. Supported by SQL version 2016-03-23 and later. To convert a timestamp string into milliseconds, see `time_to_epoch(String, String)` (p. 639).

The `parse_time` function expects the following arguments:

- **pattern**
  - (String) A date/time pattern that follows Joda-Time formats.
- **timestamp**
  - (Long) The time to be formatted in milliseconds since Unix epoch. See function `timestamp()` (p. 640).
- **timezone**
  - (String) The time zone of the formatted date/time. The default is "UTC". The function supports Joda-Time time zones. This argument is optional.

**Examples:**

When this message is published to the topic 'A/B', the payload "{ts": "1970.01.01 AD at 21:46:40 CST"} is sent to the S3 bucket:

```
{
   "topicRulePayload": {
       "sql": "SELECT parse_time("yyyy.MM.dd G 'at' HH:mm:ss z", 100000000, 'America/Belize') as ts FROM 'A/B'",
       "ruleDisabled": false,
       "awsIotSqlVersion": "2016-03-23",
       "actions": [
           {
               "s3": {
                   "roleArn": "arn:aws:iam::ACCOUNT_ID:rule:role/ROLE_NAME",
                   "bucketName": "BUCKET_NAME",
                   "key": "KEY_NAME"
               }
           }
       ],
       "ruleName": "RULE_NAME"
   }
}
```

When this message is published to the topic 'A/B', a payload similar to "{ts": "2017.06.09 AD at 17:19:46 UTC"} (but with the current date/time) is sent to the S3 bucket:

```
{
   "topicRulePayload": {
       "sql": "SELECT parse_time("yyyy.MM.dd G 'at' HH:mm:ss z", timestamp()) as ts FROM 'A/B'",
       "awsIotSqlVersion": "2016-03-23",
   }
}
```
"ruleDisabled": false,
"actions": [
  {
    "s3": {
      "roleArn": "arn:aws:iam::ACCOUNT_ID:rule:role/ROLE_NAME",
      "bucketName": "BUCKET_NAME",
      "key": "KEY_NAME"
    }
  },
  "ruleName": "RULE_NAME"
}
]

parse_time() can also be used as a substitution template. For example, when this message is published to the topic 'A/B', the payload is sent to the S3 bucket with key = "2017":

```
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'A/B'",
    "awsIotSqlVersion": "2016-03-23",
    "ruleDisabled": false,
    "actions": [{
      "s3": {
        "roleArn": "arn:aws:iam::ACCOUNT_ID:rule:role/ROLE_NAME",
        "bucketName": "BUCKET_NAME",
        "key": "${parse_time('yyyy', timestamp(), 'UTC')}"
      }
    }],
    "ruleName": "RULE_NAME"
  }
}
```

**power(Decimal, Decimal)**

Returns the first argument raised to the second argument. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later. Supported by SQL version 2015-10-08 and later.

Example: \(\text{power}(2, 5) = 32.0\).

<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>A Decimal (with double precision), raised to the second argument's power</td>
</tr>
<tr>
<td>Int/Decimal/String</td>
<td>Int/Decimal/String</td>
<td>A Decimal (with double precision), raised to the second argument's power, converted to Decimal</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**principal()**

Returns the principal that the device uses for authentication, based on how the triggering message was published. The following table describes the principal returned for each publishing method and protocol.
### How the message is published

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Protocol Type</th>
<th>Credential type</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQTT</td>
<td>MQTT</td>
<td>X.509 device certificate</td>
</tr>
<tr>
<td>AWS IoT console MQTT client</td>
<td>MQTT</td>
<td>IAM user or role</td>
</tr>
<tr>
<td>AWS CLI</td>
<td>HTTP</td>
<td>IAM user or role</td>
</tr>
<tr>
<td>AWS IoT Device SDK</td>
<td>MQTT</td>
<td>X.509 device certificate</td>
</tr>
<tr>
<td>AWS IoT Device SDK</td>
<td>MQTT over WebSocket</td>
<td>IAM user or role</td>
</tr>
</tbody>
</table>

The following examples show the different types of values that principal() can return:

- X.509 certificate thumbprint: `ba67293af50bf2506f5f93469686da660c7c844e7b3950bfb16813e0d31e9373`
- IAM role ID and session name: `ABCD1EFG3HIJK2LMNOP5:my-session-name`
- Returns a user ID: `ABCD1EFG3HIJK2LMNOP5`

### rand()

Returns a pseudorandom, uniformly distributed double between 0.0 and 1.0. Supported by SQL version 2015-10-08 and later.

Example:

```
rnd() = 0.8231909191640703
```

### regexp_matches(String, String)

Returns true if the string (first argument) contains a match for the regular expression (second argument). If you use `|` in the regular expression, use it with `()`.  

Examples:

```
regexp_matches("aaaa", "a{2,}" ) = true.
regexp_matches("aaaa", "b" ) = false.
regexp_matches("aaa", "(aaa|bbb)" ) = true.
regexp_matches("bbb", "(aaa|bbb)" ) = true.
regexp_matches("ccc", "(aaa|bbb)" ) = false.
```

**First argument:**

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The String representation of the Int.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The String representation of the Decimal.</td>
</tr>
<tr>
<td>Boolean</td>
<td>The String representation of the Boolean (&quot;true&quot; or &quot;false&quot;).</td>
</tr>
</tbody>
</table>
### Argument type | Result
---|---
String | The String.
Array | The String representation of the Array (using standard conversion rules).
Object | The String representation of the Object (using standard conversion rules).
Null | Undefined.
Undefined | Undefined.

**Second argument:**

Must be a valid regex expression. Non-string types are converted to String using the standard conversion rules. Depending on the type, the resultant string might not be a valid regular expression. If the (converted) argument is not a valid regex, the result is Undefined.

### regexp_replace(String, String, String)

Replaces all occurrences of the second argument (regular expression) in the first argument with the third argument. Reference capture groups with "\$". Supported by SQL version 2015-10-08 and later.

Example:

```sql
regexp_replace("abcd", "bc", "x") = "axd".
regexp_replace("abcd", "b(.*)d", "$1") = "ac".
```

### First argument:

| Argument type | Result |
---|---|
Int | The String representation of the Int. |
Decimal | The String representation of the Decimal. |
Boolean | The String representation of the Boolean ("true" or "false"). |
String | The source value. |
Array | The String representation of the Array (using standard conversion rules). |
Object | The String representation of the Object (using standard conversion rules). |
Null | Undefined. |
Undefined | Undefined. |

**Second argument:**

Must be a valid regex expression. Non-string types are converted to String using the standard conversion rules. Depending on the type, the resultant string might not be a valid regular expression. If the (converted) argument is not a valid regex expression, the result is Undefined.
Third argument:

Must be a valid regex replacement string. (Can reference capture groups.) Non-string types are converted to String using the standard conversion rules. If the (converted) argument is not a valid regex replacement string, the result is Undefined.

**regexp_substr(String, String)**

Finds the first match of the second parameter (regex) in the first parameter. Reference capture groups with ".". Supported by SQL version 2015-10-08 and later.

Example:

```java
regexp_substr("hihihello", "hi") = "hi"
regexp_substr("hihihello", "(hi)\*") = "hihi"
```

**First argument:**

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The String representation of the Int.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The String representation of the Decimal.</td>
</tr>
<tr>
<td>Boolean</td>
<td>The String representation of the Boolean (&quot;true&quot; or &quot;false&quot;).</td>
</tr>
<tr>
<td>String</td>
<td>The String argument.</td>
</tr>
<tr>
<td>Array</td>
<td>The String representation of the Array (using standard conversion rules).</td>
</tr>
<tr>
<td>Object</td>
<td>The String representation of the Object (using standard conversion rules).</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**Second argument:**

Must be a valid regex expression. Non-string types are converted to String using the standard conversion rules. Depending on the type, the resultant string might not be a valid regular expression. If the (converted) argument is not a valid regex expression, the result is Undefined.

**remainder(Decimal, Decimal)**

Returns the remainder of the division of the first argument by the second argument. Equivalent to mod(Decimal, Decimal) (p. 624). You can also use "%" as an infix operator for the same modulo functionality. Supported by SQL version 2015-10-08 and later.

Example: remainder(8, 3) = 2.

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>Int, the first argument</td>
</tr>
</tbody>
</table>
### Functions

<table>
<thead>
<tr>
<th>Left operand</th>
<th>Right operand</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>Decimal, the first argument modulo the second operand.</td>
</tr>
<tr>
<td>String/Int/Decimal</td>
<td>String/Int/Decimal</td>
<td>If all strings convert to decimals, the first argument modulo the second argument. Undefined otherwise.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

**replace(String, String, String)**

Replaces all occurrences of the second argument in the first argument with the third argument. Supported by SQL version 2015-10-08 and later.

Example:

```sql
replace("abcd", "bc", "x") = "axd".
```

```sql
replace("abcdabcd", "b", "x") = "axcdaxcd".
```

**All arguments**

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The String representation of the Int.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The String representation of the Decimal.</td>
</tr>
<tr>
<td>Boolean</td>
<td>The String representation of the Boolean (&quot;true&quot; or &quot;false&quot;).</td>
</tr>
<tr>
<td>String</td>
<td>The source value.</td>
</tr>
<tr>
<td>Array</td>
<td>The String representation of the Array (using standard conversion rules).</td>
</tr>
<tr>
<td>Object</td>
<td>The String representation of the Object (using standard conversion rules).</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**rpad(String, Int)**

Returns the string argument, padded on the right side with the number of spaces specified in the second argument. The Int argument must be between 0 and 1000. If the provided value is outside of this valid range, the argument is set to the nearest valid value (0 or 1000). Supported by SQL version 2015-10-08 and later.

Examples:

```sql
rpad("hello", 2) = "hello  ".
```

```sql
rpad(1, 3) = "1   ".
```
<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>Int</td>
<td>The String is padded on the right side with a number of spaces equal to the provided Int.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal</td>
<td>The Decimal argument is rounded down to the nearest Int and the string is padded on the right side with a number of spaces equal to the provided Int.</td>
</tr>
<tr>
<td>String</td>
<td>String</td>
<td>The second argument is converted to a Decimal, which is rounded down to the nearest</td>
</tr>
</tbody>
</table>
### round(Decimal)

Rounds the given Decimal to the nearest Int. If the Decimal is equidistant from two Int values (for example, 0.5), the Decimal is rounded up. Supported by SQL version 2015-10-08 and later.

Example: \( \text{Round}(1.2) = 1. \)
Round(1.5) = 2.
Round(1.7) = 2.
Round(-1.1) = -1.
Round(-1.5) = -2.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal is rounded down to the nearest Int.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal is rounded down to the nearest Int. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**rtrim(String)**

Removes all trailing white space (tabs and spaces) from the provided String. Supported by SQL version 2015-10-08 and later.

Examples:

```
rtrim(" h i ") = "hi"
```

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The String representation of the Int.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The String representation of the Decimal.</td>
</tr>
<tr>
<td>Boolean</td>
<td>The String representation of the Boolean (&quot;true&quot; or &quot;false&quot;).</td>
</tr>
<tr>
<td>Array</td>
<td>The String representation of the Array (using standard conversion rules).</td>
</tr>
<tr>
<td>Object</td>
<td>The String representation of the Object (using standard conversion rules).</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

**sign(Decimal)**

Returns the sign of the given number. When the sign of the argument is positive, 1 is returned. When the sign of the argument is negative, -1 is returned. If the argument is 0, 0 is returned. Supported by SQL version 2015-10-08 and later.

Examples:
sign(-7) = -1.
sign(0) = 0.
sign(13) = 1.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int, the sign of the Int value.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Int, the sign of the Decimal value.</td>
</tr>
<tr>
<td>String</td>
<td>Int, the sign of the Decimal value. The string is converted to a Decimal value, and the sign of the Decimal value is returned. If the String cannot be converted to a Decimal, the result is Undefined. Supported by SQL version 2015-10-08 and later.</td>
</tr>
<tr>
<td>Other value</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**sin(Decimal)**

Returns the sine of a number in radians. Decimal arguments are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: sin(0) = 0.0

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Decimal (with double precision), the sine of the argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal (with double precision), the sine of the argument.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal (with double precision), the sine of the argument. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**sinh(Decimal)**

Returns the hyperbolic sine of a number. Decimal values are rounded to double precision before function application. The result is a Decimal value of double precision. Supported by SQL version 2015-10-08 and later.

Example: sinh(2.3) = 4.936961805545957
### Argument type | Result
--- | ---
Int | Decimal (with double precision), the hyperbolic sine of the argument.
Decimal | Decimal (with double precision), the hyperbolic sine of the argument.
Boolean | Undefined.
String | Decimal (with double precision), the hyperbolic sine of the argument. If the string cannot be converted to a Decimal, the result is Undefined.
Array | Undefined.
Object | Undefined.
Null | Undefined.
Undefined | Undefined.

### sourceip()

Retrieves the IP address of a device or the router that connects to it. If your device is connected to the internet directly, the function will return the source IP address of the device. If your device is connected to a router that connects to the internet, the function will return the source IP address of the router. Supported by SQL version 2016-03-23. `sourceip()` doesn't take any parameters.

**Important**

A device's public source IP address is often the IP address of the last Network Address Translation (NAT) Gateway such as your internet service provider's router or cable modem.

Examples:

- `sourceip() = "192.158.1.38"
- `sourceip() = "1.102.103.104"
- `sourceip() = "2001:db8:ff00::12ab:34cd"

SQL example:

```
SELECT *, sourceip() as deviceIp FROM 'some/topic'
```

Examples of how to use the `sourceip()` function in AWS IoT Core rule actions:

**Example 1**

The following example shows how to call the () function as a substitution template in a DynamoDB action.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * AS message FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "dynamoDB": {
```
Example 2

The following example shows how to add the sourceip() function as an MQTT user property using substitution templates.

```json
{
  "topicRulePayload": {
    "sql": "SELECT * FROM 'some/topic'",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
      {
        "republish": {
          "topic": "${topic()}/republish",
          "roleArn": "arn:aws:iam::123456789012:role/aws_iot_republish",
          "headers": {
            "payloadFormatIndicator": "UTF8_DATA",
            "contentType": "rule/contentType",
            "correlationData": "cnVsZS8jb3jy2WkhdGlviBkYXRh",
            "userProperties": [
              {
                "key": "ruleKey1",
                "value": "ruleValue1"
              },
              {
                "key": "sourceip",
                "value": "${sourceip()}
              }
            ]
          }
        }
      }
    ]
  }
}
```

You can retrieve the source IP address from messages passing to AWS IoT Core rules from both Message Broker and Basic Ingest pathways. You can also retrieve the source IP for both IPv4 and IPv6 messages. The source IP will be displayed like the following:

IPv4: xxx.xxx.xxx.xxx

**Note**

The original source IP won't be passed through Republish action (p. 564).

### substring(String, Int[], Int[])

Expects a String followed by one or two Int values. For a String and a single Int argument, this function returns the substring of the provided String from the provided Int index (0-based, inclusive).
to the end of the String. For a String and two Int arguments, this function returns the substring of
the provided String from the first Int index argument (0-based, inclusive) to the second Int index
argument (0-based, exclusive). Indices that are less than zero are set to zero. Indices that are greater
than the String length are set to the String length. For the three argument version, if the first index is
greater than (or equal to) the second index, the result is the empty String.

If the arguments provided are not (String, Int), or (String, Int, Int), the standard conversions
are applied to the arguments to attempt to convert them into the correct types. If the types cannot be
converted, the result of the function is Undefined. Supported by SQL version 2015-10-08 and later.

Examples:

substring("012345", 0) = "012345".
substring("012345", 2) = "2345".
substring("012345", 2.745) = "2345".
substring(123, 2) = "3".
substring("012345", -1) = "012345".
substring(true, 1.2) = "true".
substring(false, -2.411E247) = "false".
substring("012345", 1, 3) = "12".
substring("012345", -50, 50) = "012345".
substring("012345", 3, 1) = "".

sql_version()  
Returns the SQL version specified in this rule. Supported by SQL version 2015-10-08 and later.

Example:

sql_version() = "2016-03-23"

sqrt(Decimal)  
Returns the square root of a number. Decimal arguments are rounded to double precision before
function application. Supported by SQL version 2015-10-08 and later.

Example: sqrt(9) = 3.0.

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The square root of the argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The square root of the argument.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>The square root of the argument. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
</tbody>
</table>
### startswith(String, String)

Returns Boolean, whether the first string argument starts with the second string argument. If either argument is `Null` or `Undefined`, the result is `Undefined`. Supported by SQL version 2015-10-08 and later.

Example:

```sql
startswith("ranger","ran") = true
```

### tan(Decimal)

Returns the tangent of a number in radians. Decimal values are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: `tan(3) = -0.1425465430742778`

---

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>String</td>
<td>String</td>
<td>Whether the first string starts with the second string. Both arguments are converted to strings using the standard conversion rules. Returns true if the first string starts with the second string. If either argument is <code>Null</code> or <code>Undefined</code>, the result is <code>Undefined</code>.</td>
</tr>
<tr>
<td>Other value</td>
<td>Other value</td>
<td>Both arguments are converted to strings. Returns true if the first string starts with the second string. If either argument is <code>Null</code> or <code>Undefined</code>, the result is <code>Undefined</code>.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Decimal (with double precision), the tangent of the argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal (with double precision), the tangent of the argument.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal (with double precision), the tangent of the argument. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Argument type</td>
<td>Result</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**tanh(Decimal)**

Returns the hyperbolic tangent of a number in radians. Decimal values are rounded to double precision before function application. Supported by SQL version 2015-10-08 and later.

Example: \( \text{tanh}(2.3) = 0.9800963962661914 \)

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Decimal (with double precision), the hyperbolic tangent of the argument.</td>
</tr>
<tr>
<td>Decimal</td>
<td>Decimal (with double precision), the hyperbolic tangent of the argument.</td>
</tr>
<tr>
<td>Boolean</td>
<td>Undefined.</td>
</tr>
<tr>
<td>String</td>
<td>Decimal (with double precision), the hyperbolic tangent of the argument. If the string cannot be converted to a Decimal, the result is Undefined.</td>
</tr>
<tr>
<td>Array</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Object</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**time_to_epoch(String, String)**

Use the `time_to_epoch` function to convert a timestamp string into a number of milliseconds in Unix epoch time. Supported by SQL version 2016-03-23 and later. To convert milliseconds to a formatted timestamp string, see `parse_time(String, Long[, String])` (p. 625).

The `time_to_epoch` function expects the following arguments:

- **timestamp**
  - (String) The timestamp string to be converted to milliseconds since Unix epoch. If the timestamp string doesn't specify a timezone, the function uses the UTC timezone.

- **pattern**
  - (String) A date/time pattern that follows [JDK11 Time Formats](https://docs.oracle.com/javase/8/docs/api/java/time/format/DateTimeFormatter.html).

Examples:

- `time_to_epoch("2020-04-03 09:45:18 UTC+01:00", "yyyy-MM-dd HH:mm:ss VV") = 1585903518000`  
- `time_to_epoch("18 December 2015", "dd MMM yyyy") = 1450396800000`
time_to_epoch("2007-12-03 10:15:30.592 America/Los_Angeles", "yyyy-MM-dd HH:mm:ss.SSS z") = 1196705730592

timestamp()

Returns the current timestamp in milliseconds from 00:00:00 Coordinated Universal Time (UTC), Thursday, 1 January 1970, as observed by the AWS IoT rules engine. Supported by SQL version 2015-10-08 and later.

Example: timestamp() = 1481825251155

topic(Decimal)

Returns the topic to which the message that triggered the rule was sent. If no parameter is specified, the entire topic is returned. The Decimal parameter is used to specify a specific topic segment, with 1 designating the first segment. For the topic foo/bar/baz, topic(1) returns foo, topic(2) returns bar, and so on. Supported by SQL version 2015-10-08 and later.

Examples:

```
(topic()) = "things/myThings/thingOne"
(topic(1)) = "things"
```

When Basic Ingest (p. 585) is used, the initial prefix of the topic ($aws/rules/rule-name) is not available to the topic() function. For example, given the topic:

```
$aws/rules/BuildingManager/Buildings/Building5/Floor2/Room201/Lights
```

topic() = "Buildings/Building5/Floor2/Room201/Lights"

topic(3) = "Floor2"

traceid()

Returns the trace ID (UUID) of the MQTT message, or Undefined if the message wasn't sent over MQTT. Supported by SQL version 2015-10-08 and later.

Example:

```
traceid() = "12345678-1234-1234-1234-123456789012"
```

transform(String, Object, Array)

Returns an array of objects that contains the result of the specified transformation of the Object parameter on the Array parameter.

Supported by SQL version 2016-03-23 and later.

**String**

The transformation mode to use. Refer to the following table for the supported transformation modes and how they create the Result from the Object and Array parameters.

**Object**

An object that contains the attributes to apply to each element of the Array.
Array

An array of objects into which the attributes of Object are applied.

Each object in this Array corresponds to an object in the function's response. Each object in the function's response contains the attributes present in the original object and the attributes provided by Object as determined by the transformation mode specified in String.

<table>
<thead>
<tr>
<th>String parameter</th>
<th>Object parameter</th>
<th>Array parameter</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>enrichArray</td>
<td>Object</td>
<td>Array of objects</td>
<td>An Array of objects in which each object contains the attributes of an element from the Array parameter and the attributes of the Object parameter.</td>
</tr>
<tr>
<td>Any other value</td>
<td>Any value</td>
<td>Any value</td>
<td>Undefined</td>
</tr>
</tbody>
</table>

**Note**
The array returned by this function is limited to 128 KiB.

**Transform function example 1**

This example shows how the `transform()` function produces a single array of objects from a data object and an array.

In this example, the following message is published to the MQTT topic A/B.

```json
{
    "attributes": {
        "data1": 1,
        "data2": 2
    },
    "values": [
        {
            "a": 3
        },
        {
            "b": 4
        },
        {
            "c": 5
        }
    ]
}
```

This SQL statement for a topic rule action uses the `transform()` function with a String value of `enrichArray`. In this example, Object is the attributes property from the message payload and Array is the values array, which contains three objects.

```
select value transform("enrichArray", attributes, values) from 'A/B'
```

Upon receiving the message payload, the SQL statement evaluates to the following response.

```json
[
]
```
Transform function example 2

This example shows how the `transform()` function can use literal values to include and rename individual attributes from the message payload.

In this example, the following message is published to the MQTT topic A/B. This is the same message that was used in the section called “Transform function example 1” (p. 641).

```json
{
    "attributes": {
        "data1": 1,
        "data2": 2
    },
    "values": [
        { "a": 3, },
        { "b": 4, },
        { "c": 5, }
    ]
}
```

This SQL statement for a topic rule action uses the `transform()` function with a `String` value of `enrichArray`. The `Object` in the `transform()` function has a single attribute named `key` with the value of `attributes.data1` in the message payload and `Array` is the values array, which contains the same three objects used in the previous example.

```sql
select value transform("enrichArray", {"key": attributes.data1}, values) from 'A/B'
```

Upon receiving the message payload, this SQL statement evaluates to the following response. Notice how the `data1` property is named `key` in the response.

```json
[  
    { "a": 3,  
      "key": 1  
    },
    { "b": 4,  
```
Transform function example 3

This example shows how the transform() function can be used in nested SELECT clauses to select multiple attributes and create new objects for subsequent processing.

In this example, the following message is published to the MQTT topic A/B.

```json
{
    "data1": "example",
    "data2": {
        "a": "first attribute",
        "b": "second attribute",
        "c": [
            {
                "x": {
                    "someInt": 5,
                    "someString": "hello"
                },
                "y": true
            },
            {
                "x": {
                    "someInt": 10,
                    "someString": "world"
                },
                "y": false
            }
        ]
    }
}
```

The object for this transform function is the object returned by the SELECT statement, which contains the a and b elements of the message's data2 object. The Array parameter consists of the two objects from the data2.c array in the original message.

```sql
SELECT value transform('enrichArray', (select a, b from data2), (select value c from data2)) from 'A/B'
```

With the preceding message, the SQL statement evaluates to the following response.

```json
[
    {
        "x": {
            "someInt": 5,
            "someString": "hello"
        },
        "y": true,
        "a": "first attribute",
        "b": "second attribute"
    },
    {
        "x": {
            "someInt": 10,
            "someString": "world"
        },
        "y": false
    }
]
```
The array returned in this response could be used with topic rule actions that support `batchMode`.

**trim(String)**

Removes all leading and trailing white space from the provided `String`. Supported by SQL version 2015-10-08 and later.

Example:

```
Trim(" hi ") = "hi"
```

<table>
<thead>
<tr>
<th>Argument type</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>The String representation of the Int with all leading and trailing white space removed.</td>
</tr>
<tr>
<td>Decimal</td>
<td>The String representation of the Decimal with all leading and trailing white space removed.</td>
</tr>
<tr>
<td>Boolean</td>
<td>The String representation of the Boolean (&quot;true&quot; or &quot;false&quot;) with all leading and trailing white space removed.</td>
</tr>
<tr>
<td>String</td>
<td>The String with all leading and trailing white space removed.</td>
</tr>
<tr>
<td>Array</td>
<td>The String representation of the Array using standard conversion rules.</td>
</tr>
<tr>
<td>Object</td>
<td>The String representation of the Object using standard conversion rules.</td>
</tr>
<tr>
<td>Null</td>
<td>Undefined.</td>
</tr>
<tr>
<td>Undefined</td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**trunc(Decimal, Int)**

Truncates the first argument to the number of Decimal places specified by the second argument. If the second argument is less than zero, it is set to zero. If the second argument is greater than 34, it is set to 34. Trailing zeroes are stripped from the result. Supported by SQL version 2015-10-08 and later.

Examples:

```
trunc(2.3, 0) = 2.
trunc(2.3123, 2) = 2.31.
trunc(2.888, 2) = 2.88.
```
trunc(2.00, 5) = 2.

<table>
<thead>
<tr>
<th>Argument type 1</th>
<th>Argument type 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Int</td>
<td>Int</td>
<td>The source value.</td>
</tr>
<tr>
<td>Int/Decimal</td>
<td>Int/Decimal</td>
<td>The first argument is divided by the second argument. If the second is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Int, the result is rounded down to the nearest Int.</td>
</tr>
<tr>
<td>Int/Decimal/String</td>
<td>Int/Decimal</td>
<td>The first argument is truncated to the length described by the second.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The second argument, if not an Int, is rounded down to the nearest Int.</td>
</tr>
<tr>
<td>Other value</td>
<td></td>
<td>Undefined.</td>
</tr>
</tbody>
</table>

**upper(String)**

Returns the uppercase version of the given String. Non-String arguments are converted to String using the standard conversion rules. Supported by SQL version 2015-10-08 and later.

Examples:

upper("hello") = "HELLO"

upper(['hello']) = ['"HELLO"]

**Literals**

You can directly specify literal objects in the SELECT and WHERE clauses of your rule SQL, which can be useful for passing information.

**Note**

Literals are available only when using SQL version 2016-03-23 or later.

JSON object syntax is used (key-value pairs, comma-separated, where keys are strings and values are JSON values, wrapped in curly brackets {}). For example:

Incoming payload published on topic topic/subtopic: {"lat_long": [47.606, -122.332]}

SQL statement: SELECT {'latitude': get(lat_long, 0),'longitude':get(lat_long, 1)} as lat_long FROM 'topic/subtopic'

The resulting outgoing payload would be: {"lat_long": {"latitude":47.606, "longitude":-122.332}}.

You can also directly specify arrays in the SELECT and WHERE clauses of your rule SQL, which allows you to group information. JSON syntax is used (wrap comma-separated items in square brackets [] to create an array literal). For example:

Incoming payload published on topic topic/subtopic: {"lat": 47.696, "long": -122.332}

SQL statement: SELECT [lat,long] as lat_long FROM 'topic/subtopic'

The resulting output payload would be: {"lat_long": [47.606,-122.332]}. 
Case statements

Case statements can be used for branching execution, like a switch statement.

Syntax:

```
CASE v WHEN t[1] THEN r[1]
    ... 
    WHEN t[n] THEN r[n]
ELSE r[e] END
```

The expression \( v \) is evaluated and matched for equality against the \( t[i] \) value of each \( WHEN \) clause. If a match is found, the corresponding \( r[i] \) expression becomes the result of the \( CASE \) statement. The \( WHEN \) clauses are evaluated in order so that if there's more than one matching clause, the result of the first matching clause becomes the result of the \( CASE \) statement. If there are no matches, \( r[e] \) of the \( ELSE \) clause is the result. If there's no match and no \( ELSE \) clause, the result is \( Undefined \).

CASE statements require at least one \( WHEN \) clause. An \( ELSE \) clause is optional.

For example:

Incoming payload published on topic \( \text{topic/subtopic} \):

```
{
    "color":"yellow"
}
```

SQL statement:

```
SELECT CASE color
    WHEN 'green' THEN 'go'
    WHEN 'yellow' THEN 'caution'
    WHEN 'red' THEN 'stop'
    ELSE 'you are not at a stop light' END as instructions
FROM \'\text{topic/subtopic}\'
```

The resulting output payload would be:

```
{
    "instructions":"caution"
}
```

Note

If \( v \) is \( Undefined \), the result of the case statement is \( Undefined \).

JSON extensions

You can use the following extensions to ANSI SQL syntax to facilitate work with nested JSON objects.

\( . \) Operator

This operator accesses members in embedded JSON objects and functions identically to ANSI SQL and JavaScript. For example:

```
SELECT foo.bar AS bar.baz FROM \'\text{topic/subtopic}\'
```
selects the value of the bar property in the foo object from the following message payload sent to the topic/subtopic topic.

```json
{
  "foo": {
    "bar": "RED",
    "bar1": "GREEN",
    "bar2": "BLUE"
  }
}
```

If a JSON property name includes a hyphen character or numeric characters, the 'dot' notation will not work. Instead, you must use the get function (p. 613) to extract the property's value.

In this example, the following message is sent to the iot/rules topic.

```json
{
  "mydata": {
    "item2": {
      "0": {
        "my-key": "myValue"
      }
    }
  }
}
```

Normally, the value of my-key would be identified as in this query.

```sql
SELECT * FROM iot/rules WHERE mydata.item2.0.my-key = "myValue"
```

However, because the property name my-key contains a hyphen and item2 contains a numeric character, the get function (p. 613) must be used as the following query shows.

```sql
SELECT * FROM iot/rules WHERE get(get(get(mydata,"item2"),"0"),"my-key") = "myValue"
```

* Operator

This functions in the same way as the * wildcard in ANSI SQL. It's used in the SELECT clause only and creates a new JSON object containing the message data. If the message payload is not in JSON format, * returns the entire message payload as raw bytes. For example:

```sql
SELECT * FROM topic/subtopic
```

Applying a Function to an Attribute Value

The following is an example JSON payload that might be published by a device:

```json
{
  "deviceid": "iot123",
  "temp": 54.98,
  "humidity": 32.43,
  "coords": {
    "latitude": 47.615694,
    "longitude": -122.3359976
  }
}
```
The following example applies a function to an attribute value in a JSON payload:

```
SELECT temp, md5(deviceid) AS hashed_id FROM topic/#
```

The result of this query is the following JSON object:

```
{
  "temp": 54.98,
  "hashed_id": "e37f81fb397e595c4ae8b5645b8cbbbd1"
}
```

**Substitution templates**

You can use a substitution template to augment the JSON data returned when a rule is triggered and AWS IoT performs an action. The syntax for a substitution template is `$\{expression\}$`, where `expression` can be any expression supported by AWS IoT in SELECT clauses, WHERE clauses, and AWS IoT rule actions (p. 502). This expression can be plugged into an action field on a rule, allowing you to dynamically configure an action. In effect, this feature substitutes a piece of information in an action. This includes functions, operators, and information present in the original message payload.

**Important**

Because an expression in a substitution template is evaluated separately from the “SELECT ...” statement, you can't reference an alias created using the AS clause. You can only reference information present in the original payload, functions (p. 598), and operators (p. 593).

For more information about supported expressions, see AWS IoT SQL reference (p. 586).

The following rule actions support substitution templates. Each action supports different fields that can be substituted.

- Apache Kafka (p. 503)
- CloudWatch alarms (p. 511)
- CloudWatch Logs (p. 513)
- CloudWatch metrics (p. 514)
- DynamoDB (p. 516)
- DynamoDBv2 (p. 518)
- Elasticsearch (p. 519)
- HTTP (p. 521)
- IoT Analytics (p. 548)
- AWS IoT Events (p. 550)
- AWS IoT SiteWise (p. 551)
- Kinesis Data Streams (p. 557)
- Kinesis Data Firehose (p. 555)
- Lambda (p. 558)
- Location (p. 560)
- OpenSearch (p. 563)
- Republish (p. 564)
- S3 (p. 566)
- SNS (p. 569)
Substitution templates appear in the action parameters within a rule:

```
{
    "sql": "SELECT *, timestamp() AS timestamp FROM 'my/iot/topic'",
    "ruleDisabled": false,
    "actions": [{
        "republish": {
            "topic": "${topic()}/republish",
            "roleArn": "arn:aws:iam::123456789012:role/my-iot-role"
        }
    ]
}
```

If this rule is triggered by the following JSON published to `my/iot/topic`:

```
{
    "deviceid": "iot123",
    "temp": 54.98,
    "humidity": 32.43,
    "coords": {
        "latitude": 47.615694,
        "longitude": -122.3359976
    }
}
```

Then this rule publishes the following JSON to `my/iot/topic/republish`, which AWS IoT substitutes from `${topic()}/republish`:

```
{
    "deviceid": "iot123",
    "temp": 54.98,
    "humidity": 32.43,
    "coords": {
        "latitude": 47.615694,
        "longitude": -122.3359976
    },
    "timestamp": 1579637878451
}
```

**Nested object queries**

You can use nested SELECT clauses to query for attributes within arrays and inner JSON objects. Supported by SQL version 2016-03-23 and later.

Consider the following MQTT message:

```
{
    "e": [
        { "n": "temperature", "u": "Cel", "t": 1234, "v": 22.5 },
        { "n": "light", "u": "lm", "t": 1235, "v": 135 },
        { "n": "acidity", "u": "pH", "t": 1235, "v": 7 }
    ]
}
```
Example

You can convert values to a new array with the following rule.

```sql
SELECT (SELECT VALUE n FROM e) as sensors FROM 'my/topic'
```

The rule generates the following output.

```
{
    "sensors": [
        "temperature",
        "light",
        "acidity"
    ]
}
```

Example

Using the same MQTT message, you can also query a specific value within a nested object with the following rule.

```sql
SELECT (SELECT v FROM e WHERE n = 'temperature') as temperature FROM 'my/topic'
```

The rule generates the following output.

```
{
    "temperature": [
        {
            "v": 22.5
        }
    ]
}
```

Example

You can also flatten the output with a more complicated rule.

```sql
SELECT get((SELECT v FROM e WHERE n = 'temperature'), 0).v as temperature FROM 'topic'
```

The rule generates the following output.

```
{
    "temperature": 22.5
}
```

**Working with binary payloads**

To handle your message payload as raw binary data (rather than a JSON object), you can use the `*` operator to refer to it in a SELECT clause.

**In this topic:**

- Binary payload examples (p. 651)
- Decoding protobuf message payloads (p. 651)
Binary payload examples

When you use * to refer to the message payload as raw binary data, you can add data to the rule. If you have an empty or a JSON payload, the resulting payload can have data added using the rule. The following shows examples of supported SELECT clauses.

- You can use the following SELECT clauses with only a * for binary payloads.
  
  ```
  SELECT * FROM 'topic/subtopic'
  
  SELECT * FROM 'topic/subtopic' WHERE timestamp() % 12 = 0
  ```

- You can also add data and use the following SELECT clauses.

  ```
  SELECT *, principal() as principal, timestamp() as time FROM 'topic/subtopic'
  
  SELECT encode(*, 'base64') AS data, timestamp() AS ts FROM 'topic/subtopic'
  ```

- You can also use these SELECT clauses with binary payloads.

  - The following refers to `device_type` in the WHERE clause.

    ```
    SELECT * FROM 'topic/subtopic' WHERE device_type = 'thermostat'
    ```

  - The following is also supported.

    ```
    {
      "sql": "SELECT * FROM 'topic/subtopic'",
      "actions": [
        {
          "republish": {
            "topic": "device/${device_id}"}
        }
      ]
    }
    ```

  The following rule actions don’t support binary payloads so you must decode them.

  - Some rule actions don’t support binary payload input, such as a [Lambda action](https://docs.aws.amazon.com/iot/core/latest/developer-guide/rule-actions.html#lambda-action), so you must decode binary payloads. The Lambda rule action can receive binary data, if it’s base64 encoded and in a JSON payload. You can do this by changing the rule to the following.

    ```
    SELECT encode(*, 'base64') AS data FROM 'my_topic'
    ```

  - The SQL statement doesn’t support string as input. To convert a string input to JSON, you can run the following command.

    ```
    SELECT decode(encode(*, 'base64'), 'base64') AS payload FROM 'topic'
    ```

Decoding protobuf message payloads

[Protocol Buffers (protobuf)](https://developers.google.com/protocol-buffers) is an open-source data format used to serialize structured data in a compact, binary form. It’s used for transmitting data over networks or storing it in files. Protobuf allows you to send data in small packet sizes and at a faster rate than other messaging formats. AWS IoT Core Rules support protobuf by providing the `decode(value, decodingScheme)` function, which allows...
you to decode protobuf-encoded message payloads to JSON format and route them to downstream services. This section details the step-by-step process to configure protobuf decoding in AWS IoT Core Rules.

In this section:
- Prerequisites (p. 652)
- Create descriptor files (p. 652)
- Upload descriptor files to S3 bucket (p. 653)
- Configure protobuf decoding in Rules (p. 654)
- Limitations (p. 654)
- Best practices (p. 654)

Prerequisites
- A basic understanding of Protocol Buffers (protobuf)
- The .proto files that define message types and related dependencies
- Installing Protobuf Compiler (protoc) on your system

Create descriptor files

If you already have your descriptor files, you can skip this step. A descriptor file (.desc) is a compiled version of a .proto file, which is a text file that defines the data structures and message types to be used in a protobuf serialization. To generate a descriptor file, you must define a .proto file and use the protoc compiler to compile it.

1. Create .proto files that define the message types. An example .proto file can look like the following:

```protobuf
syntax = "proto3";

message Person {
  optional string name = 1;
  optional int32 id = 2;
  optional string email = 3;
}
```

In this example .proto file, you use proto3 syntax and define message type Person. The Person message definition specifies three fields (name, id, and email). For more information about .proto file message formats, see Language Guide (proto3).

2. Use the protoc compiler to compile the .proto files and generate a descriptor file. An example command to create a descriptor (.desc) file can be the following:

```
protoc --descriptor_set_out=<FILENAME>.desc \ 
  --proto_path=<PATH_TO_IMPORTS_DIRECTORY> \ 
  --include_imports \ 
  <PROTO_FILENAME>.proto
```

This example command generates a descriptor file <FILENAME>.desc, which AWS IoT Core Rules can use to decode protobuf payloads that conform to the data structure defined in <PROTO_FILENAME>.proto.

- `--descriptor_set_out`
  Specifies the name of the descriptor file (<FILENAME>.desc) that should be generated.
• --proto_path

  Specifies the locations of any imported .proto files that are referenced by the file being compiled. You can specify the flag multiple times if you have multiple imported .proto files with different locations.

• --include_imports

  Specifies that any imported .proto files should also be compiled and included in the <FILENAME>.desc descriptor file.

• <PROTO_FILENAME>.proto

  Specifies the name of the .proto file that you want to compile.

For more information about the protoc reference, see API Reference.

Upload descriptor files to S3 bucket

After you create your descriptor files <FILENAME>.desc, upload the descriptor files <FILENAME>.desc to an Amazon S3 bucket, using the AWS API, AWS SDK, or the AWS Management Console.

Important considerations

• Make sure that you upload the descriptor files to an Amazon S3 bucket in your AWS account in the same AWS Region where you intend to configure your Rules.

• Make sure that you grant AWS IoT Core access to read the FileDescriptorSet from S3. If your S3 bucket has server-side encryption (SSE) disabled or if your S3 bucket is encrypted using Amazon S3-managed keys (SSE-S3), no additional policy configurations are required. This can be accomplished with the example bucket policy:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "Statement1",
      "Effect": "Allow",
      "Principal": {
        "Service": "iot.amazonaws.com"
      },
      "Action": "s3:Get*",
      "Resource": "arn:aws:s3:::<BUCKET NAME>/<FILENAME>.desc"
    }
  ]
}
```

• If your S3 bucket is encrypted using an AWS Key Management Service key (SSE-KMS), make sure that you grant AWS IoT Core permission to use the key when accessing your S3 bucket. You can do this by adding this statement to your key policy:

```json
{
  "Sid": "Statement1",
  "Effect": "Allow",
  "Principal": {
    "Service": "iot.amazonaws.com"
  },
  "Action": [
    "kms:Decrypt",
    "kms:GenerateDataKey*",
    "kms:DescribeKey"
  ],
  "Condition": {
    "StringEquals": {
      "aws:SourceArn": "arn:aws:s3:::<BUCKET NAME>/<FILENAME>.desc"
    }
  }
}
```
Configuring protobuf decoding in Rules

After you upload the descriptor files to your Amazon S3 bucket, configure a Rule that can decode your protobuf message payload format using the `decode(value, decodingScheme)` SQL function. A detailed function signature and example can be found in the `decode(value, decodingScheme)` SQL function of the AWS IoT SQL reference.

The following is an example SQL expression using the `decode(value, decodingScheme)` function:

```
SELECT VALUE decode(*, 'proto', '<BUCKET NAME>', '<FILENAME>.desc', '<PROTO_FILENAME>', '<PROTO_MESSAGE_TYPE>') FROM '<MY_TOPIC>'
```

In this example expression:

- You use the `decode(value, decodingScheme)` SQL function to decode the binary message payload referenced by `*`. This can be a binary protobuf-encoded payload or a JSON string that represents a base64-encoded protobuf payload.
- The message payload provided is encoded using the Person message type defined in `PROTO_FILENAME.proto`.
- The Amazon S3 bucket named `BUCKET NAME` contains the `FILENAME.desc` generated from `PROTO_FILENAME.proto`.

After you complete the configuration, publish a message to AWS IoT Core on the topic to which the Rule is subscribed.

Limitations

AWS IoT Core Rules support protobuf with the following limitations:

- Decoding protobuf message payloads within substitution templates is not supported.
- When decoding protobuf message payloads, you can use the `decode SQL function (p. 610)` within a single SQL expression up to two times.
- The maximum inbound payload size is 128 KiB (1KiB = 1024 bytes), the maximum outbound payload size is 128 KiB, and the maximum size for a FileDescriptorSet object stored in an Amazon S3 bucket is 32 KiB.
- Amazon S3 buckets encrypted with SSE-C encryption are not supported.

Best practices

Here are some best practices and troubleshooting tips.

- Back up your proto files in the Amazon S3 bucket.

  It’s a good practice to back up your proto files in case something goes wrong. For example, if you incorrectly modify the proto files without backups when running protoc, this can cause issues in your production stack. There are multiple ways to back up your files in an Amazon S3 bucket. For example,
you can use versioning in S3 buckets. For more information about how to back up files in Amazon S3 buckets, refer to the Amazon S3 Developer Guide.

- Configure AWS IoT logging to view log entries.

It's a good practice to configure AWS IoT logging so that you can check AWS IoT logs for your account in CloudWatch. When a rule's SQL query calls an external function, AWS IoT Core Rules generates a log entry with an eventType of FunctionExecution, which contains the reason field that will help you troubleshoot failures. Possible errors include an Amazon S3 object not found, or invalid protobuf file descriptor. For more information about how to configure AWS IoT logging and see the log entries, see Configure AWS IoT logging and Rules engine log entries.

- Update FileDescriptorSet using a new object key and update the object key in your Rule.

You can update FileDescriptorSet by uploading an updated descriptor file to your Amazon S3 bucket. Your updates to FileDescriptorSet can take up to 15 minutes to be reflected. To avoid this delay, it's a good practice to upload your updated FileDescriptorSet using a new object key, and update the object key in your Rule.

SQL versions

The AWS IoT rules engine uses an SQL-like syntax to select data from MQTT messages. The SQL statements are interpreted based on an SQL version specified with the awsIotSqlVersion property in a JSON document that describes the rule. For more information about the structure of JSON rule documents, see Creating a Rule (p. 497). The awsIotSqlVersion property lets you specify which version of the AWS IoT SQL rules engine that you want to use. When a new version is deployed, you can continue to use an earlier version or change your rule to use the new version. Your current rules continue to use the version with which they were created.

The following JSON example shows you how to specify the SQL version using the awsIotSqlVersion property.

```json
{
    "sql": "expression",
    "ruleDisabled": false,
    "awsIotSqlVersion": "2016-03-23",
    "actions": [
        {
            "republish": {
                "topic": "my-mqtt-topic",
                "roleArn": "arn:aws:iam::123456789012:role/my-iot-role"
            }
        }
    ]
}
```

AWS IoT currently supports the following SQL versions:

- 2016-03-23 – The SQL version built on 2016-03-23 (recommended).
- 2015-10-08 – The original SQL version built on 2015-10-08.
- beta – The most recent beta SQL version. This version could introduce breaking changes to your rules.

What's new in the 2016-03-23 SQL rules engine version

- Fixes for selecting nested JSON objects.
- Fixes for array queries.
- Intra-object query support. For more information, see Nested object queries (p. 649).
- Support to output an array as a top-level object.
• Addition of the `encode(value, encodingScheme)` function, which can be applied on JSON and non-JSON format data. For more information, see the `encode function (p. 612)`.

**Output an Array as a top-level object**

This feature allows a rule to return an array as a top-level object. For example, given the following MQTT message:

```json
{
    "a": {"b": "c"},
    "arr": [1, 2, 3, 4]
}
```

And the following rule:

```sql```
SELECT VALUE arr FROM 'topic'
```

The rule generates the following output.

```
[1,2,3,4]
```
AWS IoT Device Shadow service

The AWS IoT Device Shadow service adds shadows to AWS IoT thing objects. Shadows can make a device's state available to apps and other services whether the device is connected to AWS IoT or not. AWS IoT thing objects can have multiple named shadows so that your IoT solution has more options for connecting your devices to other apps and services.

AWS IoT thing objects don't have any named shadows until they are created explicitly; however, an unnamed, classic shadow is created for a thing when the thing is created. Shadows can be created, updated, and deleted by using the AWS IoT console. Devices, other web clients, and services can create, update, and delete shadows by using MQTT and the reserved MQTT topics (p. 120), HTTP using the Device Shadow REST API (p. 682), and the AWS CLI for AWS IoT. Because shadows are stored by AWS in the cloud, they can collect and report device state data from apps and other cloud services whether the device is connected or not.

Using shadows

Shadows provide a reliable data store for devices, apps, and other cloud services to share data. They enable devices, apps, and other cloud services to connect and disconnect without losing a device's state.

While devices, apps, and other cloud services are connected to AWS IoT, they can access and control the current state of a device through its shadows. For example, an app can request a change in a device's state by updating a shadow. AWS IoT publishes a message that indicates the change to the device. The device receives this message, updates its state to match, and publishes a message with its updated state. The Device Shadow service reflects this updated state in the corresponding shadow. The app can subscribe to the shadow's update or it can query the shadow for its current state.

When a device goes offline, an app can still communicate with AWS IoT and the device's shadows. When the device reconnects, it receives the current state of its shadows so that it can update its state to match that of its shadows, and then publish a message with its updated state. Likewise, when an app goes offline and the device state changes while it's offline, the device keeps the shadow updated so the app can query the shadows for its current state when it reconnects.

If your devices are frequently offline and you would like to configure your devices to receive delta messages after they reconnect, you can use the persistent session feature. For more information about the persistent session expiry period, see Persistent session expiry period.

Choosing to use named or unnamed shadows

The Device Shadow service supports named and unnamed, or classic, shadows. A thing object can have multiple named shadows, and no more than one unnamed shadow. The thing object can also have a reserved named shadow, which operates similarly to a named shadow except that you can't update its name. For more information, see Reserved named shadow.

A thing object can have both named and unnamed shadows at the same time; however, the API used to access each is slightly different, so it might be more efficient to decide which type of shadow would work best for your solution and use that type only. For more information about the API to access the shadows, see Shadow topics (p. 120).

With named shadows, you can create different views of a thing object's state. For example, you could divide a thing object with many properties into shadows with logical groups of properties, each identified by its shadow name. You could also limit access to properties by grouping them into different shadows and using policies to control access. For more information about policies to use with device shadows, see Actions, resources, and condition keys for AWS IoT and AWS IoT Core policies.
The classic, unnamed shadows are simpler, but somewhat more limited than the named shadows. Each AWS IoT thing object can have only one unnamed shadow. If you expect your IoT solution to have a limited need for shadow data, this might be how you want to get started using shadows. However, if you think you might want to add additional shadows in the future, consider using named shadows from the start.

Fleet indexing supports unnamed shadows and named shadows differently. For more information, see Manage fleet indexing (p. 886).

**Accessing shadows**

Every shadow has a reserved MQTT topic (p. 120) and HTTP URL (p. 682) that supports the get, update, and delete actions on the shadow.

Shadows use JSON shadow documents (p. 694) to store and retrieve data. A shadow's document contains a state property that describes these aspects of the device's state:

- **desired**
  
  Apps specify the desired states of device properties by updating the desired object.

- **reported**
  
  Devices report their current state in the reported object.

- **delta**
  
  AWS IoT reports differences between the desired and the reported state in the delta object.

The data stored in a shadow is determined by the state property of the update action's message body. Subsequent update actions can modify the values of an existing data object, and also add and delete keys and other elements in the shadow's state object. For more information about accessing shadows, see Using shadows in devices (p. 660) and Using shadows in apps and services (p. 663).

**Important**

Permission to make update requests should be limited to trusted apps and devices. This prevents the shadow's state property from being changed unexpectedly; otherwise, the devices and apps that use the shadow should be designed to expect the keys in the state property to change.

**Using shadows in devices, apps, and other cloud services**

Using shadows in devices, apps, and other cloud services requires consistency and coordination between all of these. The AWS IoT Device Shadow service stores the shadow state, sends messages when the shadow state changes, and responds to messages that change its state. The devices, apps, and other cloud services in your IoT solution must manage their state and keep it consistent with the device shadow's state.

The shadow state data is dynamic and can be altered by the devices, apps, and other cloud services with permission to access the shadow. For this reason, it is important to consider how each device, app, and other cloud service will interact with the shadow. For example:

- **Devices** should write only to the reported property of the shadow state when communicating state data to the shadow.

- **Apps and other cloud services** should write only to the desired property when communicating state change requests to the device through the shadow.
**Important**
The data contained in a shadow data object is independent from that of other shadows and other thing object properties, such as a thing’s attributes and the content of MQTT messages that a thing object’s device might publish. A device can, however, report the same data in different MQTT topics and shadows if necessary.
A device that supports multiple shadows must maintain the consistency of the data that it reports in the different shadows.

**Message order**

There is no guarantee that messages from the AWS IoT service will arrive at the device in any specific order. The following scenario shows what happens in this case.

Initial state document:

```
{
  "state": {
    "reported": {
      "color": "blue"
    },
    "version": 9,
    "timestamp": 123456776
  }
}
```

Update 1:

```
{
  "state": {
    "desired": {
      "color": "RED"
    },
    "version": 10,
    "timestamp": 123456777
  }
}
```

Update 2:

```
{
  "state": {
    "desired": {
      "color": "GREEN"
    },
    "version": 11,
    "timestamp": 123456778
  }
}
```

Final state document:

```
{
  "state": {
    "reported": {
      "color": "GREEN"
    },
    "version": 12,
    "timestamp": 123456779
  }
}
```
This results in two delta messages:

```
{  
  "state": {  
    "color": "RED"  
  },  
  "version": 11,  
  "timestamp": 123456778
}
```

```
{  
  "state": {  
    "color": "GREEN"  
  },  
  "version": 12,  
  "timestamp": 123456779
}
```

The device might receive these messages out of order. Because the state in these messages is cumulative, a device can safely discard any messages that contain a version number older than the one it is tracking. If the device receives the delta for version 12 before version 11, it can safely discard the version 11 message.

### Trim shadow messages

To reduce the size of shadow messages sent to your device, define a rule that selects only the fields your device needs then republishes the message on an MQTT topic to which your device is listening.

The rule is specified in JSON and should look like the following:

```
{  
  "sql": "SELECT state, version FROM 'aws/things/+/shadow/update/delta'",  
  "ruleDisabled": false,  
  "actions": [  
    {  
      "republish": {  
        "topic": "${topic(3)}/delta",  
        "roleArn": "arn:aws:iam:123456789012:role/my-iot-role"
      }
    }
  ]
}
```

The SELECT statement determines which fields from the message will be republished to the specified topic. A "+" wild card is used to match all shadow names. The rule specifies that all matching messages should be republished to the specified topic. In this case, the "topic()" function is used to specify the topic on which to republish. `topic(3)` evaluates to the thing name in the original topic. For more information about creating rules, see [Rules for AWS IoT](p. 494).

### Using shadows in devices

This section describes device communications with shadows using MQTT messages, the preferred method for devices to communicate with the AWS IoT Device Shadow service.

Shadow communications emulate a request/response model using the publish/subscribe communication model of MQTT. Every shadow action consists of a request topic, a successful response topic (accepted), and an error response topic (rejected).
If you want apps and services to be able to determine whether a device is connected, see Detecting a device is connected (p. 665).

**Important**
Because MQTT uses a publish/subscribe communication model, you should subscribe to the response topics before you publish a request topic. If you don’t, you might not receive the response to the request that you publish.

If you use an AWS IoT Device SDK (p. 1428) to call the Device Shadow service APIs, this is handled for you.

The examples in this section use an abbreviated form of the topic where the `ShadowTopicPrefix` can refer to either a named or an unnamed shadow, as described in this table.

Shadows can be named or unnamed (classic). The topics used by each differ only in the topic prefix. This table shows the topic prefix used by each shadow type.

<table>
<thead>
<tr>
<th><code>ShadowTopicPrefix</code> value</th>
<th>Shadow type</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>$aws/things/thingName/shadow</code></td>
<td>Unnamed (classic) shadow</td>
</tr>
<tr>
<td><code>$aws/things/thingName/shadow/name/shadowName</code></td>
<td>Named shadow</td>
</tr>
</tbody>
</table>

**Important**
Make sure that your app's or service's use of the shadows is consistent and supported by the corresponding implementations in your devices. For example, consider how shadows are created, updated, and deleted. Also consider how updates are handled in the device and the apps or services that access the device through a shadow. Your design should be clear about how the device's state is updated and reported and how your apps and services interact with the device and its shadows.

To create a complete topic, select the `ShadowTopicPrefix` for the type of shadow to which you want to refer, replace `thingName`, and `shadowName` if applicable, with their corresponding values, and then append that with the topic stub as shown in the following table. Remember that topics are case sensitive.

See Shadow topics (p. 120) for more information about the reserved topics for shadows.

**Initializing the device on first connection to AWS IoT**

After a device registers with AWS IoT, it should subscribe to these MQTT messages for the shadows that it supports.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Meaning</th>
<th>Action a device should take when this topic is received</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ShadowTopicPrefix/delete/accepted</code></td>
<td>The delete request was accepted and AWS IoT deleted the shadow.</td>
<td>The actions necessary to accommodate the deleted shadow, such as stop publishing updates.</td>
</tr>
<tr>
<td><code>ShadowTopicPrefix/delete/rejected</code></td>
<td>The delete request was rejected by AWS IoT and the shadow was not deleted. The message body contains the error information.</td>
<td>Respond to the error message in the message body.</td>
</tr>
<tr>
<td>Topic</td>
<td>Meaning</td>
<td>Action a device should take when this topic is received</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td><strong>ShadowTopicPrefix/get/accepted</strong></td>
<td>The get request was accepted by AWS IoT, and the message body contains the current shadow document.</td>
<td>The actions necessary to process the state document in the message body.</td>
</tr>
<tr>
<td><strong>ShadowTopicPrefix/get/rejected</strong></td>
<td>The get request was rejected by AWS IoT, and the message body contains the error information.</td>
<td>Respond to the error message in the message body.</td>
</tr>
<tr>
<td><strong>ShadowTopicPrefix/update/accepted</strong></td>
<td>The update request was accepted by AWS IoT, and the message body contains the current shadow document.</td>
<td>Confirm the updated data in the message body matches the device state.</td>
</tr>
<tr>
<td><strong>ShadowTopicPrefix/update/rejected</strong></td>
<td>The update request was rejected by AWS IoT, and the message body contains the error information.</td>
<td>Respond to the error message in the message body.</td>
</tr>
<tr>
<td><strong>ShadowTopicPrefix/update/delta</strong></td>
<td>The shadow document was updated by a request to AWS IoT, and the message body contains the changes requested.</td>
<td>Update the device's state to match the desired state in the message body.</td>
</tr>
<tr>
<td><strong>ShadowTopicPrefix/update/documents</strong></td>
<td>An update to the shadow was recently completed, and the message body contains the current shadow document.</td>
<td>Confirm the updated state in the message body matches the device's state.</td>
</tr>
</tbody>
</table>

After subscribing to the messages in the preceding table for each shadow, the device should test to see if the shadows that it supports have already been created by publishing a /get topic to each shadow. If a /get/accepted message is received, the message body contains the shadow document, which the device can use to initialize its state. If a /get/rejected message is received, the shadow should be created by publishing an /update message with the current device state.

For example, suppose you have a thing `My_IoT_Thing` which doesn't have any classic or named shadows. If you now publish a /get request on the reserved topic `$aws/things/My_IoT_Thing/shadow/get`, it returns an error on the `$aws/things/My_IoT_Thing/shadow/get/rejected` topic because the thing doesn't have any shadows. To resolve this error, first publish an /update message by using the `$aws/things/My_IoT_Thing/shadow/update` topic with the current device state such as the following payload.

```json
{
  "state": {
    "reported": {
      "welcome": "aws-iot",
      "color": "yellow"
    }
  }
}
```

A classic shadow is now created for the thing and the message is published to the `$aws/things/My_IoT_Thing/shadow/update/accepted` topic. If you publish to the topic `$aws/things/My_IoT_Thing/shadow/get`, it returns a response to the `$aws/things/My_IoT_Thing/shadow/get/accepted` topic with the device state.
For named shadows, you must first create the named shadow or publish an update with the shadow name before using the get request. For example, to create a named shadow namedShadow1, first publish the device state information to the topic \$aws/things/My_IoT_Thing/shadow/name/namedShadow1/update. To retrieve the state information, use the /get request for the named shadow, \$aws/things/My_IoT_Thing/shadow/name/namedShadow1/get.

Processing messages while the device is connected to AWS IoT

While a device is connected to AWS IoT, it can receive /update/delta messages and should keep the device state matched to the changes in its shadows by:

1. Reading all /update/delta messages received and synchronizing the device state to match.
2. Publishing an /update message with a reported message body that has the device's current state, whenever the device's state changes.

While a device is connected, it should publish these messages when indicated.

<table>
<thead>
<tr>
<th>Indication</th>
<th>Topic</th>
<th>Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>The device's state has changed.</td>
<td>ShadowTopicPrefix/update</td>
<td>A shadow document with the reported property.</td>
</tr>
<tr>
<td>The device might not be synchronized with the shadow.</td>
<td>ShadowTopicPrefix/get</td>
<td>(empty)</td>
</tr>
<tr>
<td>An action on the device indicates that a shadow will no longer be supported by the device, such as when the device is being removed or replaced.</td>
<td>ShadowTopicPrefix/delete</td>
<td>(empty)</td>
</tr>
</tbody>
</table>

Processing messages when the device reconnects to AWS IoT

When a device with one or more shadows connects to AWS IoT, it should synchronize its state with that of all the shadows that it supports by:

1. Reading all /update/delta messages received and synchronizing the device state to match.
2. Publishing an /update message with a reported message body that has the device's current state.

Using shadows in apps and services

This section describes how an app or service interacts with the AWS IoT Device Shadow service. This example assumes the app or service is interacting only with the shadow and, through the shadow, the device. This example doesn't include any management actions, such as creating or deleting shadows.

This example uses the AWS IoT Device Shadow service's REST API to interact with shadows. Unlike the example used in Using shadows in devices (p. 660), which uses a publish/subscribe communications...
model, this example uses the request/response communications model of the REST API. This means the app or service must make a request before it can receive a response from AWS IoT. A disadvantage of this model, however, is that it does not support notifications. If your app or service requires timely notifications of device state changes, consider the MQTT or MQTT over WSS protocols, which support the publish/subscribe communication model, as described in Using shadows in devices (p. 660).

**Important**

Make sure that your app's or service's use of the shadows is consistent with and supported by the corresponding implementations in your devices. Consider, for example, how shadows are created, updated, and deleted, and how updates are handled in the device and the apps or services that access the shadow. Your design should clearly specify how the device's state is updated and reported, and how your apps and services interact with the device and its shadows.

The REST API's URL for a named shadows is:

```
https://endpoint/things/thingName/shadow?name=shadowName
```

and for an unnamed shadow:

```
https://endpoint/things/thingName/shadow
```

where:

- **endpoint**
  
  The endpoint returned by the CLI command:

  ```
  aws iot describe-endpoint --endpoint-type IOT:Data-ATS
  ```

- **thingName**
  
  The name of the thing object to which the shadow belongs

- **shadowName**
  
  The name of the named shadow. This parameter is not used with unnamed shadows.

### Initializing the app or service on connection to AWS IoT

When the app first connects to AWS IoT, it should send an HTTP GET request to the URLs of the shadows it uses to get the current state of the shadows it's using. This allows it to sync the app or service to the shadow.

### Processing state changes while the app or service is connected to AWS IoT

While the app or service is connected to AWS IoT, it can query the current state periodically by sending an HTTP GET request on the URLs of the shadows it uses.

When an end user interacts with the app or service to change the state of the device, the app or service can send an HTTP POST request to the URLs of the shadows it uses to update the desired state of the
Detecting a device is connected

To determine if a device is currently connected, include a connected property in the shadow document and use an MQTT Last Will and Testament (LWT) message to set the connected property to false if a device is disconnected due to an error.

**Note**

MQTT LWT messages sent to AWS IoT reserved topics (topics that begin with $) are ignored by the AWS IoT Device Shadow service. However, they are processed by subscribed clients and by the AWS IoT rules engine, so you will need to create an LWT message that is sent to a non-reserved topic and a rule that republishes the MQTT LWT message as a shadow update message to the shadow's reserved update topic, ShadowTopicPrefix/update.

To send the Device Shadow service an LWT message

1. Create a rule that republishes the MQTT LWT message on the reserved topic. The following example is a rule that listens for messages on the my/things/myLightBulb/update topic and republishes it to $aws/things/myLightBulb/shadow/update topic and republishes it to $aws/things/myLightBulb/shadow/update.

   ```json
   {
   "rule": {
   "ruleDisabled": false,
   "sql": "SELECT * FROM 'my/things/myLightBulb/update'",
   "description": "Turn my/things/ into $aws/things/",
   "actions": [
   {
   "republish": {
   "topic": "$aws/things/myLightBulb/shadow/update",
   "roleArn": "arn:aws:iam:123456789012:role/aws_iot_republish"
   }
   ]
   }
   }
   ```

2. When the device connects to AWS IoT, it registers an LWT message to a non-reserved topic for the republish rule to recognize. In this example, that topic is my/things/myLightBulb/update and it sets the connected property to false.

   ```json
   {
   "state": {
   "reported": {
   "connected": "false"
   }
   }
   }
   ```

3. After connecting, the device publishes a message on its shadow update topic, $aws/things/myLightBulb/shadow/update, to report its current state, which includes setting its connected property to true.

   ```json
   {
   "state": {
   "reported": {
   "connected": "true"
   }
   }
   ```
Before the device disconnects gracefully, it publishes a message on its shadow update topic, $aws/things/myLightBulb/shadow/update, to report its latest state, which include setting its connected property to false.

```json
{
   "state": {
      "reported": {
         "connected": "false"
      }
   }
}
```

If the device disconnects due to an error, the AWS IoT message broker publishes the device's LWT message on behalf of the device. The republish rule detects this message and publishes the shadow update message to update the connected property of the device shadow.

## Simulating Device Shadow service communications

This topic demonstrates how the Device Shadow service acts as an intermediary and allows devices and apps to use a shadow to update, store, and retrieve a device's state.

To demonstrate the interaction described in this topic, and to explore it further, you'll need an AWS account and a system on which you can run the AWS CLI. If you don't have these, you can still see the interaction in the code examples.

In this example, the AWS IoT console represents the device. The AWS CLI represents the app or service that accesses the device by way of the shadow. The AWS CLI interface is very similar to the API that an app might use to communicate with AWS IoT. The device in this example is a smart light bulb and the app displays the light bulb's state and can change the light bulb's state.

### Setting up the simulation

These procedures initialize the simulation by opening the AWS IoT console, which simulates your device, and the command line window that simulates your app.

#### To set up your simulation environment

1. You'll need an AWS account to run the examples from this topic on your own. If you don't have an AWS account, create one, as described in [Set up your AWS account](p. 18).
2. Open the [AWS IoT console](https://console.aws.amazon.com/iot), and in the left menu, choose **Test** to open the **MQTT client**.
3. In another window, open a terminal window on a system that has the AWS CLI installed on it.

You should have two windows open: one with the AWS IoT console on the **Test** page, and one with a command line prompt.

### Initialize the device

In this simulation, we'll be working with a thing object named, `mySimulatedThing`, and its shadow named, `simShadow1`.

**Create thing object and its IoT policy**
To create a thing object, in the **AWS IoT Console**:

1. Choose **Manage** and then choose **Things**.
2. Click the **Create** button if things are listed otherwise click **Register a single thing** to create a single AWS IoT thing.
3. Enter the name `mySimulatedThing`, leave other settings to default, and then click **Next**.
4. Use one-click certificate creation to generate the certificates that will authenticate the device's connection to AWS IoT. Click **Activate** to activate the certificate.
5. You can attach the policy `My_IoT_Policy` that would give the device permission to publish and subscribe to the MQTT reserved topics. For more detailed steps about how to create an AWS IoT thing and how to create this policy, see [Create a thing object](#) (p. 40).

**Create named shadow for the thing object**

You can create a named shadow for a thing by publishing an update request to the topic `$aws/things/mySimulatedThing/shadow/name/simShadow1/update` as described below.

Alternatively, to create a named shadow:

1. In the **AWS IoT Console**, choose your thing object in the list of things displayed and then choose **Shadows**.
2. Choose **Add a shadow**, enter the name `simShadow1`, and then choose **Create** to add the named shadow.

**Subscribe and publish to reserved MQTT topics**

In the console, subscribe to the reserved MQTT shadow topics. These topics are the responses to the get, update, and delete actions so that your device will be ready to receive the responses after it publishes an action.

**To subscribe to an MQTT topic in the MQTT client**

1. In the **MQTT client**, choose **Subscribe to a topic**.
2. Enter the get, update, and delete topics to subscribe to. Copy one topic at a time from the following list, paste it in the **Topic filter** field, and then click **Subscribe**. You should see the topics appear under **Subscriptions**.

   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/delete/accepted`
   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/delete/rejected`
   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/get/accepted`
   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/get/rejected`
   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/update/accepted`
   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/update/rejected`
   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/update/delta`
   - `$aws/things/mySimulatedThing/shadow/name/simShadow1/update/documents`

At this point, your simulated device is ready to receive the topics as they are published by AWS IoT.

**To publish to an MQTT topic in the MQTT client**

After a device has initialized itself and subscribed to the response topics, it should query for the shadows it supports. This simulation supports only one shadow, the shadow that supports a thing object named, `mySimulatedThing`, named, `simShadow1`. 
To get the current shadow state from the MQTT client

1. In the MQTT client, choose Publish to a topic.
2. Under Publish, enter the following topic and delete any content from the message body window below where you entered the topic to get. You can then choose Publish to topic to publish the request. $aws/things/mySimulatedThing/shadow/name/simShadow1/get.

If you haven't created the named shadow, simShadow1, you receive a message in the $aws/things/mySimulatedThing/shadow/name/simShadow1/get/rejected topic and the code is 404, such as in this example as the shadow has not been created, so we'll create it next.

```
{
  "code": 404,
  "message": "No shadow exists with name: 'simShadow1'"
}
```

To create a shadow with the current status of the device

1. In the MQTT client, choose Publish to a topic and enter this topic:

   $aws/things/mySimulatedThing/shadow/name/simShadow1/update

2. In the message body window below where you entered the topic, enter this shadow document to show the device is reporting its ID and its current color in RGB values. Choose Publish to publish the request.

   ```
   {
   "state": {
       "reported": {
           "ID": "SmartLamp21",
           "ColorRGB": [128, 128, 128]
       },
       "clientToken": "426bfd96-e720-46d3-95cd-014e3ef12bb6"
   }
   }
   ```

If you receive a message in the topic:

- $aws/things/mySimulatedThing/shadow/name/simShadow1/update/accepted: It means that the shadow was created and the message body contains the current shadow document.
- $aws/things/mySimulatedThing/shadow/name/simShadow1/update/rejected: Review the error in the message body.
- $aws/things/mySimulatedThing/shadow/name/simShadow1/get/accepted: The shadow already exists and the message body has the current shadow state, such as in this example. With this, you could set your device or confirm that it matches the shadow state.

```
{
  "state": {
      "reported": {
          "ID": "SmartLamp21",
          "ColorRGB": [128,
```
Send an update from the app

This section uses the AWS CLI to demonstrate how an app can interact with a shadow.

To get the current state of the shadow using the AWS CLI

From the command line, enter this command.

```bash
aws iot-data get-thing-shadow --thing-name mySimulatedThing --shadow-name simShadow1 /dev/stdout
```

On Windows platforms, you can use `con` instead of `/dev/stdout`.

```bash
aws iot-data get-thing-shadow --thing-name mySimulatedThing --shadow-name simShadow1 con
```

Because the shadow exists and had been initialized by the device to reflect its current state, it should return the following shadow document.

```
{
  "state": {
    "reported": {
      "ID": "SmartLamp21",
      "ColorRGB": [
        128,
        128,
        128
      ]
    },
    "metadata": {
      "reported": {
        "ID": {
          "timestamp": 1591140517
        },
        "ColorRGB": [
          {
            "timestamp": 1591140517
          },
          {
            "timestamp": 1591140517
          },
          {
            "timestamp": 1591140517
          }
        ]
      },
      "version": 3,
      "timestamp": 1591140517,
      "clientToken": "426bfd96-e720-46d3-95cd-014e3ef12bb6"
    }
  }
}
"timestamp": 1591140517,
"ColorRGB": [
{
"timestamp": 1591140517
},
{
"timestamp": 1591140517
},
{
"timestamp": 1591140517
}
],
"version": 3,
"timestamp": 1591141111
}

The app can use this response to initialize its representation of the device state.

If the app updates the state, such as when an end user changes the color of our smart light bulb to yellow, the app would send an `update-thing-shadow` command. This command corresponds to the UpdateThingShadow REST API.

**To update a shadow from an app**

From the command line, enter this command.

**AWS CLI v2.x**

```bash
aws iot-data update-thing-shadow --thing-name mySimulatedThing --shadow-name simShadow1 \
--cli-binary-format raw-in-base64-out \
--payload '{"state":{"desired":{"ColorRGB": [255, 255, 0]}},"clientToken":"21b21b21-bfd2-4279-8c65-e2f697ff4fab"}' /dev/stdout
```

**AWS CLI v1.x**

```bash
aws iot-data update-thing-shadow --thing-name mySimulatedThing --shadow-name simShadow1 \
--payload '{"state":{"desired":{"ColorRGB": [255, 255, 0]}},"clientToken":"21b21b21-bfd2-4279-8c65-e2f697ff4fab"}' /dev/stdout
```

If successful, this command should return the following shadow document.

```json
{
  "state": {
    "desired": {
      "ColorRGB": [255, 255, 0]
    }
  },
  "metadata": {
    "desired": {
      "ColorRGB": [
      "timestamp": 1591141596
    }
  }
}
```
Respond to update in device

Returning to the **MQTT client** in the AWS console, you should see the messages that AWS IoT published to reflect the update command issued in the previous section.

**To view the update messages in the MQTT client**

In the **MQTT client**, choose `$aws/things/mySimulatedThing/shadow/name/simShadow1/update/delta` in the **Subscriptions** column. If the topic name is truncated, you can pause on it to see the full topic. In the topic log of this topic, you should see a `/delta` message similar to this one.

```
{
  "version": 4,
  "timestamp": 1591141596,
  "state": {
    "ColorRGB": [255, 255, 0]
  },
  "metadata": {
    "ColorRGB": [
      {
        "timestamp": 1591141596
      },
      {
        "timestamp": 1591141596
      },
      {
        "timestamp": 1591141596
      }
    ]
  },
  "clientToken": "21b21b21-bfd2-4279-8c65-e2f697ff4fab"
}
```

Your device would process the contents of this message to set the device state to match the desired state in the message.

After the device updates the state to match the desired state in the message, it must send the new reported state back to AWS IoT by publishing an update message. This procedure simulates this in the **MQTT client**.

**To update the shadow from the device**

1. In the **MQTT client**, choose **Publish to a topic**.
2. In the message body window, in the topic field above the message body window, enter the shadow's topic followed by the /update action: $aws/things/mySimulatedThing/shadow/name/simShadow1/update and in the message body, enter this updated shadow document, which describes the current state of the device. Click **Publish** to publish the updated device state.

```json
{
    "state": {
        "reported": {
            "ColorRGB": [255,255,0]
        },
        "clientToken": "a4dc2227-9213-4c6a-a6a5-053304f60258"
    }
}
```

If the message was successfully received by AWS IoT, you should see a new response in the `$aws/things/mySimulatedThing/shadow/name/simShadow1/update/accepted` message log in the MQTT client with the current state of the shadow, such as this example.

```json
{
    "state": {
        "reported": {
            "ColorRGB": [255,255,0]
        },
        "clientToken": "a4dc2227-9213-4c6a-a6a5-053304f60258"
    },
    "metadata": {
        "reported": {
            "ColorRGB": [
                {
                    "timestamp": 1591142747
                },
                {
                    "timestamp": 1591142747
                },
                {
                    "timestamp": 1591142747
                }
            ]
        },
        "version": 5,
        "timestamp": 1591142747,
        "clientToken": "a4dc2227-9213-4c6a-a6a5-053304f60258"
    }
}
```

A successful update to the reported state of the device also causes AWS IoT to send a comprehensive description of the shadow state in a message to the topic, such as this message body that resulted from the shadow update performed by the device in the preceding procedure.

```json
{
    "previous": {
        "state": {
            "desired": {
                "ColorRGB": [255,255,0]
            }
        }
    }
}
```
AWS IoT Core Developer Guide

Respond to update in device

```json
{
    "current": {
        "state": {
            "desired": {
                "ColorRGB": [255, 255, 0]
            },
            "reported": {
                "ID": "SmartLamp21",
                "ColorRGB": [255, 255, 0]
            }
        },
        "metadata": {
            "desired": {
                "ColorRGB": [
                    {"timestamp": 1591141596},
                    {"timestamp": 1591141596},
                    {"timestamp": 1591141596}
                ]
            },
            "reported": {
                "ID": "SmartLamp21",
                "ColorRGB": [
                    {"timestamp": 1591140517},
                    {"timestamp": 1591140517},
                    {"timestamp": 1591140517}
                ]
            }
        },
        "version": 4
    }
}
```
Observe the update in the app

The app can now query the shadow for the current state as reported by the device.

To get the current state of the shadow using the AWS CLI

1. From the command line, enter this command.

```bash
aws iot-data get-thing-shadow --thing-name mySimulatedThing --shadow-name simShadow1 /dev/stdout
```

On Windows platforms, you can use `con` instead of `/dev/stdout`.

```bash
aws iot-data get-thing-shadow --thing-name mySimulatedThing --shadow-name simShadow1 con
```

2. Because the shadow has just been updated by the device to reflect its current state, it should return the following shadow document.

```json
{
  "state": {
    "desired": {
      "ColorRGB": [255, 255, 0]
    },
    "reported": {
      "ID": {
        "timestamp": 1591140517
      },
      "ColorRGB": [
        {
          "timestamp": 1591142747
        },
        {
          "timestamp": 1591142747
        },
        {
          "timestamp": 1591142747
        }
      ]
    },
    "version": 5,
    "timestamp": 1591142747,
    "clientToken": "a4dc2227-9213-4c6a-a6a5-053304f60258"
  }
}
```
"reported": {
    "ID": "SmartLamp21",
    "ColorRGB": [
        255,
        255,
        0
    ]
},
"metadata": {
    "desired": {
        "ColorRGB": [
            {
                "timestamp": 1591141596
            },
            {
                "timestamp": 1591141596
            },
            {
                "timestamp": 1591141596
            }
        ]
    },
    "reported": {
        "ID": {
            "timestamp": 1591140517
        },
        "ColorRGB": [
            {
                "timestamp": 1591142747
            },
            {
                "timestamp": 1591142747
            },
            {
                "timestamp": 1591142747
            }
        ]
    }
},
"version": 5,
"timestamp": 1591143269
}

Going beyond the simulation

Experiment with the interaction between the AWS CLI (representing the app) and the console (representing the device) to model your IoT solution.

Interacting with shadows

This topic describes the messages associated with each of the three methods that AWS IoT provides for working with shadows. These methods include the following:

UPDATE

Creates a shadow if it doesn't exist, or updates the contents of an existing shadow with the state information provided in the message body. AWS IoT records a timestamp with each update to indicate when the state was last updated. When the shadow's state changes, AWS IoT sends /delta


messages to all MQTT subscribers with the difference between the desired and the reported states. Devices or apps that receive a /delta message can perform actions based on the difference. For example, a device can update its state to the desired state, or an app can update its UI to reflect the device's state change.

GET

Retrieves a current shadow document that contains the complete state of the shadow, including metadata.

DELETE

Deletes the device shadow and its content.

You can't restore a deleted device shadow document, but you can create a new device shadow with the name of a deleted device shadow document. If you create a device shadow document that has the same name as one that was deleted within the past 48 hours, the version number of the new device shadow document will follow that of the deleted one. If a device shadow document has been deleted for more than 48 hours, the version number of a new device shadow document with the same name will be 0.

Protocol support

AWS IoT supports MQTT and a REST API over HTTPS protocols to interact with shadows. AWS IoT provides a set of reserved request and response topics for MQTT publish and subscribe actions. Devices and apps should subscribe to the response topics before publishing a request topic for information about how AWS IoT handled the request. For more information, see Device Shadow MQTT topics (p. 686) and Device Shadow REST API (p. 682).

Requesting and reporting state

When designing your IoT solution using AWS IoT and shadows, you should determine the apps or devices that will request changes and those that will implement them. Typically, a device implements and reports changes back to the shadow and apps and services respond to and request changes in the shadow. Your solution could be different, but the examples in this topic assume that the client app or service requests changes in the shadow and the device performs the changes and reports them back to the shadow.

Updating a shadow

Your app or service can update a shadow's state by using the UpdateThingShadow (p. 683) API or by publishing to the /update (p. 689) topic. Updates affect only the fields specified in the request.

Updating a shadow when a client requests a state change

When a client requests a state change in a shadow by using the MQTT protocol

1. The client should have a current shadow document so that it can identify the properties to change. See the /get action for how to obtain the current shadow document.
2. The client subscribes to these MQTT topics:
   - $aws/things/thingName/shadow/name/shadowName/update/accepted
   - $aws/things/thingName/shadow/name/shadowName/update/rejected
   - $aws/things/thingName/shadow/name/shadowName/update/delta
   - $aws/things/thingName/shadow/name/shadowName/update/documents
3. The client publishes a `$aws/things/thingName/shadow/name/shadowName/update` request topic with a state document that contains the desired state of the shadow. Only the properties to change need to be included in the document. This is an example of a document with the desired state.

```json
{
  "state": {
    "desired": {
      "color": {
        "r": 10
      },
      "engine": "ON"
    }
  }
}
```

4. If the update request is valid, AWS IoT updates the desired state in the shadow and publishes messages on these topics:

- `$aws/things/thingName/shadow/name/shadowName/update/accepted`
- `$aws/things/thingName/shadow/name/shadowName/update/delta`


5. If the update request is not valid, AWS IoT publishes a message with the `$aws/things/thingName/shadow/name/shadowName/update/rejected` topic with an `Error response document (p. 698)` shadow document that describes the error.

**When a client requests a state change in a shadow by using the API**

1. The client calls the `UpdateThingShadow (p. 683)` API with a `Request state document (p. 695)` state document as its message body.

2. If the request was valid, AWS IoT returns an HTTP success response code and an `/accepted response state document (p. 695)` shadow document as its response message body.

   AWS IoT will also publish an MQTT message to the `$aws/things/thingName/shadow/name/shadowName/update/delta` topic with a `/delta response state document (p. 696)` shadow document for any devices or clients that subscribe to it.

3. If the request was not valid, AWS IoT returns an HTTP error response code an `Error response document (p. 698)` as its response message body.

When the device receives the `/desired` state on the `/update/delta` topic, it makes the desired changes in the device. It then sends a message to the `/update` topic to report its current state to the shadow.

**Updating a shadow when a device reports its current state**

**When a device reports its current state to the shadow by using the MQTT protocol**

1. The device should subscribe to these MQTT topics before updating the shadow:

   - `$aws/things/thingName/shadow/name/shadowName/update/accepted`
   - `$aws/things/thingName/shadow/name/shadowName/update/rejected`
   - `$aws/things/thingName/shadow/name/shadowName/update/delta`
• $aws/things/thingName/shadow/name/ shadowName/update/documents

2. The device reports its current state by publishing a message to the $aws/things/thingName/shadow/name/ shadowName/update topic that reports the current state, such as in this example.

```
{
    "state": {
        "reported": {
            "color": { "r": 10 },
            "engine": "ON"
        }
    }
}
```

3. If AWS IoT accepts the update, it publishes a message to the $aws/things/thingName/shadow/name/ shadowName/update/accepted topic with an /accepted response state document (p. 695) shadow document.

4. If the update request is not valid, AWS IoT publishes a message with the $aws/things/thingName/shadow/name/ shadowName/update/rejected topic with an Error response document (p. 698) shadow document that describes the error.

When a device reports its current state to the shadow by using the API

1. The device calls the UpdateThingShadow (p. 683) API with a Request state document (p. 695) state document as its message body.

2. If the request was valid, AWS IoT updates the shadow and returns an HTTP success response code with an /accepted response state document (p. 695) shadow document as its response message body.

   AWS IoT will also publish an MQTT message to the $aws/things/thingName/shadow/name/ shadowName/update/delta topic with a /delta response state document (p. 696) shadow document for any devices or clients that subscribe to it.

3. If the request was not valid, AWS IoT returns an HTTP error response code an Error response document (p. 698) as its response message body.

Optimistic locking

You can use the state document version to ensure you are updating the most recent version of a device's shadow document. When you supply a version with an update request, the service rejects the request with an HTTP 409 conflict response code if the current version of the state document does not match the version supplied. The conflict response code can also occur on any API that modifies ThingShadow, including DeleteThingShadow.

For example:

Initial document:

```
{
    "state": {
        "desired": {
            "colors": [
                "RED",
                "GREEN",
                "BLUE"
            ]
        },
        "version": 10
}
```
Retrieving a shadow document

You can retrieve a shadow document by using the **GetThingShadow** API or by subscribing and publishing to the `/get` topic. This retrieves a complete shadow document, including any delta between the desired and reported states. The procedure for this task is the same whether the device or a client is making the request.

**To retrieve a shadow document by using the MQTT protocol**

1. The device or client should subscribe to these MQTT topics before updating the shadow:
• $aws/things/thingName/shadow/name/shadowName/get/accepted
• $aws/things/thingName/shadow/name/shadowName/get/rejected

2. The device or client publishes a message to the $aws/things/thingName/shadow/name/shadowName/get topic with an empty message body.

3. If the request is successful, AWS IoT publishes a message to the $aws/things/thingName/shadow/name/shadowName/get/accepted topic with an accepted response state document (p. 695) in the message body.

4. If the request was not valid, AWS IoT publishes a message to the $aws/things/thingName/shadow/name/shadowName/get/rejected topic with an Error response document (p. 698) in the message body.

To retrieve a shadow document by using a REST API

1. The device or client call the GetThingShadow (p. 683) API with an empty message body.

2. If the request is valid, AWS IoT returns an HTTP success response code with an accepted response state document (p. 695) shadow document as its response message body.

3. If the request is not valid, AWS IoT returns an HTTP error response code an Error response document (p. 698) as its response message body.

Deleting shadow data

There are two ways to delete shadow data: you can delete specific properties in the shadow document and you can delete the shadow completely.

• To delete specific properties from a shadow, update the shadow; however set the value of the properties that you want to delete to null. Fields with a value of null are removed from the shadow document.

• To delete the entire shadow, use the DeleteThingShadow (p. 684) API or publish to the /delete (p. 692) topic.

    Note
    Deleting a shadow doesn’t immediately reset its version number to zero. It will be reset to zero after 48 hours.

Deleting a property from a shadow document

To delete a property from a shadow by using the MQTT protocol

1. The device or client should have a current shadow document so that it can identify the properties to change. See Retrieving a shadow document (p. 679) for information on how to obtain the current shadow document.

2. The device or client subscribes to these MQTT topics:

   • $aws/things/thingName/shadow/name/shadowName/update/accepted
   • $aws/things/thingName/shadow/name/shadowName/update/rejected

3. The device or client publishes a $aws/things/thingName/shadow/name/shadowName/update request topic with a state document that assigns null values to the properties of the shadow to delete. Only the properties to change need to be included in the document. This is an example of a document that deletes the engine property.

```json
{
}
```
Deleting shadow data

4. If the update request is valid, AWS IoT deletes the specified properties in the shadow and publishes a message with the $aws/things/thingName/shadow/name/shadowName/update/accepted topic with an /accepted response state document (p. 695) shadow document in the message body.

5. If the update request is not valid, AWS IoT publishes a message with the $aws/things/thingName/shadow/name/shadowName/update/rejected topic with an Error response document (p. 698) shadow document that describes the error.

To delete a property from a shadow by using the REST API

1. The device or client calls the UpdateThingShadow (p. 683) API with a Request state document (p. 695) that assigns null values to the properties of the shadow to delete. Include only the properties that you want to delete in the document. This is an example of a document that deletes the engine property.

   ```json
   { "state": { "desired": { "engine": null } } }
   ```

2. If the request was valid, AWS IoT returns an HTTP success response code and an /accepted response state document (p. 695) shadow document as its response message body.

3. If the request was not valid, AWS IoT returns an HTTP error response code and an Error response document (p. 698) as its response message body.

Deleting a shadow

Following are some considerations when deleting a device's shadow.

- Setting the device's shadow state to null does not delete the shadow. The shadow version will be incremented on the next update.
- Deleting a device's shadow does not delete the thing object. Deleting a thing object does not delete the corresponding device's shadow.
- Deleting a shadow doesn't immediately reset its version number to zero. It will be reset to zero after 48 hours.

To delete a shadow by using the MQTT protocol

1. The device or client subscribes to these MQTT topics:

   - $aws/things/thingName/shadow/name/shadowName/delete/accepted
   - $aws/things/thingName/shadow/name/shadowName/delete/rejected

2. The device or client publishes a $aws/things/thingName/shadow/name/shadowName/delete with an empty message buffer.

3. If the delete request is valid, AWS IoT deletes the shadow and publishes a message with the $aws/things/thingName/shadow/name/shadowName/delete/accepted topic and an abbreviated
/accepted response state document (p. 695) shadow document in the message body. This is an example of the accepted delete message:

```
{
  "version": 4,
  "timestamp": 1591057529
}
```

4. If the update request is not valid, AWS IoT publishes a message with the $aws/things/thingName/shadow/name/shadowName/delete/rejected topic with an Error response document (p. 698) shadow document that describes the error.

To delete a shadow by using the REST API

1. The device or client calls the DeleteThingShadow (p. 684) API with an empty message buffer.
2. If the request was valid, AWS IoT returns an HTTP success response code and an /accepted response state document (p. 695) and an abbreviated /accepted response state document (p. 695) shadow document in the message body. This is an example of the accepted delete message:

```
{
  "version": 4,
  "timestamp": 1591057529
}
```

3. If the request was not valid, AWS IoT returns an HTTP error response code an Error response document (p. 698) as its response message body.

Device Shadow REST API

A shadow exposes the following URI for updating state information:

https://account-specific-prefix-ats.iot.region.amazonaws.com/things/thingName/shadow

The endpoint is specific to your AWS account. To find your endpoint, you can:

- Use the describe-endpoint command from the AWS CLI.
- Use the AWS IoT console settings. In Settings, the endpoint is listed under Custom endpoint
- Use the AWS IoT console thing details page. In the console:
  1. Open Manage and under Manage, choose Things.
  2. In the list of things, choose the thing for which you want to get the endpoint URI.
  3. Choose the Device Shadows tab and choose your shadow. You can view the endpoint URI in the Device Shadow URL section of the Device Shadow details page.

The format of the endpoint is as follows:

identifier.iot.region.amazonaws.com

The shadow REST API follows the same HTTPS protocols/port mappings as described in Device communication protocols (p. 85).

Note

To use the APIs, you must use iotdevicegateway as the service name for authentication. For more information, see IoTDataPlane.
API actions

- GetThingShadow (p. 683)
- UpdateThingShadow (p. 683)
- DeleteThingShadow (p. 684)
- ListNamedShadowsForThing (p. 685)

You can also use the API to create a named shadow by providing name=shadowName as part of the query parameter of the API.

**GetThingShadow**

Gets the shadow for the specified thing.

The response state document includes the delta between the desired and reported states.

**Request**

The request includes the standard HTTP headers plus the following URI:

```
HTTP GET https://endpoint/things/thingName/shadow?name=shadowName
```

Request body: (none)

The name query parameter is not required for unnamed (classic) shadows.

**Response**

Upon success, the response includes the standard HTTP headers plus the following code and body:

```
HTTP 200
Response Body: response state document
```

For more information, see Example Response State Document (p. 695).

**Authorization**

Retrieving a shadow requires a policy that allows the caller to perform the iot:GetThingShadow action. The Device Shadow service accepts two forms of authentication: Signature Version 4 with IAM credentials or TLS mutual authentication with a client certificate.

The following is an example policy that allows a caller to retrieve a device's shadow:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": "iot:GetThingShadow",
            "Resource": [
                "arn:aws:iot:region:account:thing/thing"
            ]
        }
    ]
}
```

**UpdateThingShadow**

Updates the shadow for the specified thing.
Updates affect only the fields specified in the request state document. Any field with a value of null is removed from the device's shadow.

**Request**

The request includes the standard HTTP headers plus the following URI and body:

```
HTTP POST https://endpoint/things/thingName/shadow?name=shadowName
Request body: request state document
```

The name query parameter is not required for unnamed (classic) shadows.

For more information, see Example Request State Document (p. 695).

**Response**

Upon success, the response includes the standard HTTP headers plus the following code and body:

```
HTTP 200
Response body: response state document
```

For more information, see Example Response State Document (p. 695).

**Authorization**

Updating a shadow requires a policy that allows the caller to perform the `iot:UpdateThingShadow` action. The Device Shadow service accepts two forms of authentication: Signature Version 4 with IAM credentials or TLS mutual authentication with a client certificate.

The following is an example policy that allows a caller to update a device's shadow:

```
{
   "Version": "2012-10-17",
   "Statement": [
   {
      "Effect": "Allow",
      "Action": "iot:UpdateThingShadow",
      "Resource": [
         "arn:aws:iot:region:account:thing/thing"
      ]
   }
   ]
}
```

**DeleteThingShadow**

Deletes the shadow for the specified thing.

**Request**

The request includes the standard HTTP headers plus the following URI:

```
HTTP DELETE https://endpoint/things/thingName/shadow?name=shadowName
Request body: (none)
```

The name query parameter is not required for unnamed (classic) shadows.

**Response**
Upon success, the response includes the standard HTTP headers plus the following code and body:

<table>
<thead>
<tr>
<th>HTTP 200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response body: <em>Empty response state document</em></td>
</tr>
</tbody>
</table>

Note that deleting a shadow does not reset its version number to 0.

**Authorization**

Deleting a device's shadow requires a policy that allows the caller to perform the `iot:DeleteThingShadow` action. The Device Shadow service accepts two forms of authentication: Signature Version 4 with IAM credentials or TLS mutual authentication with a client certificate.

The following is an example policy that allows a caller to delete a device's shadow:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iot:DeleteThingShadow",
      "Resource": [
        "arn:aws:iot:region:account:thing/thing"
      ]
    }
  ]
}
```

**ListNamedShadowsForThing**

Lists the shadows for the specified thing.

**Request**

The request includes the standard HTTP headers plus the following URI:

HTTP GET /api/things/shadow/ListNamedShadowsForThing/thingName?
nextToken=nextToken&pageSize=pageSize

Request body: (none)

**Response**

Upon success, the response includes the standard HTTP headers plus the following response code and a *Shadow name list response document* (p. 698).
Note
The unnamed (classic) shadow does not appear in this list. The response is an empty list if you only have a classic shadow or if the thingName you specify doesn’t exist.

HTTP 200
Response body: Shadow name list document

Authorization

Listing a device’s shadow requires a policy that allows the caller to perform the iot:ListNamedShadowsForThing action. The Device Shadow service accepts two forms of authentication: Signature Version 4 with IAM credentials or TLS mutual authentication with a client certificate.

The following is an example policy that allows a caller to list a thing’s named shadows:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iot:ListNamedShadowsForThing",
      "Resource": [
        "arn:aws:iot:region:account:thing/thing"
      ]
    }
  ]
}
```

Device Shadow MQTT topics

The Device Shadow service uses reserved MQTT topics to enable devices and apps to get, update, or delete the state information for a device (shadow).

Publishing and subscribing on shadow topics requires topic-based authorization. AWS IoT reserves the right to add new topics to the existing topic structure. For this reason, we recommend that you avoid wild card subscriptions to shadow topics. For example, avoid subscribing to topic filters like $aws/things/thingName/shadow/# because the number of topics that match this topic filter might increase as AWS IoT introduces new shadow topics. For examples of the messages published on these topics see Interacting with shadows (p. 675).

Shadows can be named or unnamed (classic). The topics used by each differ only in the topic prefix. This table shows the topic prefix used by each shadow type.

<table>
<thead>
<tr>
<th>ShadowTopicPrefix value</th>
<th>Shadow type</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/things/thingName/shadow</td>
<td>Unnamed (classic) shadow</td>
</tr>
<tr>
<td>$aws/things/thingName/shadow/name/shadowName</td>
<td>Named shadow</td>
</tr>
</tbody>
</table>

To create a complete topic, select the ShadowTopicPrefix for the type of shadow to which you want to refer, replace thingName, and shadowName if applicable, with their corresponding values, and then append that with the topic stub as shown in the following sections.
The following are the MQTT topics used for interacting with shadows.

**Topics**
- `/get` *(p. 687)*
- `/get/accepted` *(p. 687)*
- `/get/rejected` *(p. 688)*
- `/update` *(p. 689)*
- `/update/delta` *(p. 690)*
- `/update/accepted` *(p. 690)*
- `/update/documents` *(p. 691)*
- `/update/rejected` *(p. 692)*
- `/delete` *(p. 692)*
- `/delete/accepted` *(p. 693)*
- `/delete/rejected` *(p. 693)*

### /get

Publish an empty message to this topic to get the device's shadow:

```
ShadowTopicPrefix/get
```

AWS IoT responds by publishing to either `/get/accepted` *(p. 687)* or `/get/rejected` *(p. 688)*.

### Example policy

The following is an example of the required policy:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Publish"],
      "Resource": ["arn:aws:iot:region:account:topic/$aws/things/thingName/shadow/get"
    }
  ]
}
```

### /get/accepted

AWS IoT publishes a response shadow document to this topic when returning the device's shadow:

```
ShadowTopicPrefix/get/accepted
```

For more information, see [Response state documents (p. 695)].

---

687
Example policy

The following is an example of the required policy:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Subscribe"],
            "Resource": [
                "arn:aws:iot:region:account:topicfilter/$aws/things/thingName/shadow/get/accepted"
            ]
        },
        {
            "Effect": "Allow",
            "Action": ["iot:Receive"],
            "Resource": [
                "arn:aws:iot:region:account:topic/$aws/things/thingName/shadow/get/accepted"
            ]
        }
    ]
}
```

/get/rejected

AWS IoT publishes an error response document to this topic when it can't return the device's shadow:

```
ShadowTopicPrefix/get/rejected
```

For more information, see Error response document (p. 698).

Example policy

The following is an example of the required policy:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Subscribe"],
            "Resource": [
                "arn:aws:iot:region:account:topicfilter/$aws/things/thingName/shadow/get/accepted"
            ]
        },
        {
            "Action": ["iot:Receive"],
            "Resource": [
                "arn:aws:iot:region:account:topic/$aws/things/thingName/shadow/get/accepted"
            ]
        }
    ]
}
```
Publish a request state document to this topic to update the device's shadow:

ShadowTopicPrefix/update

The message body contains a partial request state document (p. 695).

A client attempting to update the state of a device would send a JSON request state document with the desired property such as this:

```
{
    "state": {
        "desired": {
            "color": "red",
            "power": "on"
        }
    }
}
```

A device updating its shadow would send a JSON request state document with the reported property, such as this:

```
{
    "state": {
        "reported": {
            "color": "red",
            "power": "on"
        }
    }
}
```

AWS IoT responds by publishing to either /update/accepted (p. 690) or /update/rejected (p. 692).

Example policy

The following is an example of the required policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Publish"],
            "Resource": [
                "arn:aws:iot:region:account:topic/$aws/things/thingName/shadow/update"
            ]
        }
    ]
}
```
/update/delta

AWS IoT publishes a response state document to this topic when it accepts a change for the device's shadow, and the request state document contains different values for desired and reported states:

ShadowTopicPrefix/update/delta

The message buffer contains a /delta response state document (p. 696).

Message body details

- A message published on update/delta includes only the desired attributes that differ between the desired and reported sections. It contains all of these attributes, regardless of whether these attributes were contained in the current update message or were already stored in AWS IoT. Attributes that do not differ between the desired and reported sections are not included.
- If an attribute is in the reported section but has no equivalent in the desired section, it is not included.
- If an attribute is in the desired section but has no equivalent in the reported section, it is included.
- If an attribute is deleted from the reported section but still exists in the desired section, it is included.

Example policy

The following is an example of the required policy:

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": ["iot:Subscribe"],
      },
      {
         "Effect": "Allow",
         "Action": ["iot:Receive"],
      }
   ]
}
```

/update/accepted

AWS IoT publishes a response state document to this topic when it accepts a change for the device's shadow:

ShadowTopicPrefix/update/accepted
The message buffer contains a \(\text{accepted response state document (p. 695)}.\)

### Example policy

The following is an example of the required policy:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Subscribe"],
            "Resource": [
                "arn:aws:iot:region:account:topicfilter/$aws/things/thingName/shadow/update/accepted"
            ]
        },
        {
            "Effect": "Allow",
            "Action": ["iot:Receive"],
            "Resource": [
                "arn:aws:iot:region:account:topic/$aws/things/thingName/shadow/update/accepted"
            ]
        }
    ]
}
```

---

### /update/documents

AWS IoT publishes a state document to this topic whenever an update to the shadow is successfully performed:

\(\text{ShadowTopicPrefix}/update/documents\)

The message body contains a \(\text{documents response state document (p. 696)}.\)

### Example policy

The following is an example of the required policy:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Subscribe"],
            "Resource": [
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:Subscribe",
                "iot:Receive",
                "iot:Subscribe"
            ],
            "Resource": [
            ]
        }
    ]
}
```
/update/rejected

AWS IoT publishes an error response document to this topic when it rejects a change for the device's shadow:

ShadowTopicPrefix/update/rejected

The message body contains an Error response document (p. 698).

Example policy

The following is an example of the required policy:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Subscribe"
      ],
      "Resource": [
        "arn:aws:iot:region:account:topicfilter/$aws/things/thingName/shadow/update/rejected"
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Receive"
      ],
      "Resource": [
      ]
    }
  ]
}
```

/delete

To delete a device's shadow, publish an empty message to the delete topic:

ShadowTopicPrefix/delete

The content of the message is ignored.

Note that deleting a shadow does not reset its version number to 0.

AWS IoT responds by publishing to either /delete/accepted (p. 693) or /delete/rejected (p. 693).
Example policy

The following is an example of the required policy:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [ "iot:Publish" ],
    }
  ]
}
```

/delete/accepted

AWS IoT publishes a message to this topic when a device’s shadow is deleted:

```
ShadowTopicPrefix/delete/accepted
```

Example policy

The following is an example of the required policy:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [ "iot:Subscribe" ],
    },
    {
      "Effect": "Allow",
      "Action": [ "iot:Receive" ],
    }
  ]
}
```

/delete/rejected

AWS IoT publishes an error response document to this topic when it can’t delete the device’s shadow:
The message body contains an Error response document (p. 698).

Example policy

The following is an example of the required policy:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Subscribe"
      ],
      "Resource": [
        "arn:aws:iot:region:account:topicfilter/$aws/things/thingName/shadow/delete/rejected"
      ]
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Receive"
      ],
      "Resource": [
        "arn:aws:iot:region:account:topic/$aws/things/thingName/shadow/delete/rejected"
      ]
    }
  ]
}
```

Device Shadow service documents

The Device Shadow service respects all rules of the JSON specification. Values, objects, and arrays are stored in the device's shadow document.

Contents

- Shadow document examples (p. 694)
- Document properties (p. 699)
- Delta state (p. 699)
- Versioning shadow documents (p. 701)
- Client tokens in shadow documents (p. 701)
- Empty shadow document properties (p. 701)
- Array values in shadow documents (p. 702)

Shadow document examples

The Device Shadow service uses these documents in UPDATE, GET, and DELETE operations using the REST API (p. 682) or MQTT Pub/Sub Messages (p. 686).

Examples
• **Request state document** (p. 695)
• **Response state documents** (p. 695)
• **Error response document** (p. 698)
• **Shadow name list response document** (p. 698)

**Request state document**

A request state document has the following format:

```
{
    "state": {
        "desired": {
            "attribute1": integer2,
            "attribute2": "string2",
            ...
            "attributeN": boolean2
        },
        "reported": {
            "attribute1": integer1,
            "attribute2": "string1",
            ...
            "attributeN": boolean1
        }
    },
    "clientToken": "token",
    "version": version
}
```

- **state** — Updates affect only the fields specified. Typically, you’ll use either the desired or the reported property, but not both in the same request.
- **desired** — The state properties and values requested to be updated in the device.
- **reported** — The state properties and values reported by the device.
- **clientToken** — If used, you can match the request and corresponding response by the client token.
- **version** — If used, the Device Shadow service processes the update only if the specified version matches the latest version it has.

**Response state documents**

Response state documents have the following format depending on the response type.

**/accepted response state document**

```
{
    "state": {
        "desired": {
            "attribute1": integer2,
            "attribute2": "string2",
            ...
            "attributeN": boolean2
        }
    },
    "metadata": {
        "desired": {
            "attribute1": {
                "timestamp": timestamp
            }
        }
    }
}
```
/delta response state document

```
{
  "state": {
    "attribute1": integer2,
    "attribute2": "string2",
    ...
    "attributeN": boolean2
  },
  "metadata": {
    "attribute1": {
      "timestamp": timestamp
    },
    "attribute2": {
      "timestamp": timestamp
    },
    ...
    "attributeN": {
      "timestamp": timestamp
    }
  },
  "timestamp": timestamp,
  "clientToken": "token",
  "version": version
}
```

/documents response state document

```
{
  "previous": {
    "state": {
      "desired": {
        "attribute1": integer2,
        "attribute2": "string2",
        ...
        "attributeN": boolean2
      },
      "reported": {
        "attribute1": integer1,
        "attribute2": "string1",
        ...
        "attributeN": boolean1
      }
    },
    "metadata": {
      "desired": {
        "attribute1": {
          "timestamp": timestamp
        }
      }
    }
  }
}
```
"attribute2": {
  "timestamp": timestamp
},
...
"attributeN": {
  "timestamp": timestamp
}
},
"reported": {
  "attribute1": {
    "timestamp": timestamp
  },
  "attribute2": {
    "timestamp": timestamp
  },
  ...
  "attributeN": {
    "timestamp": timestamp
  }
}
},
"current": {
  "state": {
    "desired": {
      "attribute1": integer2,
      "attribute2": "string2",
      ...
      "attributeN": boolean2
    },
    "reported": {
      "attribute1": integer2,
      "attribute2": "string2",
      ...
      "attributeN": boolean2
    }
  },
  "metadata": {
    "desired": {
      "attribute1": {
        "timestamp": timestamp
      },
      "attribute2": {
        "timestamp": timestamp
      },
      ...
      "attributeN": {
        "timestamp": timestamp
      }
    },
    "reported": {
      "attribute1": {
        "timestamp": timestamp
      },
      "attribute2": {
        "timestamp": timestamp
      },
      ...
      "attributeN": {
        "timestamp": timestamp
      }
    }
  }
},
"version": version
Response state document properties

- previous — After a successful update, contains the state of the object before the update.
- current — After a successful update, contains the state of the object after the update.
- state
  - reported — Present only if a thing reported any data in the reported section and contains only fields that were in the request state document.
  - desired — Present only if a device reported any data in the desired section and contains only fields that were in the request state document.
  - delta — Present only if the desired data differs from the shadow's current reported data.
  - metadata — Contains the timestamps for each attribute in the desired and reported sections so that you can determine when the state was updated.
- timestamp — The Epoch date and time the response was generated by AWS IoT.
- clientToken — Present only if a client token was used when publishing valid JSON to the /update topic.
- version — The current version of the document for the device's shadow shared in AWS IoT. It is increased by one over the previous version of the document.

Error response document

An error response document has the following format:

```json
{
  "code": error-code,
  "message": "error-message",
  "timestamp": timestamp,
  "clientToken": "token"
}
```

- code — An HTTP response code that indicates the type of error.
- message — A text message that provides additional information.
- timestamp — The date and time the response was generated by AWS IoT. This property is not present in all error response documents.
- clientToken — Present only if a client token was used in the published message.

For more information, see Device Shadow error messages (p. 703).

Shadow name list response document

A shadow name list response document has the following format:

```json
{
  "results": [
    "shadowName-1",
    "shadowName-2",
    "shadowName-3",
  ]
}
```
Document properties

A device's shadow document has the following properties:

state

- desired
  The desired state of the device. Apps can write to this portion of the document to update the state of a device directly without having to connect to it.
- reported
  The reported state of the device. Devices write to this portion of the document to report their new state. Apps read this portion of the document to determine the device's last-reported state.

metadata

Information about the data stored in the state section of the document. This includes timestamps, in Epoch time, for each attribute in the state section, which enables you to determine when they were updated.

Note

Metadata do not contribute to the document size for service limits or pricing. For more information, see AWS IoT Service Limits.

timestamp

Indicates when the message was sent by AWS IoT. By using the timestamp in the message and the timestamps for individual attributes in the desired or reported section, a device can determine a property's age, even if the device doesn't have an internal clock.

clientToken

A string unique to the device that enables you to associate responses with requests in an MQTT environment.

version

The document version. Every time the document is updated, this version number is incremented. Used to ensure the version of the document being updated is the most recent.

For more information, see Shadow document examples (p. 694).

Delta state

Delta state is a virtual type of state that contains the difference between the desired and reported states. Fields in the desired section that are not in the reported section are included in the delta.
Fields that are in the reported section and not in the desired section are not included in the delta. The delta contains metadata, and its values are equal to the metadata in the desired field. For example:

```json
{
  "state": {
    "desired": {
      "color": "RED",
      "state": "STOP"
    },
    "reported": {
      "color": "GREEN",
      "engine": "ON"
    },
    "delta": {
      "color": "RED",
      "state": "STOP"
    }
  },
  "metadata": {
    "desired": {
      "color": {
        "timestamp": 12345
      },
      "state": {
        "timestamp": 12345
      }
    },
    "reported": {
      "color": {
        "timestamp": 12345
      },
      "engine": {
        "timestamp": 12345
      }
    },
    "delta": {
      "color": {
        "timestamp": 12345
      },
      "state": {
        "timestamp": 12345
      }
    }
  },
  "version": 17,
  "timestamp": 123456789
}
```

When nested objects differ, the delta contains the path all the way to the root.

```json
{
  "state": {
    "desired": {
      "lights": {
        "color": {
          "r": 255,
          "g": 255,
          "b": 255
        }
      }
    },
    "reported": {
      "lights": {
        "color": {
          "r": 255,
          "g": 255,
          "b": 255
        }
      }
    }
  }
}
```
Versioning shadow documents

The Device Shadow service calculates the delta by iterating through each field in the desired state and comparing it to the reported state.

Arrays are treated like values. If an array in the desired section doesn't match the array in the reported section, then the entire desired array is copied into the delta.

Versioning shadow documents

The Device Shadow service supports versioning on every update message, both request and response. This means that with every update of a shadow, the version of the JSON document is incremented. This ensures two things:

- A client can receive an error if it attempts to overwrite a shadow using an older version number. The client is informed it must resync before it can update a device's shadow.
- A client can decide not to act on a received message if the message has a lower version than the version stored by the client.

A client can bypass version matching by not including a version in the shadow document.

Client tokens in shadow documents

You can use a client token with MQTT-based messaging to verify the same client token is contained in a request and request response. This ensures the response and request are associated.

Note

The client token can be no longer than 64 bytes. A client token that is longer than 64 bytes causes a 400 (Bad Request) response and an Invalid clientToken error message.

Empty shadow document properties

The reported and desired properties in a shadow document can be empty or omitted when they don't apply to the current shadow state. For example, a shadow document contains a desired property only if it has a desired state. The following is a valid example of a state document with no desired property:

```json
{
    "reported" : { "temp": 55 }
}
```
The reported property can also be empty, such as if the shadow has not been updated by the device:

```
{
  "desired" : { "color" : "RED" }
}
```

If an update causes the desired or reported properties to become null, it is removed from the document. The following shows how to remove the desired property by setting it to null. You might do this when a device updates its state, for example.

```
{
  "state": {
    "reported": {
      "color": "red"
    },
    "desired": null
  }
}
```

A shadow document can also have neither desired or reported properties, making the shadow document empty. This is an example of an empty, yet valid shadow document.

```
{
}
```

### Array values in shadow documents

Shadows support arrays, but treat them as normal values in that an update to an array replaces the whole array. It is not possible to update part of an array.

Initial state:

```
{
  "desired" : { "colors" : ["RED", "GREEN", "BLUE"] }
}
```

Update:

```
{
  "desired" : { "colors" : ["RED"] }
}
```

Final state:

```
{
  "desired" : { "colors" : ["RED"] }
}
```

Arrays can't have null values. For example, the following array is not valid and will be rejected.

```
{
  "desired" : {
    "colors" : [ null, "RED", "GREEN" ]
  }
}
```
Device Shadow error messages

The Device Shadow service publishes a message on the error topic (over MQTT) when an attempt to change the state document fails. This message is only emitted as a response to a publish request on one of the reserved `$aws` topics. If the client updates the document using the REST API, then it receives the HTTP error code as part of its response, and no MQTT error messages are emitted.

<table>
<thead>
<tr>
<th>HTTP error code</th>
<th>Error messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>400 (Bad Request)</td>
<td>• Invalid JSON</td>
</tr>
<tr>
<td></td>
<td>• Missing required node: state</td>
</tr>
<tr>
<td></td>
<td>• State node must be an object</td>
</tr>
<tr>
<td></td>
<td>• Desired node must be an object</td>
</tr>
<tr>
<td></td>
<td>• Reported node must be an object</td>
</tr>
<tr>
<td></td>
<td>• Invalid version</td>
</tr>
<tr>
<td></td>
<td>• Invalid clientToken</td>
</tr>
<tr>
<td></td>
<td><strong>Note</strong></td>
</tr>
<tr>
<td></td>
<td>A client token that is longer than 64 bytes will cause this response.</td>
</tr>
<tr>
<td></td>
<td>• JSON contains too many levels of nesting; maximum is 6</td>
</tr>
<tr>
<td></td>
<td>• State contains an invalid node</td>
</tr>
<tr>
<td>401 (Unauthorized)</td>
<td>• Unauthorized</td>
</tr>
<tr>
<td>403 (Forbidden)</td>
<td>• Forbidden</td>
</tr>
<tr>
<td>404 (Not Found)</td>
<td>• Thing not found</td>
</tr>
<tr>
<td></td>
<td>• No shadow exists with name: <code>shadowName</code></td>
</tr>
<tr>
<td>409 (Conflict)</td>
<td>• Version conflict</td>
</tr>
<tr>
<td>413 (Payload Too Large)</td>
<td>• The payload exceeds the maximum size allowed</td>
</tr>
<tr>
<td>415 (Unsupported Media Type)</td>
<td>• Unsupported documented encoding; supported encoding is UTF-8</td>
</tr>
<tr>
<td>429 (Too Many Requests)</td>
<td>• The Device Shadow service will generate this error message when there are more than 10 in-flight requests on a single connection. An in-flight request is an in-progress request that has been started but not yet completed.</td>
</tr>
<tr>
<td>500 (Internal Server Error)</td>
<td>• Internal service failure</td>
</tr>
</tbody>
</table>
Jobs

Use AWS IoT Jobs to define a set of remote operations that can be sent to and run on one or more devices connected to AWS IoT. For example, you can define a job that instructs a set of devices to download and install applications, run firmware updates, reboot, rotate certificates, or perform remote troubleshooting operations.

Accessing AWS IoT jobs

You can get started with AWS IoT Jobs by using the console or the AWS IoT Core API.

Using the console

Sign in to the AWS Management Console, and go to the AWS IoT console. In the navigation pane, choose Manage, and then choose Jobs. You can create and manage jobs from this section. If you want to create and manage job templates, in the navigation pane, choose Job templates. For more information, see Create and manage jobs by using the AWS Management Console (p. 713).

Using the API or CLI

You can get started by using the AWS IoT Core API operations. For more information, see AWS IoT API Reference. The AWS IoT Core API that AWS IoT jobs is built on is supported by the AWS SDK. For more information, see AWS SDKs and Toolkits.

You can use the AWS CLI to run commands for creating and managing jobs and job templates. For more information, see AWS IoT CLI reference.

AWS IoT Jobs Regions and endpoints

AWS IoT Jobs supports control plane and data plane API endpoints that are specific to your AWS Region. The data plane API endpoints are specific to your AWS account and AWS Region. For more information about the AWS IoT Jobs endpoints, see AWS IoT Device Management - jobs data endpoints in the AWS General Reference.

What is AWS IoT Jobs?

Use AWS IoT Jobs to define a set of remote operations that can be sent to and run on one or more devices connected to AWS IoT.

To create jobs, first define a job document that contains a list of instructions describing operations that the device must perform remotely. To perform these operations, specify a list of targets, which are individual things, thing groups (p. 276), or both. The job document and targets together constitute a deployment.

Each deployment can have additional configurations:

- **Rollout**: This configuration defines how many devices receive the job document every minute.
• **Abort**: If a certain number of devices don't receive the job notification, use this configuration to cancel the job. This avoids sending a bad update to an entire fleet.

• **Timeout**: If a response isn't received from your job targets within a certain duration, the job can fail. You can track the job that's running on these devices.

• **Retry**: If a device reports failure or a job times out, you can use AWS IoT Jobs to resend the job document to the device automatically.

• **Scheduling**: This configuration enables you to schedule a job for a future date and time. It also enables you to create recurring maintenance windows that update devices during predefined, low-traffic periods.

AWS IoT Jobs sends a message to inform the targets that a job is available. The target starts the execution of the job by downloading the job document, performing the operations it specifies, and reporting its progress to AWS IoT. You can track the progress of a job for a specific target or for all targets by running commands that are provided by AWS IoT Jobs. When a job starts, it has a status of *in progress*. The devices then report incremental updates while displaying this status until the job succeeds, fails, or times out.

The following topics describe some key concepts of jobs and the lifecycle of jobs and job executions.

**Topics**

- [Jobs key concepts](#)
- [Jobs and job execution states](#)

**Jobs key concepts**

The following concepts provide details about AWS IoT Jobs and how to create and deploy jobs to run remote operations on your devices.

**Basic concepts**

The following are basic concepts you must know when using AWS IoT Jobs.

**Job**

A job is a remote operation that is sent to and run on one or more devices connected to AWS IoT. For example, you can define a job that instructs a set of devices to download and install an application or run firmware updates, reboot, rotate certificates, or perform remote troubleshooting operations.

**Job document**

To create a job, you must first create a job document that is a description of the remote operations to be performed by the devices.

Job documents are UTF-8 encoded JSON documents and contain information that your devices require to perform a job. A job document contains one or more URLs where the device can download an update or other data. The job document can be stored in an Amazon S3 bucket, or be included inline with the command that creates the job.

**Tip**

For job document examples, see the [jobs-agent.js](#) example in the AWS IoT SDK for JavaScript.

**Target**

When you create a job, you specify a list of targets that are the devices that should perform the operations. The targets can be things or [thing groups](#) or both. The AWS IoT Jobs service sends a message to each target to inform it that a job is available.
Deployment

After you create a job by providing the job document and specifying your list of targets, the job document is then deployed to the remote target devices for which you want to perform the update. For snapshot jobs, the job will complete after deploying to the target devices. For continuous jobs, a job is deployed to a group of devices as they are added to the groups.

Job execution

A job execution is an instance of a job on a target device. The target starts an execution of a job by downloading the job document. It then performs the operations specified in the document, and reports its progress to AWS IoT. An execution number is a unique identifier of a job execution on a specific target. The AWS IoT Jobs service provides commands to track the progress of a job execution on a target and the progress of a job across all targets.

Job types concepts

The following concepts can help you understand more about the different types of jobs that you can create with AWS IoT Jobs.

Snapshot job

By default, a job is sent to all targets that you specify when you create the job. After those targets complete the job (or report that they’re unable to do so), the job is complete.

Continuous job

A continuous job is sent to all targets that you specify when you create the job. It continues to run and is sent to any new devices (things) that are added to the target group. For example, a continuous job can be used to onboard or upgrade devices as they’re added to a group. You can make a job continuous by setting an optional parameter when you create the job.

Note
When targeting your IoT fleet using dynamic thing groups, we recommend that you use continuous jobs instead of snapshot jobs. By using continuous jobs, devices that join the group receive the job execution even after the job has been created.

Presigned URLs

For secure, time-limited access to data that’s not included in the job document, you can use presigned Amazon S3 URLs. Place your data in an Amazon S3 bucket and add a placeholder link to the data in the job document. When AWS IoT Jobs receives a request for the job document, it parses the job document by looking for the placeholder links, and then replaces the links with presigned Amazon S3 URLs.

The placeholder link is in the following format:

${aws:iot:s3-presigned-url:https://s3.amazonaws.com/bucket/key}

where bucket is your bucket name and key is the object in the bucket to which you are linking.

In the Beijing and Ningxia Regions, presigned URLs work only if the resource owner has an ICP (Internet Content Provider) license. For more information, see Amazon Simple Storage Service in the Getting Started with AWS Services in China documentation.

Job configuration concepts

The following concepts can help you understand how to configure jobs.
Rollouts

You can specify how quickly targets are notified of a pending job execution. This allows you to create a staged rollout to better manage updates, reboots, and other operations. You can create a rollout configuration by using either a static rollout rate or an exponential rollout rate. To specify the maximum number of job targets to inform per minute, use a static rollout rate.

For examples of setting rollout rates and for more information about configuring job rollouts, see Job rollout, scheduling, and abort configurations (p. 742).

Scheduling

Job scheduling enables you to schedule the rollout timeframe of a job document to all devices in the target group for continuous and snapshot jobs. Additionally, you can create an optional maintenance window containing specific dates and times that a job will rollout the job document to all devices in the target group. A maintenance window is a recurring instance with a frequency of daily, weekly, monthly, or custom dates and times selected during the initial job or job template creation. Only continuous jobs can be scheduled to perform a rollout during a maintenance window.

Jobs Scheduling is specific to your job. Individual Job Executions can’t be scheduled. For more information, see Job rollout, scheduling, and abort configurations (p. 742).

Abort

You can create a set of conditions to cancel rollouts when criteria that you specify have been met. For more information, see Job rollout, scheduling, and abort configurations (p. 742).

Timeouts

Job timeouts notify you whenever a job deployment gets stuck in the IN_PROGRESS state for an unexpectedly long period of time. There are two types of timers: in-progress timers and step timers. When the job is IN_PROGRESS, you can monitor and track the progress of your job deployment.

Rollouts and abort configurations are specific to your job, whereas the timeout configuration is specific to a job deployment. For more information, see Job execution timeout and retry configurations (p. 747).

Retries

Job retries make it possible to retry the job execution when a job fails, times out, or both. You can have up to 10 attempted retries to execute the job. You can monitor and track the progress of your retry attempt and whether the job execution succeeded.

Rollouts and abort configurations are specific to your job, whereas the timeout and retry configurations are specific to a job execution. For more information, see Job execution timeout and retry configurations (p. 747).

Jobs and job execution states

The following sections describe the lifecycle of an AWS IoT job and the lifecycle of a job execution.

Job states

The following diagram shows the different states of an AWS IoT job.
A job that you create using AWS IoT Jobs can be in one of the following states:

- **SCHEDULED**

  During the initial job or job template creation using the AWS IoT console, `CreateJob` API, or `CreateJobTemplate` API, you can select the optional scheduling configuration in the AWS IoT console or the `SchedulingConfig` in the `CreateJob` API or `CreateJobTemplate` API. When you start a scheduled job containing a specific `startTime`, `endTime`, and `endBehavior`, the job status updates to SCHEDULED. When the job reaches your selected `startTime` or the `startTime` of the next maintenance window (if you selected job rollout during a maintenance window), the status will update from SCHEDULED to IN_PROGRESS and begin rollout of the job document to all devices in the target group.

- **IN_PROGRESS**

  When you create a job using the AWS IoT console or the `CreateJob` API, the job status updates to IN_PROGRESS. During job creation, AWS IoT Jobs starts rolling out job executions to the devices in your target group. After all the job executions have rolled out, AWS IoT Jobs waits for devices to complete the remote action.

  For information about concurrency and limits that apply to in-progress jobs, see [Job limits](p. 805).

  **Note**

  When an IN_PROGRESS job reaches the end of the current maintenance window, the rollout of the job document will stop. The job will update to SCHEDULED until the `startTime` of the next maintenance window.

- **COMPLETED**

  A continuous job is handled in one of the following ways:
  - For a continuous job without the optional scheduling configuration selected, it's always in progress and continues to run for any new devices that are added to the target group. It will never reach a status state of COMPLETED.
  - For a continuous job with the optional scheduling configuration selected, the following is true:
    - If an `endTime` was provided, a continuous job will reach COMPLETED status when `endTime` has passed and all job executions have reached a terminal status state.
    - If an `endTime` was not provided in the optional scheduling configuration, the continuous job will continue to perform the job document rollout.

  For a snapshot job, the job status changes to COMPLETED when all of its job executions enter a terminal state, such as SUCCEEDED, FAILED, TIMED_OUT, REMOVED, or CANCELED.

- **CANCELED**
When you cancel a job using the AWS IoT console, the `CancelJob` API, or the Job abort configuration (p. 747), the job status changes to CANCELED. During job cancellation, AWS IoT Jobs starts canceling previously created job executions.

For information about concurrency and limits that apply to jobs that are being canceled, see Job limits (p. 805).

- **DELETION_IN_PROGRESS**

When you delete a job using the AWS IoT console or the `DeleteJob` API, the job status changes to DELETION_IN_PROGRESS. During job deletion, AWS IoT Jobs starts deleting previously created job executions. After all job executions have been deleted, the job disappears from your AWS account.

### Job execution states

The following table shows the different states of an AWS IoT job execution and whether the state change is initiated by the device or by AWS IoT Jobs.

#### Job execution states and source

<table>
<thead>
<tr>
<th>Job execution state</th>
<th>Initiated by device?</th>
<th>Initiated by AWS IoT Jobs?</th>
<th>Terminal status?</th>
<th>Can be retried?</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUEUED</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Not applicable</td>
</tr>
<tr>
<td>IN_PROGRESS</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Not applicable</td>
</tr>
<tr>
<td>SUCCEEDED</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Not applicable</td>
</tr>
<tr>
<td>FAILED</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>TIMED_OUT</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>REJECTED</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>REMOVED</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>CANCELED</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

The following section describes more about the states of a job execution that’s rolled out when you create a job with AWS IoT Jobs.

- **QUEUED**

When AWS IoT Jobs rolls out a job execution for a target device, the job execution status is set to QUEUED. The job execution remains in the QUEUED state until:

  - Your device receives the job execution and invokes the Jobs API operations and reports the status as IN_PROGRESS.
  - You cancel the job or job execution, or when the abort criteria that you specified is met, and the status changes to CANCELED.
  - Your device is removed from the target group and the status changes to REMOVED.
• **IN_PROGRESS**

If your IoT device subscribes to the reserved Job topics $(p. 117)$ $\$notify$ and $\$notify\_next$, and your device invokes either the StartPendingJobExecution API or the UpdateJobExecution API with a status of IN_PROGRESS, AWS IoT Jobs will set the job execution status to IN_PROGRESS.

The UpdateJobExecution API can be invoked multiple times with a status of IN_PROGRESS. You can specify additional details about the execution steps using the statusDetails object.

**Note**

If you create multiple jobs for each device, AWS IoT Jobs and the MQTT protocol don't guarantee order of delivery.

• **SUCCEEDED**

When your device successfully completes the remote operation, the device must invoke the UpdateJobExecution API with a status of SUCCEEDED to indicate that the job execution succeeded. AWS IoT Jobs then updates and returns the job execution status as SUCCEEDED.

• **FAILED**

When your device fails to complete the remote operation, the device must invoke the UpdateJobExecution API with a status of Failed to indicate that the job execution failed. AWS IoT Jobs then updates and returns the job execution status as Failed. You can retry this job execution for the device using the Job execution retry configuration $(p. 749)$.

• **TIMED_OUT**

When your device fails to complete a job step when the status is IN_PROGRESS, or when it fails to complete the remote operation within the timeout duration of the in-progress timer, AWS IoT Jobs sets the job execution status to TIMED_OUT. You also have a step timer for each job step of an in-progress job and applies only to the job execution. The in-progress timer duration is specified using the inProgressTimeoutInMinutes property of the Job execution timeout configuration $(p. 748)$. You can retry this job execution for the device using the Job execution retry configuration $(p. 749)$.
Managing jobs

Use jobs to notify devices of a software or firmware update. You can use the AWS IoT console, the Job management and control API operations (p. 774), the AWS Command Line Interface, or the AWS SDKs to create and manage jobs.

Code signing for jobs

When sending code to devices, for devices to detect whether the code has been modified in transit, we recommend that you sign the code file by using the AWS CLI. For instructions, see Create and manage jobs by using the AWS CLI (p. 715).

For more information, see What Is Code Signing for AWS IoT?

Job document

Before you create a job, you must create a job document. If you're using code signing for AWS IoT, you must upload your job document to a versioned Amazon S3 bucket. For more information about creating an Amazon S3 bucket and uploading files to it, see Getting Started with Amazon Simple Storage Service in the Amazon S3 Getting Started Guide.
Tip
For job document examples, see the jobs-agent.js example in the AWS IoT SDK for JavaScript.

Presigned URLs

Your job document can contain a presigned Amazon S3 URL that points to your code file (or other file). Presigned Amazon S3 URLs are valid only for a limited amount of time and are generated when a device requests a job document. Because the presigned URL isn't created when you're creating the job document, use a placeholder URL in your job document instead. A placeholder URL looks like the following:

`${aws:iot:s3-presigned-url:https://s3.region.amazonaws.com/<bucket>/<code file>}`

where:

- `bucket` is the Amazon S3 bucket that contains the code file.
- `code file` is the Amazon S3 key of the code file.

When a device requests the job document, AWS IoT generates the presigned URL and replaces the placeholder URL with the presigned URL. Your job document is then sent to the device.

IAM role to grant permission to download files from S3

When you create a job that uses presigned Amazon S3 URLs, you must provide an IAM role. The role must grant permission to download files from the Amazon S3 bucket where the data or updates are stored. The role must also grant permission for AWS IoT to assume the role.

You can specify an optional timeout for the presigned URL. For more information, see CreateJob.

Grant AWS IoT Jobs permission to assume your role

1. Go to the Roles hub of the IAM console and choose your role.
2. On the Trust Relationships tab, choose Edit Trust Relationship and replace the policy document with the following JSON. Choose Update Trust Policy.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "Service": ["iot.amazonaws.com"]
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```

3. To protect against the confused deputy problem, add the global condition context keys aws:SourceArn and aws:SourceAccount to the policy.

   Important
   Your aws:SourceArn must comply with the format: arn:aws:iot:region:account-id:* . Make sure that region matches your AWS IoT Region and account-id matches your customer account ID. For more information, see Cross-service confused deputy prevention (p. 346).
Create and manage jobs by using the AWS Management Console

To create a job

1. Sign in to the AWS Management Console and log in to the AWS IoT console.
2. On the left navigation pane, under the Manage section, choose Remote Actions, and then choose Jobs.
3. On the Jobs page in the Jobs dialog box, choose Create job.
4. Depending on the device that you're using, you can create a custom job, a FreeRTOS OTA update job, or an AWS IoT Greengrass job. For this example, choose Create a custom job. Choose Next.
5. On the Custom job properties page, in the Job properties dialog box, enter your information for the following fields:
• **Name:** Enter a unique, alphanumeric job name.
• **Description - optional:** Enter an optional description about your Job.
• **Tags - optional:**

  **Note**

  We recommend that you don't use personally identifiable information in your job IDs and description.

  Choose Next.

6. On the **File configuration** page in the **Job targets** dialog box, select the **Things** or **Thing groups** that you want to run this job.

   In the **Job document** dialog box, select one of the following options:

   • **From file:** A JSON job file you previously uploaded to an Amazon S3 bucket
   • **Code signing**

     In the job document located in your Amazon S3 URL, `${aws:iot:code-sign-signature:s3://region.bucket/code-file@code-file-version-id}` is required as a placeholder until it is replaced with the signed code file path using your **Code signing profile**.

     The new signed code file will initially appear in a SignedImages folder in your Amazon S3 source bucket. A new job document containing a Codesigned_ prefix will be created with the signed code file path replacing the code-sign placeholder and placed in your Amazon S3 URL for creating a new job.

   • **Pre-sign resource URLs**

     In the **Pre-signing role** drop down, choose the IAM role you created in **Presigned URLs**. Using `${aws:iot:s3-presigned-url:` to presign URLs for objects located in Amazon S3 is a best security practice for devices downloading objects from Amazon S3.

     If you want to use presigned URLs for a code signing placeholder, use the following example template:

     ```
     ${aws:iot:s3-presigned-url:${aws:iot:code-sign-signature:<S3 URL>}
     ```

   • **From template:** A job template containing a job document and job configurations. The job template can be a custom job template you created or an AWS managed template.

     If you're creating a job for performing frequently used remote actions such as rebooting your device, you can use an AWS managed template. These templates have already been preconfigured for use. For more information, see [Create a custom job template](p. 736) and [Create custom job templates from managed templates](p. 733).

7. On the **Job configuration** page in the **Job configuration** dialog box, select one of the following job types:

   • **Snapshot job:** A snapshot job is complete when it's finished its run on the target devices and groups.
   • **Continuous job:** A continuous job applies to thing groups and runs on any device that you later add to a specified target group.

8. In the **Additional configurations - optional** dialog box, review the following optional Job configurations and make your selections accordingly:

   • **Rollout configuration**
   • **Scheduling configuration**
Create and manage jobs using the CLI

- Job executions timeout configuration
- Job executions retry configuration - new
- Abort configuration

Refer to the following sections for additional information on Job configurations:
- Job rollout, scheduling, and abort configurations (p. 742)
- Job execution timeout and retry configurations (p. 747)

Review all of your job selections and then choose Submit to create your job.

After you create the job, the console generates a JSON signature and places it in your job document. You can use the AWS IoT console to view the status, cancel, or delete a job. To manage jobs, go to the Job hub of the console.

Create and manage jobs by using the AWS CLI

This section describes how to create and manage jobs.

Create jobs

To create an AWS IoT job, use the CreateJob command. The job is queued for execution on the targets (things or thing groups) that you specify. To create an AWS IoT job, you need a job document that can be included in the body of the request or as a link to an Amazon S3 document. If the job includes downloading files using presigned Amazon S3 URLs, you need an IAM role Amazon Resource Name (ARN) that has permission to download the file and grants permission to the AWS IoT Jobs service to assume the role.

For more information on the syntax when entering the date and time using an API command or the AWS CLI, see Timestamp.

Code signing with jobs

If you're using code signing for AWS IoT, you must start a code signing job and include the output in your job document. This will replace the code sign signature placeholder in your job document, which is required as a placeholder until it is replaced with the signed code file path using your Code signing profile. The code sign signature placeholder will look like the following:

```
${aws:iot:code-sign-signature:s3://region.bucket/code-file@code-file-version-id}
```

Use the start-signing-job command to create a code signing job. start-signing-job returns a job ID. To get the Amazon S3 location where the signature is stored, use the describe-signing-job command. You can then download the signature from Amazon S3. For more information about code signing jobs, see Code signing for AWS IoT.

Your job document must contain a presigned URL placeholder for your code file and the JSON signature output placed in an Amazon S3 bucket using the start-signing-job command:

```
{
  "presign": "$\{aws:iot:s3-presigned-url:https://s3.region.amazonaws.com/bucket/image\}$",
}
```
Create a job with a job document

The following command shows how to create a job using a job document (job-document.json) stored in an Amazon S3 bucket (jobBucket), and a role with permission to download files from Amazon S3 (S3DownloadRole).

```bash
aws iot create-job
  --job-id 010
  --targets arn:aws:iot:us-east-1:123456789012:thing/thingOne
  --timeout-config inProgressTimeoutInMinutes=100
  --job-executions-rollout-config "{"exponentialRate": { "baseRatePerMinute": 50,
                                            "incrementFactor": 2,
                                            "rateIncreaseCriteria": { "numberOfNotifiedThings": 1000,
                                                                       "numberOfSucceededThings": 1000},
                                            "maximumPerMinute": 1000}"
  --abort-config "{"criteriaList": [{ "action": "CANCEL", "failureType": "FAILED",
                                      "minNumberOfExecutedThings": 100, "thresholdPercentage": 20},
                                      { "action": "CANCEL", "failureType": "TIMED_OUT",
                                      "minNumberOfExecutedThings": 200, "thresholdPercentage": 50}]}"
  --presigned-url-config "{"roleArn": "arn:aws:iam::123456789012:role/S3DownloadRole",
                           "expiresInSec": 3600}"
```

The job is run on thingOne.

The optional timeout-config parameter specifies the amount of time each device has to finish its execution of the job. The timer starts when the job execution status is set to IN_PROGRESS. If the job execution status isn't set to another terminal state before the time expires, it's set to TIMED_OUT.

The in-progress timer can't be updated and applies to all job executions for the job. Whenever a job execution remains in the IN_PROGRESS state for longer than this interval, it fails and switches to the terminal TIMED_OUT status. AWS IoT also publishes an MQTT notification.

For more information about creating configurations for job rollouts and aborts, see Job Rollout and Abort Configuration.

**Note**

Job documents that are specified as Amazon S3 files are retrieved at the time you create the job. If you change the contents of the Amazon S3 file that you used as the source of your job document after you've created the job document, then what's sent to the job targets doesn't change.

Update a job

To update a job, use the UpdateJob command. You can update the description, presignedUrlConfig, jobExecutionsRolloutConfig, abortConfig, and timeoutConfig fields of a job.

```bash
aws iot update-job
  --job-id 010
  --description "updated description"
  --timeout-config inProgressTimeoutInMinutes=100
  --job-executions-rollout-config "{"exponentialRate": { "baseRatePerMinute": 50,
                                             "incrementFactor": 2,
                                             "rateIncreaseCriteria": { "numberOfNotifiedThings": 1000,
                                                                         "numberOfSucceededThings": 1000},
                                             "maximumPerMinute": 1000}"
  --abort-config "{"criteriaList": [{ "action": "CANCEL", "failureType": "FAILED",
                                     "minNumberOfExecutedThings": 100, "thresholdPercentage": 20},
                                     { "action": "CANCEL", "failureType": "TIMED_OUT",
                                     "minNumberOfExecutedThings": 200, "thresholdPercentage": 50}]}"
  --presigned-url-config "{"roleArn": "arn:aws:iam::123456789012:role/S3DownloadRole",
                           "expiresInSec": 3600}"
```

For more information, see Job Rollout and Abort Configuration.
Cancel a job

To cancel a job, use the **CancelJob** command. Canceling a job stops AWS IoT from rolling out any new job executions for the job. It also cancels any job executions that are in a QUEUED state. AWS IoT keeps any job executions in a terminal state untouched because the device has already completed the job. If the status of a job execution is IN_PROGRESS, it also remains untouched unless you use the optional **--force** parameter.

The following command shows how to cancel a job with ID 010.

```bash
aws iot cancel-job --job-id 010
```

The command displays the following output:

```json
{
   "jobArn": "string",
   "jobId": "string",
   "description": "string"
}
```

When you cancel a job, job executions that are in a QUEUED state are canceled. Job executions that are in an IN_PROGRESS state are canceled, but only if you specify the optional **--force** parameter. Job executions in a terminal state aren't canceled.

**Warning**

Canceling a job that's in the IN_PROGRESS state (by setting the **--force** parameter) cancels any job executions that are in progress and causes the device that's running the job to be unable to update the job execution status. Use caution and make sure that each device executing a canceled job can recover to a valid state.

The status of a canceled job or of one of its job executions is eventually consistent. AWS IoT stops scheduling new job executions and QUEUED job executions for that job to devices as soon as possible. Changing the status of a job execution to CANCELED might take some time, depending on the number of devices and other factors.

If a job is canceled because it's met the criteria defined by an AbortConfig object, the service adds auto-populated values for the comment and reasonCode fields. You can create your own values for reasonCode when the job cancellation is user-driven.

Cancel a job execution

To cancel a job execution on a device, use the **CancelJobExecution** command. It cancels a job execution that's in a QUEUED state. If you want to cancel a job execution that's in progress, you must use the **--force** parameter.

The following command shows how to cancel the job execution from job 010 running on myThing.

```bash
aws iot cancel-job-execution --job-id 010 --thing-name myThing
```

The command displays no output.

A job execution that's in a QUEUED state is canceled. A job execution that's in an IN_PROGRESS state is canceled, but only if you specify the optional **--force** parameter. Job executions in a terminal state can't be canceled.

**Warning**

When you cancel a job execution that's in the IN_PROGRESS state, the device can't update the job execution status. Use caution and make sure that the device can recover to a valid state.
If the job execution is in a terminal state, or if the job execution is in an IN PROGRESS state and the --force parameter isn't set to true, this command causes an InvalidStateTransitionException.

The status of a canceled job execution is eventually consistent. Changing the status of a job execution to CANCELED might take some time, depending on various factors.

Delete a job

To delete a job and its job executions, use the DeleteJob command. By default, you can only delete a job that's in a terminal state (SUCCEEDED or CANCELED). Otherwise, an exception occurs. You can delete a job in the IN PROGRESS state, however, only if the force parameter is set to true.

To delete a job, run the following command:

```bash
aws iot delete-job --job-id 010 --force|--no-force
```

The command displays no output.

**Warning**

When you delete a job that's in the IN PROGRESS state, the device that's deploying the job can't access job information or update the job execution status. Use caution and make sure that each device deploying a job that's been deleted can recover to a valid state.

It can take some time to delete a job, depending on the number of job executions created for the job and other factors. While the job is being deleted, DELETION_IN_PROGRESS appears as the status of the job. An error results if you attempt to delete or cancel a job with a status that's already DELETION_IN_PROGRESS.

Only 10 jobs can have a status of DELETION_IN_PROGRESS at the same time. Otherwise, a LimitExceededException occurs.

Get a job document

To retrieve a job document for a job, use the GetJobDocument command. A job document is a description of the remote operations to be performed by the devices.

To get a job document, run the following command:

```bash
aws iot get-job-document --job-id 010
```

The command returns the job document for the specified job:

```json
{
  "document": "{\n    "operation": "install",
    "url": "http://amazon.com/firmWareUpdate-01",
    "data": "${aws:iot:s3-presigned-url:https://s3.amazonaws.com/job-test-bucket/datafile}"
  }"
}
```

**Note**

When you use this command to retrieve a job document, placeholder URLs aren't replaced by presigned Amazon S3 URLs. When a device calls the GetPendingJobExecutions API operation, the placeholder URLs are replaced by presigned Amazon S3 URLs in the job document.

List jobs

To get a list of all jobs in your AWS account, use the ListJobs command. Job data and job execution data are retained for a limited time. Run the following command to list all jobs in your AWS account:
aws iot list-jobs

The command returns all jobs in your account, sorted by the job status:

```json
{  "jobs": [      {         "status": "IN_PROGRESS",         "lastUpdatedAt": 1486687079.743,         "jobArn": "arn:aws:iot:us-east-1:123456789012:job/013",         "createdAt": 1486687079.743,         "targetSelection": "SNAPSHOT",         "jobId": "013"      },      {         "status": "SUCCEEDED",         "lastUpdatedAt": 1486685868.444,         "jobArn": "arn:aws:iot:us-east-1:123456789012:job/012",         "createdAt": 1486685868.444,         "completedAt": 148668789.690,         "targetSelection": "SNAPSHOT",         "jobId": "012"      },      {         "status": "CANCELED",         "lastUpdatedAt": 1486678850.575,         "jobArn": "arn:aws:iot:us-east-1:123456789012:job/011",         "createdAt": 1486678850.575,         "targetSelection": "SNAPSHOT",         "jobId": "011"      }  ]}
```

**Describe a job**

To get the status of a job, run the `DescribeJob` command. The following command shows how to describe a job:

```
$ aws iot describe-job --job-id 010
```

The command returns the status of the specified job. For example:

```json
{  "documentSource": "https://s3.amazonaws.com/job-test-bucket/job-document.json",  "job": {    "status": "IN_PROGRESS",    "jobArn": "arn:aws:iot:us-east-1:123456789012:job/010",    "targets": [      "arn:aws:iot:us-east-1:123456789012:thing/myThing"    ],    "jobProcessDetails": {      "numberOfCanceledThings": 0,      "numberOfFailedThings": 0,      "numberOfInProgressThings": 0,      "numberOfQueuedThings": 0,      "numberOfRejectedThings": 0,      "numberOfRemovedThings": 0,      "numberOfSucceededThings": 0,      "numberOfTimedOutThings": 0,      "processingTargets": [    ]  }  }}
```
arn:aws:iot:us-east-1:123456789012:thing/thingOne,
arn:aws:iot:us-east-1:123456789012:thinggroup/thinggroupOne,
arn:aws:iot:us-east-1:123456789012:thing/thingTwo,
arn:aws:iot:us-east-1:123456789012:thinggroup/thinggroupTwo
],
"presignedUrlConfig": {
  "expiresInSec": 60,
  "roleArn": "arn:aws:iam::123456789012:role/S3DownloadRole"
},
"jobId": "010",
"lastUpdatedAt": 1486593195.006,
"createdAt": 1486593195.006,
"targetSelection": "SNAPSHOT",
"jobExecutionsRolloutConfig": {
  "exponentialRate": {
    "baseRatePerMinute": integer,
    "incrementFactor": integer,
    "rateIncreaseCriteria": {
      "numberOfNotifiedThings": integer, // Set one or the other
      "numberOfSucceededThings": integer // of these two values.
    },
    "maximumPerMinute": integer
  }
},
"abortConfig": {
  "criteriaList": [
    {
      "action": "string",
      "failureType": "string",
      "minNumberOfExecutedThings": integer,
      "thresholdPercentage": integer
    }
  ]
},
"timeoutConfig": {
  "inProgressTimeoutInMinutes": number
}
}

List executions for a job

A job running on a specific device is represented by a job execution object. Run the
ListJobExecutionsForJob command to list all job executions for a job. The following shows how to list
the executions for a job:

aws iot list-job-executions-for-job --job-id 010

The command returns a list of job executions:

[  
  {  
    "executionSummaries": [
      {  
        "thingArn": "arn:aws:iot:us-east-1:123456789012:thing/thingOne",
        "jobExecutionSummary": {
          "status": "QUEUED",
          "lastUpdatedAt": 1486593196.378,
          "queuedAt": 1486593196.378,
          "executionNumber": 1234567890
        }
      }
    ]
  }
]
List job executions for a thing

Run the **ListJobExecutionsForThing** command to list all job executions running on a thing. The following shows how to list job executions for a thing:

```
aws iot list-job-executions-for-thing --thing-name thingOne
```

The command returns a list of job executions that are running or have run on the specified thing:

```
[
  {
    "executionSummaries": [
      {
        "jobExecutionSummary": {
          "status": "QUEUED",
          "lastUpdatedAt": 1486687082.071,
          "queuedAt": 1486687082.071,
          "executionNumber": 9876543210
        },
        "jobId": "013"
      },
      {
        "jobExecutionSummary": {
          "status": "IN_PROGRESS",
          "startAt": 1486685870.729,
          "lastUpdatedAt": 1486685870.729,
          "queuedAt": 1486685870.729,
          "executionNumber": 1357924680
        },
        "jobId": "012"
      },
      {
        "jobExecutionSummary": {
          "status": "SUCCEEDED",
          "startAt": 1486678853.415,
          "lastUpdatedAt": 1486678853.415,
          "queuedAt": 1486678853.415,
          "executionNumber": 4357680912
        },
        "jobId": "011"
      },
      {
        "jobExecutionSummary": {
          "status": "CANCELED",
          "startAt": 1486593196.378,
          "lastUpdatedAt": 1486593196.378,
          "queuedAt": 1486593196.378,
          "executionNumber": 2143174250
        },
        "jobId": "010"
      }
    ]
  }
]
```
Describe job execution

Run the DescribeJobExecution command to get the status of a job execution. You must specify a job ID and thing name and, optionally, an execution number to identify the job execution. The following shows how to describe a job execution:

```
aws iot describe-job-execution --job-id 017 --thing-name thingOne
```

The command returns the JobExecution. For example:

```
{
  "execution": {
    "jobId": "017",
    "executionNumber": 6516820379,
    "thingArn": "arn:aws:iot:us-east-1:123456789012:thing/thingOne",
    "versionNumber": 123,
    "createdAt": 1489084805.285,
    "lastUpdatedAt": 1489086279.937,
    "startedAt": 1489086279.937,
    "status": "IN_PROGRESS",
    "approximateSecondsBeforeTimedOut": 100,
    "statusDetails": {
      "status": "IN_PROGRESS",
      "detailsMap": {
        "percentComplete": "10"
      }
    }
  }
}
```

Delete job execution

Run the DeleteJobExecution command to delete a job execution. You must specify a job ID, a thing name, and an execution number to identify the job execution. The following shows how to delete a job execution:

```
aws iot delete-job-execution --job-id 017 --thing-name thingOne --execution-number 1234567890 --force|--no-force
```

The command displays no output.

By default, the status of the job execution must be QUEUED or in a terminal state (SUCCEEDED, FAILED, REJECTED, TIMED_OUT, REMOVED, or CANCELED). Otherwise, an error occurs. To delete a job execution with a status of IN_PROGRESS, you can set the force parameter to true.

**Warning**

When you delete a job execution with a status of IN_PROGRESS, the device that's executing the job can't access job information or update the job execution status. Use caution and make sure that the device can recover to a valid state.

Job templates

Use job templates to preconfigure jobs that you can deploy to multiple sets of target devices. To deploy frequently performed remote actions to your devices, like rebooting or installing an application, you
can use templates to define standard configurations. To perform operations such as deploying security patches and bug fixes, you can create templates from existing jobs.

When creating a job template, specify the following additional configurations and resources.

- Job properties
- Job documents and targets
- Rollout, scheduling, and cancel criteria
- Timeout and retry criteria

**Custom and AWS managed templates**

Depending on the remote action that you want to perform, you can either create a custom job template or use an AWS managed template. Use custom job templates to provide your own custom job document and create reusable jobs to deploy to your devices. AWS managed templates are job templates provided by AWS IoT Jobs for commonly performed actions. These templates have a predefined job document for some remote actions so you don’t have to create your own job document. Managed templates help you create reusable jobs for faster launch to your devices.

**Topics**

- Use AWS managed templates to deploy common remote operations (p. 723)
- Create custom job templates (p. 736)

**Use AWS managed templates to deploy common remote operations**

AWS managed templates are job templates provided by AWS. They’re used for frequently performed remote actions such as rebooting, downloading a file, or installing an application on your devices. These templates have a predefined job document for each remote action so you don’t have to create your own job document.

You can choose from a set of predefined configurations and create jobs using these templates without writing any additional code. Using managed templates, you can view the job document deployed to your fleets. You can create a job using these templates and create a custom job template that you can reuse for your remote operations.

**What do managed templates contain?**

Each AWS managed template contains:

- The environment to run the commands in the job document.
- A job document that specifies the name of the operation and its parameters. For example, if you use a Download file template, the operation name is Download file and the parameters can be:
  - The URL of the file that you want to download to your device. This can be an internet resource or a public or pre-signed Amazon Simple Storage Service (Amazon S3) URL.
  - A local file path on the device to store the downloaded file.

For more information about the job documents and its parameters, see Managed template remote actions and job documents (p. 724).

**Note**

The total number of substitution patterns in a job document should be less than or equal to ten.
**Prerequisites**

For your devices to run the remote actions specified by the managed template job document, you must:

- **Install the specific software on your device**

  Use your own device software and job handlers, or the AWS IoT Device Client. Depending on your business case, you can also run them both so that they perform different functions.

- **Use your own device software and job handlers**

  You can write your own code for the devices by using the AWS IoT Device SDK and its library of handlers that support the remote operations. To deploy and run jobs, verify that the device agent libraries have been installed correctly and are running on the devices.

  You can also choose to use your own handlers that support the remote operations. For more information, see [Sample job handlers](#) in the AWS IoT Device Client GitHub repository.

- **Use the AWS IoT Device Client**

  Alternatively, you can install and run the AWS IoT Device Client on your devices because it supports using all managed templates directly from the console by default.

  The Device Client is an open-source software written in C++ that you can compile and install on your embedded Linux-based IoT devices. The Device Client has a base client and discrete client-side features. The base client establishes connectivity with AWS IoT over MQTT protocol and can connect with the different client-side features.

  To perform remote operations on your devices, use the client-side Jobs feature of the Device Client. This feature contains a parser to receive the job document and job handlers that implement the remote actions specified in the job document. For more information about the Device Client and its features, see [AWS IoT Device Client](#).

  When running on devices, the Device Client receives the job document and has a platform-specific implementation that it uses to run commands in the document. For more information about setting up the Device Client and using the Jobs feature, see [AWS IoT tutorials](#).

- **Use a supported environment**

  For each managed template, you'll find information about the environment that you can use to run the remote actions. We recommend that you use the template with a supported Linux environment as specified in the template. Use the AWS IoT Device Client to run the managed template remote actions because it supports common microprocessors and Linux environments, like Debian and Ubuntu.

**Managed template remote actions and job documents**

The following section lists the different AWS managed templates for AWS IoT Jobs, and describes the remote actions that can be performed on the devices. The following section has information about the job document and a description of the job document parameters for each remote action. Your device-side software uses the template name and the parameters to perform the remote action.

AWS managed templates accept input parameters for which you specify a value when creating a job using the template. All managed templates have two optional input parameters in common: `runAsUser` and `pathToHandler`. Except for the AWS-Reboot template, the templates require additional input parameters for which you must specify a value when creating a job using the template. These required input parameters vary depending on the template that you choose. For example, if you choose the AWS-Download-File template, you must specify a list of packages to install, and a URL to download files from.
Specify a value for the input parameters when using the AWS IoT console or the AWS Command Line Interface (AWS CLI) to create a job that uses a managed template. When using the CLI, provide these values by using the document-parameters object. For more information, see `documentParameters`.

**Note**

Use `document-parameters` only when creating jobs from AWS managed templates. This parameter can't be used with custom job templates or to create jobs from them.

The following shows a description of the common optional input parameters. You'll see a description of other input parameters that each managed template requires in the next section.

### runAsUser

This parameter specifies whether to run the job handler as another user. If it's not specified during job creation, the job handler is run as the same user as the Device Client. When you run the job handler as another user, specify a string value that's not longer than 256 characters.

### pathToHandler

The path to the job handler running on the device. If it's not specified during job creation, the Device Client uses the current working directory.

The following shows the different remote actions, their job documents, and parameters that they accept. All these templates support the Linux environment for running the remote operation on the device.

**AWS–Download–File**

**Template name**

AWS–Download–File

**Template description**

A managed template provided by AWS for downloading a file.

**Input parameters**

This template has the following required parameters. You can also specify the optional parameters `runAsUser` and `pathToHandler`.

**downloadUrl**

The URL to download the file from. This can be an internet resource, an object in Amazon S3 that can be publicly accessed, or an object in Amazon S3 that can only be accessed by your device using a presigned URL. For more information about using presigned URLs and granting permissions, see [Presigned URLs](p. 712).

**filePath**

A local file path that shows the location in the device to store the downloaded file.

**Device behavior**

The device downloads the file from the specified location, verifies that the download is complete, and stores it locally.

**Job document**

The following shows the job document and its latest version. The template shows the path to the job handler and the shell script, `download-file.sh`, that the job handler must run to download the file. It also shows the required parameters `downloadUrl` and `filePath`. 
AWS--Install--Application

Template name
AWS--Install--Application

Template description
A managed template provided by AWS for installing one or more applications.

Input parameters
This template has the following required parameter, packages. You can also specify the optional parameters runAsUser and pathToHandler.

packages
A space-separated list of one or more applications to be installed.

Device behavior
The device installs the applications as specified in the job document.

Job document
The following shows the job document and its latest version. The template shows the path to the job handler and the shell script, install-packages.sh, that the job handler must run to download the file. It also shows the required parameter packages.

```json
{
  "version": "1.0",
  "steps": [
    {
      "action": {
        "name": "Install-Application",
        "type": "runHandler",
        "input": {
          "handler": "install-packages.sh",
          "args": [
            "${aws:iot:parameter:packages}"
          ],
          "path": "${aws:iot:parameter:pathToHandler}"
        },
        "runAsUser": "${aws:iot:parameter:runAsUser}"}
    }
  ]
}
```
Use AWS managed templates

**AWS–Reboot**

**Template name**
AWS–Reboot

**Template description**
A managed template provided by AWS for rebooting your device.

**Input parameters**
This template has no required parameters. You can specify the optional parameters `runAsUser` and `pathToHandler`.

**Device behavior**
The device reboots successfully.

**Job document**
The following shows the job document and its latest version. The template shows the path to the job handler and the shell script, `reboot.sh`, that the job handler must run to reboot the device.

```json
{
    "version": "1.0",
    "steps": [
        {
            "action": {
                "name": "Reboot",
                "type": "runHandler",
                "input": {
                    "handler": "reboot.sh",
                    "path": "${aws:iot:parameter:pathToHandler}"
                },
                "runAsUser": "${aws:iot:parameter:runAsUser}"  
            }
        }
    ]
}
```

**AWS–Remove–Application**

**Template name**
AWS–Remove–Application

**Template description**
A managed template provided by AWS for uninstalling one or more applications.

**Input parameters**
This template has the following required parameter, `packages`. You can also specify the optional parameters `runAsUser` and `pathToHandler`.
packages
A space-separated list of one or more applications to be uninstalled.

Device behavior
The device uninstalls the applications as specified in the job document.

Job document
The following shows the job document and its latest version. The template shows the path to the job handler and the shell script, remove-packages.sh, that the job handler must run to download the file. It also shows the required parameter packages.

```
{
    "version": "1.0",
    "steps": [
        {
            "action": {
                "name": "Remove-Application",
                "type": "runHandler",
                "input": {
                    "handler": "remove-packages.sh",
                    "args": [
                        "${aws:iot:parameter:packages}"
                    ],
                    "path": "${aws:iot:parameter:pathToHandler}"
                },
                "runAsUser": "${aws:iot:parameter:runAsUser}"
            }
        }
    ]
}
```

AWS–Restart–Application

Template name
AWS–Restart–Application

Template description
A managed template provided by AWS for stopping and restarting one or more services.

Input parameters
This template has the following required parameter, services. You can also specify the optional parameters runAsUser and pathToHandler.

Services
A space-separated list of one or more applications to be restarted.

Device behavior
The specified applications are stopped and then restarted on the device.

Job document
The following shows the job document and its latest version. The template shows the path to the job handler and the shell script, restart-services.sh, that the job handler must run to restart the system services. It also shows the required parameter services.
Use AWS managed templates

AWS–Start–Application

**Template name**
AWS-Start-Application

**Template description**
A managed template provided by AWS for starting one or more services.

**Input parameters**
This template has the following required parameter, services. You can also specify the optional parameters runAsUser and pathToHandler.

**services**
A space-separated list of one or more applications to be started.

**Device behavior**
The specified applications start running on the device.

**Job document**
The following shows the job document and its latest version. The template shows the path to the job handler and the shell script, start-services.sh, that the job handler must run to start the system services. It also shows the required parameter services.

```
{
  "version": "1.0",
  "steps": [
    {
      "action": {
        "name": "Start-Application",
        "type": "runHandler",
        "input": {
          "handler": "start-services.sh",
          "args": [
            "${aws:iot:parameter:services}"
          ],
          "path": "${aws:iot:parameter:pathToHandler}"
        },
        "runAsUser": "${aws:iot:parameter:runAsUser}"}
    }
  ]
}
```
Use AWS managed templates

AWS–Stop–Application

Template name
AWS–Stop–Application

Template description
A managed template provided by AWS for stopping one or more services.

Input parameters
This template has the following required parameter, services. You can also specify the optional parameters runAsUser and pathToHandler.

services
A space-separated list of one or more applications to be stopped.

Device behavior
The specified applications stop running on the device.

Job document
The following shows the job document and its latest version. The template shows the path to the job handler and the shell script, stop-services.sh, that the job handler must run to stop the system services. It also shows the required parameter services.

```
{
  "version": "1.0",
  "steps": [
    {
      "action": {
        "name": "Stop-Application",
        "type": "runHandler",
        "input": {
          "handler": "stop-services.sh",
          "args": [
            "${aws:iot:parameter:services}"
          ],
          "path": "${aws:iot:parameter:pathToHandler}"
        },
        "runAsUser": "${aws:iot:parameter:runAsUser}""n
      }
    }
  ]
}
```

AWS–Run–Command

Template name
AWS–Run–Command

Template description
A managed template provided by AWS for running a shell command.

**Input parameters**

This template has the following required parameter, command. You can also specify the optional parameter runAsUser.

- **command**

  A comma separated string of command. Any comma contained in the command itself must be escaped.

**Device behavior**

The device runs the shell command as specified in the job document.

**Job document**

The following shows the job document and its latest version. The template shows the path to the job command and the command that you provided which the device will run.

```
{
  "version": "1.0",
  "steps": [
    {
      "action": {
        "name": "Run-Command",
        "type": "runCommand",
        "input": {
          "command": "${aws:iot:parameter:command}"
        },
        "runAsUser": "${aws:iot:parameter:runAsUser}"
      }
    }
  ]
}
```

**Topics**

- [Create a job from AWS managed templates by using the AWS Management Console](p. 731)
- [Create a job from AWS managed templates by using the AWS CLI](p. 733)

**Create a job from AWS managed templates by using the AWS Management Console**

Use the AWS Management Console to get information about AWS managed templates and create a job by using these templates. You can then save the job you create as your own custom template.

**Get details about managed templates**

You can get information about the different managed templates that are available to use from the AWS IoT console.

1. To see your available managed templates, go to the [Job templates hub of the AWS IoT console](#) and choose the **Managed templates** tab.
2. To view details, choose a managed template.

The details page contains the following information:
Use AWS managed templates

• Name, description, and Amazon Resource Name (ARN) of the managed template.
• The environment on which the remote operations can be performed, such as Linux.
• The JSON job document that specifies the path to the job handler and the commands to run on the device. For example, the following shows an example job document for the AWS-Reboot template. The template shows the path to the job handler and the shell script, reboot.sh, that the job handler must run to reboot the device.

```json
{
   "version": "1.0",
   "steps": [
      {
         "action": {
            "name": "Reboot",
            "type": "runHandler",
            "input": {
               "handler": "reboot.sh",
               "path": "${aws:iot:parameter:pathToHandler}"
            },
            "runAsUser": "${aws:iot:parameter:runAsUser}"
         }
      }
   ]
}
```

For more information about the job document and its parameters for various remote actions, see Managed template remote actions and job documents (p. 724).

• The latest version of the job document.

Create a job using managed templates

You can use the AWS Management console to choose an AWS managed template to use to create a job. This section shows you how.

You can also start the job creation workflow and then choose the AWS managed template that you want to use while creating the job. For more information about this workflow, see Create and manage jobs by using the AWS Management Console (p. 713).

1. **Choose your AWS managed template**

   Go to the Job templates hub of the AWS IoT console, choose the Managed templates tab, and then choose your template.

2. **Create a job using your managed template**

   1. In the details page of your template, choose Create job.

      The console switches to the Custom job properties step of the Create job workflow where your template configuration has been added.

   2. Enter a unique alphanumeric job name, and optional description and tags, and then choose Next.

   3. Choose the things or thing groups as job targets that you want to run in this job.

   4. In the Job document section, your template is displayed with its configuration settings and input parameters. Enter values for the input parameters of your chosen template. For example, if you chose the AWS-Download-File template:

      • For downloadUrl, enter the URL of the file to download, for example:

      • For filePath, enter the path on the device to store the downloaded file, for example: path/to/file.
You can also optionally enter values for the parameters runAsUser and pathToHandler. For more information about the input parameters of each template, see Managed template remote actions and job documents (p. 724).

5. On the Job configuration page, choose the job type as continuous or a snapshot job. A snapshot job is complete when it finishes its run on the target devices and groups. A continuous job applies to thing groups and runs on any device that you add to a specified target group.

6. Continue to add any additional configurations for your job and then review and create your job. For information about the additional configurations, see:
   - Job rollout, scheduling, and abort configurations (p. 742)
   - Job execution timeout and retry configurations (p. 747)

Create custom job templates from managed templates

You can use an AWS managed template and a custom job as a starting point to create your own custom job template. To create a custom job template, first create a job from your AWS managed template as described in the previous section.

You can then save the custom job as a template to create your own custom job template. To save as template:

1. Go to the Job hub of the AWS IoT console and choose the job containing your managed template.
2. Choose Save as a job template and then create your custom job template. For more information about creating a custom job template, see Create a job template from an existing job (p. 737).

Create a job from AWS managed templates by using the AWS CLI

Use the AWS CLI to get information about AWS managed templates and create a job by using these templates. You can then save the job as a template and then create your own custom template.

List managed templates

The list-managed-job-templates AWS CLI command lists all of the job templates in your AWS account.

```
aws iot list-managed-job-templates
```

By default, running this command displays all available AWS managed templates and their details.

```
[
  "managedJobTemplates": [
    {
      "templateArn": "arn:aws:iot:region::jobtemplate/AWS-Reboot:1.0",
      "templateName": "AWS-Reboot",
      "description": "A managed job template for rebooting the device.",
      "environments": ["LINUX"],
      "templateVersion": "1.0"
    },
    {
      "templateArn": "arn:aws:iot:region::jobtemplate/AWS-Remove-Application:1.0",
      "templateName": "AWS-Remove-Application",
    }
  ]
]}
```
For more information, see ListManagedJobTemplates.

Get details about a managed template

The describe-managed-job-template AWS CLI command gets details about a specified job template. Specify the job template name and an optional template version. If the template version is not specified, the predefined, default version is returned. The following shows an example of running the command to get details about the AWS-Download-File template.

```
aws iot describe-managed-job-template \
  --template-name AWS-Download-File
```

The command displays the template details and ARN, its job document, and the documentParameters parameter, which is a list of key-value pairs of input parameters of the template. For information about the different templates and input parameters, see Managed template remote actions and job documents (p. 724).

**Note**
The documentParameters object returned when you use this API must only be used when creating jobs from AWS managed templates. The object must not be used for custom job templates. For an example that shows how to use this parameter, see Create a job by using managed templates (p. 735).
Use AWS managed templates

For more information, see DescribeManagedJobTemplate.

Create a job by using managed templates

The create-job AWS CLI command can be used to create a job from a job template. It targets a device named thingOne and specifies the Amazon Resource Name (ARN) of the managed template to use as the basis for the job. You can override advanced configurations, such as timeout and cancel configurations, by passing the associated parameters of the create-job command.

The example shows how to create a job that uses the AWS-Download-File template. It also shows how to specify the input parameters of the template by using the document-parameters parameter.

Note
Use the document-parameters object only with AWS managed templates. This object must not be used with custom job templates.

```
aws iot create-job 
--targets arn:aws:iot:region:account-id:thing/thingOne 
--job-id "new-managed-template-job" 
```
where:

- **region** is the AWS Region.
- **account-id** is the unique AWS account number.
- **thingOne** is the name of the IoT thing for which the job is targeted.
- **AWS-Download-File:1.0** is the name of the managed template.
- **https://example.com/index.html** is the URL to download the file from.
- **https://path/to/file/index** is the path on the device to store the downloaded file.

Run the following command to create a job for the template, **AWS-Download-File**.

```
{
    "jobId": "new-managed-template-job",
    "description": "A managed job template for downloading a file."
}
```

Create a custom job template from an existing job

1. Create a job using a managed template as described in the previous section.
2. Create a custom job template by using the ARN of the job that you created. For more information, see Create a job template from an existing job (p. 739).

Create custom job templates

You can create job templates by using the AWS CLI and the AWS IoT console. You can also create jobs from job templates by using the AWS CLI, the AWS IoT console, and Fleet Hub for AWS IoT Device Management web applications. For more information about working with job templates in Fleet Hub applications, see Working with job templates in Fleet Hub for AWS IoT Device Management.

**Note**

The total number of substitution patterns in a job document should be less than or equal to ten.

**Topics**

- Create custom job templates by using the AWS Management Console (p. 736)
- Create custom job templates by using the AWS CLI (p. 739)

Create custom job templates by using the AWS Management Console

This topic explains how to create, delete, and view details about job templates by using the AWS IoT console.

Create a custom job template

You can either create an original custom job template or create a job template from an existing job. You can also create a custom job template from an existing job that was created using an AWS managed template. For more information, see Create custom job templates from managed templates (p. 733).
Create an original job template

1. **Start creating your job template**
   1. Go to the [Job templates hub of the AWS IoT console](https://aws.amazon.com) and choose the **Custom templates** tab.
   2. Choose **Create job template**.

   **Note**
   You can also navigate to the **Job templates** page from the **Related services** page under **Fleet Hub**.

2. **Specify job template properties**
   In the **Create job template** page, enter an alphanumeric identifier for your job name and an alphanumeric description to provide additional details about the template.

   **Note**
   We don't recommend using personally identifiable information in your job IDs or descriptions.

3. **Provide job document**
   Provide a JSON job file that is either stored in an S3 bucket or as an inline job document that is specified within the job. This job file will become the job document when you create a job using this template.

   If the job file is stored in an S3 bucket, enter the S3 URL or choose **Browse S3**, and then navigate to your job document and select it.

   **Note**
   You can select only S3 buckets in your current Region.

4. Continue to add any additional configurations for your job and then review and create your job. For information about the additional, optional configurations, refer to the following links:

   - [Job rollout, scheduling, and abort configurations](https://aws.amazon.com) (p. 742)
   - [Job execution timeout and retry configurations](https://aws.amazon.com) (p. 747)

Create a job template from an existing job

1. **Choose your job**
   1. Go to the [Job hub of the AWS IoT console](https://aws.amazon.com) and choose the job that you want to use as the basis for your job template.
   2. Choose **Save as a job template**.

   **Note**
   Optionally, you can choose a different job document or edit the advanced configurations from the original job, and then choose **Create job template**. Your new job template appears on the **Job templates** page.

2. **Specify job template properties**
   In the **Create job template** page, enter an alphanumeric identifier for your job name and an alphanumeric description to provide additional details about the template.

   **Note**
   The job document is the job file that you specified when creating the template. If the job document is specified within the job instead of an S3 location, you can see the job document in the details page of this job.
3. Continue to add any additional configurations for your job and then review and create your job. For information about the additional configurations, see:
   - Job rollout, scheduling, and abort configurations (p. 742)
   - Job execution timeout and retry configurations (p. 747)

Create a job from a custom job template

You can create a job from a custom job template by going to the details page of your job template as described in this topic. You can also create a job or by choosing the job template you want to use when running the job creation workflow. For more information, see Create and manage jobs by using the AWS Management Console (p. 713).

This topic shows how to create a job from the details page of a custom job template. You can also create a job from an AWS managed template. For more information, see Create a job using managed templates (p. 732).

1. Choose your custom job template
   Go to the Job templates hub of the AWS IoT console and choose the Custom templates tab, and then choose your template.

2. Create a job using your custom template
   To create a job:
   1. In the details page of your template, choose Create job.
      The console switches to the Custom job properties step of the Create job workflow where your template configuration has been added.
   2. Enter a unique alphanumeric job name, and optional description and tags, and then choose Next.
   3. Choose the things or thing groups as job targets that you want to run in this job.
      In the Job document section, your template is displayed with its configuration settings. If you want to use a different job document, choose Browse and select a different bucket and document. Choose Next.
   4. On the Job configuration page, choose the job type as continuous or a snapshot job. A snapshot job is complete when it finishes its run on the target devices and groups. A continuous job applies to thing groups and runs on any device that you add to a specified target group.
   5. Continue to add any additional configurations for your job and then review and create your job.
      For information about the additional configurations, see:
      - Job rollout, scheduling, and abort configurations (p. 742)
      - Job execution timeout and retry configurations (p. 747)

Note
When a job created from a job template updates the existing parameters provided by the job template, those updated parameters will override the existing parameters provided by the job template for that job.

You can also create jobs from job templates with Fleet Hub web applications. For information about creating jobs in Fleet Hub, see Working with job templates in Fleet Hub for AWS IoT Device Management.

Delete a job template

To delete a job template, first go to the Job templates hub of the AWS IoT console and choose the Custom templates tab. Then, choose the job template you want to delete and choose Next.
Create custom job templates by using the AWS CLI

This topic explains how to create, delete, and retrieve details about job templates by using the AWS CLI.

Create a job template from scratch

The following AWS CLI command shows how to create a job using a job document (job-document.json) stored in an S3 bucket and a role with permission to download files from Amazon S3 (S3DownloadRole).

```bash
aws iot create-job-template  
  --job-template-id 010  
  --timeout-config inProgressTimeoutInMinutes=100  
  --job-executions-rollout-config "{ \"exponentialRate\": { \"baseRatePerMinute\": 50, \"incrementFactor\": 2, \"rateIncreaseCriteria\": { \"numberOfNotifiedThings\": 1000, \"numberOfSucceededThings\": 1000}, \"maximumPerMinute\": 1000}  
  --abort-config "{ \"criterialist\": [ { \"action\": \"CANCEL\", \"failureType\": \"FAILED\"}, \"minNumberOfExecutedThings\": 100, \"thresholdPercentage\": 20}, { \"action\": \"CANCEL\", \"failureType\": \"TIMED_OUT\", \"minNumberOfExecutedThings\": 200, \"thresholdPercentage\": 50}]}  
  --presigned-url-config "{ \"roleArn\": \"arn:aws:iam::123456789012:role/S3DownloadRole\", \"expiresInSec\": 3600}"
```

The optional `timeout-config` parameter specifies the amount of time each device has to finish running the job. The timer starts when the job execution status is set to IN_PROGRESS. If the job execution status isn't set to another terminal state before the time expires, it's set to TIMED_OUT.

The in-progress timer can't be updated and applies to all job launches for the job. Whenever a job launch remains in the IN_PROGRESS state for longer than this interval, the job launch fails and switches to the terminal TIMED_OUT status. AWS IoT also publishes an MQTT notification.

For more information about creating configurations about job rollouts and aborts, see [Job rollout and abort configuration](#).  

**Note**  
Job documents that are specified as Amazon S3 files are retrieved at the time you create the job. If you change the contents of the Amazon S3 file you used as the source of your job document after you create the job, what is sent to the targets of the job doesn't change.

Create a job template from an existing job

The following AWS CLI command creates a job template by specifying the Amazon Resource Name (ARN) of an existing job. The new job template uses all of the configurations specified in the job. Optionally, you can change any of the configurations in the existing job by using any of the optional parameters.

```bash
aws iot create-job-template  
  --timeout-config inProgressTimeoutInMinutes=100
```

Get details about a job template

The following AWS CLI command gets details about a specified job template.
aws iot describe-job-template \
  --job-template-id template-id

The command displays the following output.

```
{
  "abortConfig": {
    "criteriaList": [
      {
        "action": "string",
        "failureType": "string",
        "minNumberOfExecutedThings": number,
        "thresholdPercentage": number
      }
    ],
    "createdAt": number,
    "description": "string",
    "document": "string",
    "documentSource": "string",
    "jobExecutionsRolloutConfig": {
      "exponentialRate": {
        "baseRatePerMinute": number,
        "incrementFactor": number,
        "rateIncreaseCriteria": {
          "numberOfNotifiedThings": number,
          "numberOfSucceededThings": number
        }
      },
      "maximumPerMinute": number
    },
    "jobTemplateArn": "string",
    "jobTemplateId": "string",
    "presignedUrlConfig": {
      "expiresInSec": number,
      "roleArn": "string"
    },
    "timeoutConfig": {
      "inProgressTimeoutInMinutes": number
    }
  }
}
```

**List job templates**

The following AWS CLI command lists all of the job templates in your AWS account.

```
aws iot list-job-templates
```

The command displays the following output.

```
{
  "jobTemplates": [
    {
      "createdAt": number,
      "description": "string",
      "document": "string",
      "documentSource": "string",
      "jobExecutionsRolloutConfig": {
        "exponentialRate": {
          "baseRatePerMinute": number,
          "incrementFactor": number,
          "rateIncreaseCriteria": {
            "numberOfNotifiedThings": number,
            "numberOfSucceededThings": number
          }
        },
        "maximumPerMinute": number
      },
      "jobTemplateArn": "string",
      "jobTemplateId": "string",
      "presignedUrlConfig": {
        "expiresInSec": number,
        "roleArn": "string"
      },
      "timeoutConfig": {
        "inProgressTimeoutInMinutes": number
      }
    }
  ]
}
```
To retrieve additional pages of results, use the value of the nextToken field.

**Delete a job template**

The following AWS CLI command deletes a specified job template.

```
aws iot delete-job-template
   --job-template-id template-id
```

The command displays no output.

**Create a job from a custom job template**

The following AWS CLI command creates a job from a custom job template. It targets a device named thingOne and specifies the Amazon Resource Name (ARN) of the job template to use as the basis for the job. You can override advanced configurations, such as timeout and cancel configurations, by passing the associated parameters of the create-job command.

**Warning**
The document-parameters object must be used with the create-job command only when creating jobs from AWS managed templates. This object must not be used with custom job templates. For an example that shows how to create jobs using this parameter, see [Create a job by using managed templates](p. 735).

```
aws iot create-job
   --targets arn:aws:iot:region:123456789012:thing/thingOne
```

**Job configurations**

You can have the following additional configurations for each job that you deploy to the specified targets.

- **Rollout**: Defines how many devices receive the job document every minute.
- **Scheduling**: Schedules a job for a future date and time in addition to using recurring maintenance windows.
- **Abort**: Cancels a job in cases such as when some devices don't receive the job notification, or your devices report failure for their job executions.
- **Timeout**: If there isn't a response from your job targets within a certain duration after their job executions have started, the job can fail.
- **Retry**: Retries the job execution if your device reports failure when attempting to complete a job execution, or if your job execution times out.

By using these configurations, you can monitor the status of your job execution and avoid a bad update from being sent to an entire fleet.
How job configurations work

You use the rollout and abort configurations when you're deploying a job, and the timeout and retry configurations for job execution. The following sections show more information about how these configurations work.

Job rollout, scheduling, and abort configurations

You can use the job rollout, scheduling, and abort configurations to define how many devices receive the job document, schedule a job rollout, and determine the criteria for canceling a job.

Job rollout configuration

You can specify how quickly targets are notified of a pending job execution. You can also create a staged rollout to manage updates, reboots, and other operations. To specify how your targets are notified, use job rollout rates.

Job rollout rates

You can create a rollout configuration by using either a constant rollout rate or an exponential rollout rate. To specify the maximum number of job targets to inform per minute, use a constant rollout rate.

AWS IoT jobs can be deployed using exponential rollout rates as various criteria and thresholds are met. If the number of failed jobs matches a set of criteria that you specify, then you can cancel the job rollout. You set the job rollout rate criteria when you create a job by using the JobExecutionsRolloutConfig object. You also set the job abort criteria at job creation by using the AbortConfig object.

The following example shows how rollout rates work. For example, a job rollout with a base rate of 50 per minute, increment factor of 2, and number of notified and succeeded devices each as 1,000, would work as follows: The job will start at a rate of 50 job executions per minute and continue at that rate until either 1,000 things have received job execution notifications, or 1,000 successful job executions have occurred.

The following table illustrates how the rollout would proceed over the first four increments.

<table>
<thead>
<tr>
<th>Rollout rate per minute</th>
<th>50</th>
<th>100</th>
<th>200</th>
<th>400</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of notified devices or successful job executions to satisfy a rate increase</td>
<td>1,000</td>
<td>2,000</td>
<td>3,000</td>
<td>4,000</td>
</tr>
</tbody>
</table>

Note

If you're at your max concurrent limit of 500 Jobs (isConcurrent = True), then all active jobs will remain with a status of IN-PROGRESS and not roll out any new job executions until the number of concurrent jobs is 499 or less (isConcurrent = False). This applies to snapshot and continuous jobs.
If `isConcurrent = True`, the job is currently rolling out job executions to all devices in your target group. If `isConcurrent = False`, the job has completed the rollout of all job executions to all devices in your target group. It will update its status state once all devices in your target group reach a terminal state, or a threshold percentage of your target group if you selected a job abort configuration. The Job level status states for `isConcurrent = True` and `isConcurrent = False` are both `IN_PROGRESS`.

For more information about active and concurrent job limits, see [Active and concurrent job limits](p. 805).

### Job rollout rates for continuous jobs using dynamic thing groups

When you use a continuous job to roll out remote operations on your fleet, AWS IoT Jobs rolls out job executions for devices in your target thing group. For new devices that are added to the dynamic thing group, these job executions continue to roll out to those devices even after the job has been created.

The rollout configuration can control the rollout rates only for devices that are added to the group until job creation. After a job has been created, for any new devices, the job executions are created in near real time as soon as the devices join the target group.

### Job scheduling configuration

You can schedule a continuous or snapshot job up to a year in advance using a pre-determined start time, end time, and end behavior for what will happen to each job execution upon reaching the end time. Additionally, you can create an optional recurring maintenance window with a flexible frequency, start time, and duration for continuous jobs to roll out a job document to all devices within the target group.

#### Job scheduling configurations

**Start time**

The start time of a scheduled job is the future date and time that job will begin rollout of the job document to all devices in the target group. Start time for a scheduled job applies to continuous jobs and snapshot jobs. When a scheduled job is initially created, it maintains a status state of `SCHEDULED`. Upon arriving at the `startTime` that you selected, it updates to `IN_PROGRESS` and begins the job document rollout. The `startTime` must be less than or equal to one year from the initial date and time that you created the scheduled job.

For more information on the syntax for `startTime` when using an API command or the AWS CLI, see [Timestamp].

For a job with the optional scheduling configuration that takes place during a recurring maintenance window in a location observing daylight savings time (DST), the time will change by one hour when switching from DST to standard time and from standard time to DST.

**Note**

The time zone displayed in the AWS Management Console is your current system time zone. However, these time zones will be converted into UTC in the system.

**End time**

The end time of a scheduled job is the future date and time that the job will stop rollout of the job document to any remaining devices in the target group. End time for a scheduled job applies to continuous jobs and snapshot jobs. After a scheduled job arrives at the selected `endTime`, and all job executions have reached a terminal state, it updates its status state from `IN_PROGRESS` to `COMPLETED`. The `endTime` must be less than or equal to two years from the initial date and time that you created the scheduled job. The minimum duration between `startTime` and `endTime` is 30 minutes. Job execution retry attempts will occur until the job reaches the `endTime`, then the `endBehavior` will dictate how to proceed.

For more information on the syntax for `endTime` when using an API command or the AWS CLI, see [Timestamp].
For a job with the optional scheduling configuration that takes place during a recurring maintenance window in a location observing daylight savings time (DST), the time will change by one hour when switching from DST to standard time and from standard time to DST.

**Note**
The time zone displayed in the AWS Management Console is your current system time zone. However, these time zones will be converted into UTC in the system.

**End behavior**
The end behavior of a scheduled job determines what happens to the job and all unfinished job executions when the job reaches the selected endTime.

The following lists the end behaviors that you can select from when creating the job or job template:

- **STOP_ROLLOUT**
  - STOP_ROLLOUT stops the rollout of the job document to all remaining devices in the target group for the job. Additionally, all QUEUED and IN_PROGRESS job executions will continue until they reach a terminal state. This is the default end behavior unless you select CANCEL or FORCECANCEL.

- **CANCEL**
  - CANCEL stops the rollout of the job document to all remaining devices in the target group for the job. Additionally, all QUEUED job executions will be cancelled while all IN_PROGRESS job executions will continue until they reach a terminal state.

- **FORCECANCEL**
  - FORCECANCEL stops the rollout of the job document to all remaining devices in the target group for the job. Additionally, all QUEUED and IN_PROGRESS job executions will be cancelled.

**Note**
You must select an endtime in order to select an endbehavior.

**Max duration**
The max duration of a scheduled job must be less than or equal to two years regardless of the startTime and endTime.

The following table lists common duration scenarios of a scheduled job:

<table>
<thead>
<tr>
<th>Scheduled Job example number</th>
<th>startTime</th>
<th>endTime</th>
<th>Max duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Immediately after initial job creation.</td>
<td>One year after initial job creation.</td>
<td>One year</td>
</tr>
<tr>
<td>2</td>
<td>One month after initial job creation.</td>
<td>13 months after initial job creation.</td>
<td>One year</td>
</tr>
<tr>
<td>3</td>
<td>One year after initial job creation.</td>
<td>Two years after initial job creation.</td>
<td>One year</td>
</tr>
<tr>
<td>4</td>
<td>Immediately after initial job creation.</td>
<td>Two years after initial job creation.</td>
<td>Two years</td>
</tr>
</tbody>
</table>

**Recurring maintenance window**
The maintenance window is an optional configuration within the scheduling configuration of the AWS Management Console and SchedulingConfig within the CreateJob and CreateJobTemplate.
APIs. You can set up a recurring maintenance window with a predetermined start time, duration, and frequency (daily, weekly, or monthly) that the maintenance window occurs. Maintenance windows only apply to continuous jobs. The maximum duration of a recurring maintenance window is 23 hours, 50 minutes.

The following diagram illustrates the job status states for various scheduled job scenarios with an optional maintenance window:

For more information about job status states, see Jobs and job execution states (p. 707).

Note
If a job arrives at the endTime during a maintenance window, it will update from IN_PROGRESS to COMPLETED. Additionally, any remaining job executions will follow the endBehavior for the job.

Cron expressions

For scheduled jobs rolling out the job document during a maintenance window with a custom frequency, the custom frequency is entered using a cron expression. A cron expression has six required fields, which are separated by white space.

Syntax

```
cron(fields)
```

<table>
<thead>
<tr>
<th>Field</th>
<th>Values</th>
<th>Wildcards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes</td>
<td>0-59</td>
<td>, - */</td>
</tr>
<tr>
<td>Hours</td>
<td>0-23</td>
<td>, - */</td>
</tr>
<tr>
<td>Day-of-month</td>
<td>1-31</td>
<td>, - *? / L W</td>
</tr>
<tr>
<td>Month</td>
<td>1-12 or JAN-DEC</td>
<td>, - */</td>
</tr>
<tr>
<td>Day-of-week</td>
<td>1-7 or SUN-SAT</td>
<td>, - *? L #</td>
</tr>
</tbody>
</table>
Field | Values | Wildcards
---|---|---
Year | 1970-2199 | , - */

**Wildcards**

- The , (comma) wildcard includes additional values. In the Month field, JAN,FEB,MAR would include January, February, and March.
- The - (dash) wildcard specifies ranges. In the Day field, 1-15 would include days 1 through 15 of the specified month.
- The * (asterisk) wildcard includes all values in the field. In the Hours field, * would include every hour. You can't use * in both the Day-of-month and Day-of-week fields. If you use it in one, you must use ? in the other.
- The / (forward slash) wildcard specifies increments. In the Minutes field, you could enter 1/10 to specify every tenth minute, starting from the first minute of the hour (for example, the 11th, 21st, and 31st minute, and so on).
- The ? (question mark) wildcard specifies one or another. In the Day-of-month field, you could enter 7 and if you didn't care what day of the week the 7th was, you could enter ? in the Day-of-week field.
- The L wildcard in the Day-of-month or Day-of-week fields specifies the last day of the month or week.
- The W wildcard in the Day-of-month field specifies a weekday. In the Day-of-month field, 3W specifies the weekday closest to the third day of the month.
- The # wildcard in the Day-of-week field specifies a certain instance of the specified day of the week within a month. For example, 3#2 would be the second Tuesday of the month: the 3 refers to Tuesday because it is the third day of each week, and the 2 refers to the second day of that type within the month.

**Note**

If you use a '#' character, you can define only one expression in the day-of-week field. For example, "3#1,6#3" isn't valid because it's interpreted as two expressions.

**Restrictions**

- You can't specify the Day-of-month and Day-of-week fields in the same cron expression. If you specify a value (or a *) in one of the fields, you must use a ? in the other.

**Examples**

Refer to the following sample cron strings when using a cron expression for the `startTime` of a recurring maintenance window.

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Hours</th>
<th>Day of month</th>
<th>Month</th>
<th>Day of week</th>
<th>Year</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>*</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>Run at 10:00 am (UTC) every day</td>
</tr>
<tr>
<td>15</td>
<td>12</td>
<td>*</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>Run at 12:15 pm (UTC) every day</td>
</tr>
<tr>
<td>0</td>
<td>18</td>
<td>?</td>
<td>*</td>
<td>MON-FRI</td>
<td>*</td>
<td>Run at 6:00 pm</td>
</tr>
</tbody>
</table>
### Recurring maintenance window duration end logic

When a job rollout during a maintenance window reaches the end of the current maintenance window occurrence duration, the following actions will occur:

- The Job will cease all rollouts of the job document to any remaining devices in your target group. It will resume at the `startTime` of the next maintenance window.
- All job executions with a status of `QUEUED` will remain in `QUEUED` until the `startTime` of the next maintenance window occurrence. In the next window, they can switch to `IN_PROGRESS` when the device is ready to begin performing the actions specified in the job document.
- All job executions with a status of `IN_PROGRESS` will continue performing the actions specified in the job document until they reach a terminal state. Any retry attempts as specified in `JobExecutionsRetryConfig` will take place at the `startTime` of the next maintenance window.

### Job abort configuration

Use this configuration to create a criteria to cancel a job when a threshold percentage of devices meet that criteria. For example, you can use this configuration to cancel a job in the following cases:

- When a threshold percentage of devices don’t receive the job execution notifications, such as when your device is incompatible for an Over-The-Air (OTA) update. In this case, your device can report a `REJECTED` status.
- When a threshold percentage of devices report failure for their job executions, such as when your device encounters a disconnection when attempting to download the job document from an Amazon S3 URL. In such cases, your device must be programmed to report the `FAILURE` status to AWS IoT.
- When a `TIMED_OUT` status is reported because the job execution times out for a threshold percentage of devices after the job executions have started.
- When there are multiple retry failures. When you add a retry configuration, each retry attempt can incur additional charges to your AWS account. In such cases, canceling the job can cancel queued job executions and avoid retry attempts for these executions. For more information about the retry configuration and using it with the abort configuration, see [Job execution timeout and retry configurations](#) (p. 747).

You can set up a job abort condition by using the AWS IoT console or the AWS IoT Jobs API.

### Job execution timeout and retry configurations

Use the job execution timeout configuration to send you [Jobs notifications](#) (p. 763) when a job execution has been in progress for longer than the set duration. Use the job execution retry configuration to retry the execution when the job fails or times out.

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Hours</th>
<th>Day of month</th>
<th>Month</th>
<th>Day of week</th>
<th>Year</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
<td>1</td>
<td>*</td>
<td>?</td>
<td>*</td>
<td>(UTC) every Monday through Friday</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Run at 8:00 am (UTC) every first day of the month</td>
</tr>
</tbody>
</table>
Job execution timeout configuration

Use the job execution timeout configuration to notify you whenever a job execution gets stuck in the IN_PROGRESS state for an unexpectedly long period of time. When the job is IN_PROGRESS, you can monitor the progress of your job execution.

Timers for job timeouts

There are two types of timers: in-progress timers and step timers.

In-progress timers

When you create a job or a job template, you can specify a value for the in-progress timer that's between 1 minute and 7 days. You can update the value of this timer until the start of your job execution. After your timer starts, it can't be updated, and the timer value applies to all job executions for the job. Whenever a job execution remains in the IN_PROGRESS status for longer than this interval, the job execution fails and switches to the terminal TIMED_OUT status. AWS IoT also publishes an MQTT notification.

Step timer

You can also set a step timer that applies to only the job execution that you want to update. This timer has no effect on the in-progress timer. Each time you update a job execution, you can set a new value for the step timer. You can also create a new step timer when starting the next pending job execution for a thing. If the job execution remains in the IN_PROGRESS status for longer than the step timer interval, it fails and switches to the terminal TIMED_OUT status.

Note

You can set the in-progress timer by using the AWS IoT console or the AWS IoT Jobs API. To specify the step timer, use the API.

How timers work for job timeouts

The following illustrates the ways in which in-progress timeouts and step timeouts interact with each other in a 20-minute timeout period.

The following shows the different steps:

1. 12:00
A new job is created and an in-progress timer for twenty minutes is started when creating a job. The in-progress timer starts to run and the job execution switches to IN_PROGRESS status.

2. 12:05 PM

A new step timer with a value of 7 minutes is created. The job execution will now time out at 12:12 PM.

3. 12:10 PM

A new step timer with a value of 5 minutes is created. When a new step timer is created, the previous step timer is discarded, and the job execution will now time out at 12:15 PM.

4. 12:13 PM

A new step timer with a value of 9 minutes is created. The previous step timer is discarded and the job execution will now time out at 12:20 PM because the in-progress timer times out at 12:20 PM. The step timer can't exceed the in-progress timer's absolute bound.

**Job execution retry configuration**

You can use the retry configuration to retry the job execution when a certain set of criteria is met. A retry can be attempted when a job times out or when the device fails. To retry execution because of a timeout failure, you must enable the timeout configuration.

**How to use the retry configuration**

Use the following steps to retry the configuration:

1. Determine whether to use the retry configuration for FAILED, TIMED_OUT, or both failure criteria. For the TIMED_OUT status, after the status is reported, AWS IoT Jobs automatically retries the job execution for the device.

2. For the FAILED status, check whether your job execution failure can be retried. If it's retryable, program your device to report a FAILURE status to AWS IoT. The following section describes more about retryable and non-retryable failures.

3. Specify the number of retries to use for each failure type by using the preceding information. For a single device, you can specify up to 10 retries for both failure types combined. The retry attempts stop automatically when an execution succeeds or when it reaches the specified number of attempts.

4. Add an abort configuration to cancel the job if there are repeated retry failures to avoid additional charges from being incurred with a large number of retry attempts.

**Note**

When a job reaches the end of a recurring maintenance window occurrence, all IN_PROGRESS job executions will continue performing actions identified in the job document until they reach a terminal state. If a job execution reaches a terminal state of FAILED or TIMED_OUT outside of a maintenance window, a retry attempt will occur in the next window if the attempts aren't exhausted. At the startTime of the next maintenance window occurrence, a new job execution will be created and enter a status state of QUEUED until the device is ready to begin.

**Retry and abort configuration**

Each retry attempt incurs additional charges to your AWS account. To avoid incurring additional charges from repeated retry failures, we recommend adding an abort configuration. For more information about pricing, see [AWS IoT Device Management pricing](https://aws.amazon.com/iot-device-management/pricing/).

You might encounter multiple retry failures when a high threshold percentage of your devices either time out or report failure. In this case, you can use the abort configuration to cancel the job and avoid any queued job executions or further retry attempts.
Note
When the abort criteria is met for canceling a job execution, only QUEUED job executions are canceled. Any queued retries for the device will not be attempted. However, current job executions that have an IN_PROGRESS status will not be canceled.

Before retrying a failed job execution, we also recommend that you check whether your job execution failure is retryable, as described in the following section.

Retry for failure type of FAILED
To attempt retries for failure type of FAILED, your devices must be programmed to report the FAILURE status for a failed job execution to AWS IoT. Set the retry configuration with the criteria to retry FAILED job executions and specify the number of retries to be performed. When AWS IoT Jobs detects the FAILURE status, it will then automatically attempt to retry the job execution for the device. The retries continue until the job execution succeeds or when it reaches the maximum number of retry attempts.

You can track each retry attempt and the job that’s running on these devices. By tracking the execution status, after the specified number of retries have been attempted, you can use your device to report failures and initiate another retry attempt.

Retryable and non-retryable failures
Your job execution failure can be retryable or non-retryable. Each retry attempt can incur charges to your AWS account. To avoid incurring additional charges from multiple retry attempts, first consider checking whether your job execution failure is retryable. An example of retryable failure includes a connection error that your device encounters while attempting to download the job document from an Amazon S3 URL. If your job execution failure is retryable, program your device to report a FAILURE status in case the job execution fails. Then, set the retry configuration to retry FAILED executions.

If the execution can't be retried, to avoid retrying and potentially incurring additional charges to your account, we recommend that you program the device to report a REJECTED status to AWS IoT. Examples of non-retryable failure include when your device is incompatible of receiving a job update, or when it experiences a memory error while executing a job. In these cases, AWS IoT Jobs will not retry the job execution because it retries the job execution only when it detects a FAILED or TIMED_OUT status.

After you’ve determined that a job execution failure is retryable, if a retry attempt still fails, consider checking the device logs.

Note
When a job with the optional scheduling configuration reaches its endTime, the selected endBehavior will stop the rollout of the job document to all remaining devices in the target group and dictate how to proceed with the remaining job executions. The attempts are retried if selected via the retry configuration.

Retry for failure type of TIMEOUT
If you enable timeout when creating a job, then AWS IoT Jobs will attempt to retry the job execution for the device when the status changes from IN_PROGRESS to TIMED_OUT. This status change can occur when the in-progress timer times out, or when a step timer that you specify is in IN_PROGRESS and then times out. The retries continue until the job execution succeeds, or when it reaches the maximum number of retry attempts for this failure type.

Continuous jobs and thing group membership updates
For continuous jobs that have a job status as IN_PROGRESS, the number of retry attempts is reset to zero when there are updates to a thing's group membership. For example, consider that you specified five retry attempts and three retries have already been performed. If a thing is now removed from the thing group and then rejoins the group, such as with dynamic thing groups, the number of retry attempts is reset to zero. You can now perform five retry attempts for your thing group instead of the
two attempts that were remaining. In addition, when a thing is removed from the thing group, additional retry attempts are canceled.

**Specify additional configurations**

When you create a job or job template, you can specify these additional configurations. The following shows when you can specify these configurations.

- When creating a custom job template. The additional configuration settings that you specify will be saved when you create a job from the template.
- When creating a custom job by using a job file. The job file can be a JSON file that's uploaded in an S3 bucket.
- When creating a custom job by using a custom job template. If the template already has these settings specified, you can either reuse them or override them by specifying new configuration settings.
- When creating a custom job by using an AWS managed template.

**Topics**

- Specify job configurations by using the AWS Management Console (p. 751)
- Specify job configurations by using the AWS IoT Jobs API (p. 753)

**Specify job configurations by using the AWS Management Console**

You can add the different configurations for your job by using the AWS IoT console. After you've created a job, you can see the status details of your job configurations on the job details page. For more information about the different configurations and how they work, see [How job configurations work (p. 742)](#).

Add the job configurations when you create a job or a job template.

**When creating a custom job template**

To specify the rollout configuration when creating a custom job template

1. Go to the [Job templates hub of the AWS IoT console](#) and choose Create job template.
2. Specify the job template properties, provide the job document, expand the configuration that you want to add, and then specify the configuration parameters.

**When creating a custom job**

To specify the rollout configuration when creating a custom job

1. Go to the [Job hub of the AWS IoT console](#) and choose Create job.
2. Choose Create a custom job and specify the job properties, targets, and whether to use a job file or a template for the job document. You can use a custom template or an AWS managed template.
3. Choose the job configuration and then expand Rollout configuration to specify whether to use a Constant rate or Exponential rate. Then, specify the configuration parameters.

The next section shows the parameters that you can specify for each configuration.

**Rollout configuration**

You can specify whether to use a constant rollout rate or an exponential rate.
• **Set a constant rollout rate**

To set a constant rate for job executions, choose **Constant rate**, then specify the **Maximum per minute** for the upper limit of the rate. This value is optional and ranges from 1 to 1000. If you don't set it, it uses 1000 as the default value.

• **Set an exponential rollout rate**

To set an exponential rate, choose **Exponential rate** and then specify these parameters:

  • **Base rate per minute**

    The rate at which the jobs are executed until the **Number of notified devices** or **Number of succeeded devices** threshold is met for **Rate increase criteria**.

  • **Increment factor**

    The exponential factor by which the rollout rate increases after the **Number of notified devices** or **Number of succeeded devices** threshold is met for **Rate increase criteria**.

  • **Rate increase criteria**

    The threshold for either **Number of notified devices** or **Number of succeeded devices**.

**Abort configuration**

Choose **Add new configuration** and specify the following parameters for each configuration:

  • **Failure type**

    Specifies the failure types that initiate a job abort. These include **FAILED**, **REJECTED**, **TIMED_OUT**, or **ALL**.

  • **Increment factor**

    Specifies the number of completed job executions that must occur before the job abort criteria has been met.

  • **Threshold percentage**

    Specifies the total number of executed things that initiate a job abort.

**Scheduling configuration**

Each job can start immediately upon initial creation, scheduled to start at a later date and time, or take place during a recurring maintenance window.

Choose **Add new configuration** and specify the following parameters for each configuration:

  • **Job start**

    Specify the date and time when the job will start.

  • **Recurring maintenance window**

    A recurring maintenance window defines the specific date and time that a job can deploy the job document to the target devices in the job. The maintenance window can repeat daily, weekly, monthly, or a custom day and time recurrence.

  • **Job end**

    Specify the date and time when the job will end.

  • **Job end behavior**
Specify additional configurations

Select an end behavior for all unfinished job executions when the job is over.

**Note**
When a job with the optional scheduling configuration and selected end time reaches the end
time, the job stops the rollout to all remaining devices in the target group. It also leverages
the selected end behavior on how to proceed with the remaining job executions and their retry
attempts per the retry configuration.

**Timeout configuration**

By default, there's no timeout and your job runs canceled or deleted. To use timeouts, choose **Enable
timeout**, and then specify a timeout value between 1 minute and 7 days.

**Retry configuration**

**Note**
After a job has been created, the number of retries can't be updated. You can only remove the
retry configuration for all failure types. When you're creating a job, consider the appropriate
number of retries to use for your configuration. To avoid incurring excess costs because of
potential retry failures, add an abort configuration.

Choose **Add new configuration** and specify the following parameters for each configuration:

- **Failure type**
  
  Specifies the failure types that should trigger a job execution retry. These include **Failed**, **Timeout**, and **All**.

- **Number of retries**
  
  Specifies the number of retries for the chosen **Failure type**. For both failure types combined, up to 10
  retries can be attempted.

**Specify job configurations by using the AWS IoT Jobs API**

You can use the [CreateJob](#) or the [CreateJobTemplate](#) API to specify the different job configurations. The
following sections describe how to add these configurations. After you've added the configurations, you
can use [JobExecutionSummary](#) and [JobExecutionSummaryForJob](#) to view their status.

For more information about the different configurations and how they work, see [How job configurations
work](#).  

**Rollout configuration**

You can specify a constant rollout rate or an exponential rollout rate for your rollout configuration.

- **Set a constant rollout rate**

  To set a constant rollout rate, use the [JobExecutionsRolloutConfig](#) object to add the
  maximumPerMinute parameter to the CreateJob request. This parameter specifies the upper limit
  of the rate at which job executions can occur. This value is optional and ranges from 1 to 1000. If you
don't set the value, it uses 1000 as the default value.

  ```json
  "jobExecutionsRolloutConfig": {
    "maximumPerMinute": 1000
  }
  ```
• **Set an exponential rollout rate**

To set a variable job rollout rate, use the `JobExecutionsRolloutConfig` object. You can configure the `ExponentialRolloutRate` property when you run the `CreateJob` API operation. The following example sets an exponential rollout rate by using the `exponentialRate` parameter. For more information about the parameters, see `ExponentialRolloutRate`.

```json
{
  ...
  "jobExecutionsRolloutConfig": {
    "exponentialRate": {
      "baseRatePerMinute": 50,
      "incrementFactor": 2,
      "rateIncreaseCriteria": {
        "numberOfNotifiedThings": 1000,
        "numberOfSucceededThings": 1000
      },
      "maximumPerMinute": 1000
    }
  }
  ...
}
```

Where the parameter:

**baseRatePerMinute**

Specifies the rate at which the jobs are executed until the `numberOfNotifiedThings` or `numberOfSucceededThings` threshold has been met.

**incrementFactor**

Specifies the exponential factor by which the rollout rate increases after the `numberOfNotifiedThings` or `numberOfSucceededThings` threshold has been met.

**rateIncreaseCriteria**

Specifies either the `numberOfNotifiedThings` or `numberOfSucceededThings` threshold.

**Abort configuration**

To add this configuration by using the API, specify the `AbortConfig` parameter when you run the `CreateJob` or the `CreateJobTemplate` API operation. The following example shows an abort configuration for a job rollout that was experiencing multiple failed executions, as specified with the `CreateJob` API operation.

**Note**

Deleting a job execution affects the computation value of the total completed execution. When a job aborts, the service creates an automated comment and `reasonCode` to differentiate a user-driven cancellation from a job abort cancellation.

```json
"abortConfig": {
  "criteriaList": [
    {
      "action": "CANCEL",
      "failureType": "FAILED",
      "minNumberOfExecutedThings": 100,
      "thresholdPercentage": 20
    },
    {
    }
  ]
}
```
Specify additional configurations

```json
{  
    "action": "CANCEL",
    "failureType": "TIMED_OUT",
    "minNumberOfExecutedThings": 200,
    "thresholdPercentage": 50
}
```

Where the parameter:

**action**

Specifies the action to take when the abort criteria has been met. This parameter is required, and CANCEL is the only valid value.

**failureType**

Specifies which failure types should initiate a job abort. Valid values are FAILED, REJECTED, TIMED_OUT, and ALL.

**minNumberOfExecutedThings**

Specifies the number of completed job executions that must occur before the job abort criteria has been met. In this example, AWS IoT doesn't check to see if a job abort should occur until at least 100 devices have completed job executions.

**thresholdPercentage**

Specifies the total number of things for which jobs are executed that can initiate a job abort. In this example, AWS IoT checks sequentially and initiates a job abort if the threshold percentage is met. If at least 20% of the complete executions failed after 100 executions are complete, it cancels the job rollout. If this criteria isn't met, AWS IoT then checks if at least 50% of completed executions timed out after 200 executions are complete. If this is the case, it cancels the job rollout.

**Scheduling configuration**

To add this configuration by using the API, specify the optional `SchedulingConfig` when you run the `CreateJob`, or the `CreateJobTemplate` API operation.

```json
"SchedulingConfig": {  
    "endBehavior": string
    "endTime": string
    "maintenanceWindows": string
    "startTime": string
}
```

Where the parameter:

**startTime**

Specifies the date and time when the job will start.

**endTime**

Specifies the date and time when the job will end.

**maintenanceWindows**

Specifies if an optional maintenance window was selected for the scheduled job to rollout the job document to all devices in the target group. The string format for `maintenanceWindow` is YYYY/MM/DD for the date and hh:mm for the time.
endBehavior

Specifies the job behavior for a scheduled job upon reaching the endTime.

**Note**
The optional SchedulingConfig for a job is viewable in the DescribeJob and DescribeJobTemplate APIs.

**Timeout configuration**

To add this configuration by using the API, specify the TimeoutConfig parameter when you run the CreateJob, or the CreateJobTemplate API operation.

To use the timeout configuration

1. To set the in-progress timer when you're creating a job or job template, set a value for the inProgressTimeoutInMinutes property of the optional TimeoutConfig object.

   ```json
   "timeoutConfig": {
   "inProgressTimeoutInMinutes": number
   }
   ```

2. To specify a step timer for a job execution, set a value for stepTimeoutInMinutes when you call UpdateJobExecution. The step timer applies only to the job execution that you update. You can set a new value for this timer each time you update a job execution.

   **Note**
   UpdateJobExecution can discard a step timer that's already been created by creating a new step timer with a value of -1.

   ```json
   [ ...
   "statusDetails": {
   "string" : "string"
   },
   "stepTimeoutInMinutes": number
   ]
   ```

3. To create a new step timer, you can also call the StartNextPendingJobExecution API operation.

**Retry configuration**

**Note**
When you're creating a job, consider the appropriate number of retries to use for your configuration. To avoid incurring excess costs because of potential retry failures, add an abort configuration. After a job has been created, the number of retries can't be updated. You can only set the number of retries to 0 by using the UpdateJob API operation.

To add this configuration by using the API, specify the jobExecutionsRetryConfig parameter when you run the CreateJob, or the CreateJobTemplate API operation.

```json
[ ...
   "jobExecutionsRetryConfig": {
   "criteriaList": [
   {
   "failureType": "string",
   "numberOfRetries": number
   }
   ]
   }
]```
Devices and jobs

Devices can communicate with AWS IoT Jobs using MQTT, HTTP Signature Version 4, or HTTP TLS. To determine the endpoint to use when your device communicates with AWS IoT Jobs, run the DescribeEndpoint command. For example, if you run this command:

```
aws iot describe-endpoint --endpoint-type iot:Data-ATS
```

you get a result similar to the following:

```
{
   "endpointAddress": "a1b2c3d4e5f6g7-ats.iot.us-west-2.amazonaws.com"
}
```

Using the MQTT protocol

Devices can communicate with AWS IoT Jobs using MQTT protocol. Devices subscribe to MQTT topics to be notified of new jobs and to receive responses from the AWS IoT Jobs service. Devices publish on MQTT topics to query or update the state of a job launch. Each device has its own general MQTT topic. For more information about publishing and subscribing to MQTT topics, see Device communication protocols (p. 85).

With this method of communication, your device uses its device-specific certificate and private key to authenticate with AWS IoT Jobs.

Your devices can subscribe to the following topics. thing-name is the name of the thing associated with the device.

- `$aws/things/thing-name/jobs/notify`
  
  Subscribe to this topic to notify you when a job launch is added or removed from the list of pending job launches.

- `$aws/things/thing-name/jobs/notify-next`
  
  Subscribe to this topic to notify you when the next pending job execution has changed.

- `$aws/things/thing-name/request-name/accepted`
  
  The AWS IoT Jobs service publishes success and failure messages on an MQTT topic. The topic is formed by appending accepted or rejected to the topic used to make the request. Here, request-name is the name of a request such as Get and the topic can be: `$aws/things/myThing/jobs/get`. AWS IoT Jobs then publishes success messages on the `$aws/things/myThing/jobs/get/accepted` topic.

- `$aws/things/thing-name/request-name/rejected`
  
  Here, request-name is the name of a request such as Get. If the request failed, AWS IoT Jobs publishes failure messages on the `$aws/things/myThing/jobs/get/rejected` topic.
You can also use the following HTTPS API operations:

- Update the status of a job execution by calling the `UpdateJobExecution` API.
- Query the status of a job execution by calling the `DescribeJobExecution` API.
- Retrieve a list of pending job executions by calling the `GetPendingJobExecutions` API.
- Retrieve the next pending job execution by calling the `DescribeJobExecution` API with `jobId` as `$next`.
- Get and start the next pending job execution by calling the `StartNextPendingJobExecution` API.

**Using HTTP Signature Version 4**

Devices can communicate with AWS IoT Jobs using HTTP Signature Version 4 on port 443. This is the method used by the AWS SDKs and CLI. For more information about those tools, see AWS CLI Command Reference: `iot-jobs-data` or AWS SDKs and Tools and refer to the IotJobsDataPlane section for your preferred language.

With this method of communication, your device uses IAM credentials to authenticate with AWS IoT Jobs.

The following commands are available using this method:

- `DescribeJobExecution`
  ```sh
  aws iot-jobs-data describe-job-execution ...
  ```
- `GetPendingJobExecutions`
  ```sh
  aws iot-jobs-data get-pending-job-executions ...
  ```
- `StartNextPendingJobExecution`
  ```sh
  aws iot-jobs-data start-next-pending-job-execution ...
  ```
- `UpdateJobExecution`
  ```sh
  aws iot-jobs-data update-job-execution ...
  ```

**Using HTTP TLS**

Devices can communicate with AWS IoT Jobs using HTTP TLS on port 8443 using a third-party software client that supports this protocol.

With this method, your device uses X.509 certificate-based authentication (for example, its device-specific certificate and private key).

The following commands are available using this method:

- `DescribeJobExecution`
- `GetPendingJobExecutions`
- `StartNextPendingJobExecution`
- `UpdateJobExecution`

**Programming devices to work with jobs**

The examples in this section use MQTT to illustrate how a device works with the AWS IoT Jobs service. Alternatively, you could use the corresponding API or CLI commands. For these examples, we assume a device called `MyThing` that subscribes to the following MQTT topics:
• $aws/things/MyThing/jobs/notify (or $aws/things/MyThing/jobs/notify-next)
• $aws/things/MyThing/jobs/get/accepted
• $aws/things/MyThing/jobs/get/rejected
• $aws/things/MyThing/jobs/jobId/get/accepted
• $aws/things/MyThing/jobs/jobId/get/rejected

If you're using code signing for AWS IoT, your device code must verify the signature of your code file. The signature is in the job document in the codesign property. For more information about verifying a code file signature, see Device Agent Sample.

Topics
• Device workflow (p. 759)
• Jobs workflow (p. 760)
• Jobs notifications (p. 763)

Device workflow

A device can handle jobs that it runs using either of the following ways.

• Get the next job

1. When a device first comes online, it should subscribe to the device's notify-next topic.
2. Call the DescribeJobExecution (p. 787) MQTT API with jobid $next to get the next job, its job document, and other details, including any state saved in statusDetails. If the job document has a code file signature, you must verify the signature before proceeding with processing the job request.
3. Call the UpdateJobExecution (p. 788) MQTT API to update the job status. Or, to combine this and the previous step in one call, the device can call StartNextPendingJobExecution (p. 786).
4. (Optional) You can add a step timer by setting a value for stepTimeoutInMinutes when you call either UpdateJobExecution (p. 788) or StartNextPendingJobExecution (p. 786).
5. Perform the actions specified by the job document using the UpdateJobExecution (p. 788) MQTT API to report on the progress of the job.
6. Continue to monitor the job execution by calling the DescribeJobExecution (p. 787) MQTT API with this jobid. If the job execution is deleted, DescribeJobExecution (p. 787) returns a ResourceNotFoundException.

   The device should be able to recover to a valid state if the job execution is canceled or deleted while the device is running the job.
7. Call the UpdateJobExecution (p. 788) MQTT API when finished with the job to update the job status and report success or failure.
8. Because this job's execution status has been changed to a terminal state, the next job available for execution (if any) changes. The device is notified that the next pending job execution has changed. At this point, the device should continue as described in step 2.

If the device remains online, it continues to receive notifications of the next pending job execution. This includes its job execution data, when it completes a job or a new pending job execution is added. When this occurs, the device continues as described in step 2.

• Select from available jobs

1. When a device first comes online, it should subscribe to the thing's notify topic.
2. Call the GetPendingJobExecutions (p. 786) MQTT API to get a list of pending job executions.
3. If the list contains one or more job executions, select one.
4. Call the DescribeJobExecution (p. 787) MQTT API to get the job document and other details, including any state saved in statusDetails.
5. Call the UpdateJobExecution (p. 788) MQTT API to update the job status. If the includeJobDocument field is set to true in this command, the device can skip the previous step and retrieve the job document at this point.
6. Optionally, you can add a step timer by setting a value for stepTimeoutInMinutes when you call UpdateJobExecution (p. 788).
7. Perform the actions specified by the job document using the UpdateJobExecution (p. 788) MQTT API to report on the progress of the job.
8. Continue to monitor the job execution by calling the DescribeJobExecution (p. 787) MQTT API with this jobId. If the job execution is canceled or deleted while the device is running the job, the device should be able to recover to a valid state.
9. Call the UpdateJobExecution (p. 788) MQTT API when finished with the job to update the job status and to report success or failure.

If the device remains online, it is notified of all pending job executions when a new pending job execution becomes available. When this occurs, the device can continue as described in step 2.

If the device is unable to carry out the job, it should call the UpdateJobExecution (p. 788) MQTT API to update the job status to REJECTED.

Jobs workflow

The following shows the different steps in the jobs workflow from starting a new job to reporting the completion status of a job execution.

Start a new job

When a new job is created, AWS IoT Jobs publishes a message on the $aws/things/thing-name/jobs/notify topic for each target device.

The message contains the following information:

```
{
   "timestamp":1476214217017,
   "jobs":{
   "QUEUED":[{
       "jobId":"0001",
       "queuedAt":1476214216981,
       "lastUpdatedAt":1476214216981,
       "versionNumber" : 1
    }]
  }
}
```

The device receives this message on the '$aws/things/thingName/jobs/notify' topic when the job execution is queued.

**Note**
For jobs with the optional SchedulingConfig, the job will maintain an initial status state of SCHEDULED. When the job reaches the selected startTime, the following will occur:

- The job status state will update to IN_PROGRESS.
- The job will begin rollout of the job document to all devices in the target group.
Get job information

To get more information about a job execution, the device calls the DescribeJobExecution (p. 787) MQTT API with the includeJobDocument field set to true (the default).

If the request is successful, the AWS IoT Jobs service publishes a message on the $aws/things/MyThing/jobs/0023/get/accepted topic:

```
{
   "clientToken" : "client-001",
   "timestamp" : 1489097434407,
   "execution" : {
      "approximateSecondsBeforeTimedOut": number,
      "jobId" : "023",
      "status" : "QUEUED",
      "queuedAt" : 1489097374841,
      "lastUpdatedAt" : 1489097374841,
      "versionNumber" : 1,
      "jobDocument" : {
         < contents of job document >
      }
   }
}
```

If the request fails, the AWS IoT Jobs service publishes a message on the $aws/things/MyThing/jobs/0023/get/rejected topic.

The device now has the job document that it can use to perform the remote operations for the job. If the job document contains an Amazon S3 presigned URL, the device can use that URL to download any required files for the job.

Report job execution status

As the device is executing the job, it can call the UpdateJobExecution (p. 788) MQTT API to update the status of the job execution.

For example, a device can update the job execution status to IN_PROGRESS by publishing the following message on the $aws/things/MyThing/jobs/0023/update topic:

```
{
   "status":"IN_PROGRESS",
   "statusDetails": {
      "progress":"50%"
   },
   "expectedVersion":"1",
   "clientToken":"client001"
}
```

Jobs respond by publishing a message to the $aws/things/MyThing/jobs/0023/update/accepted or $aws/things/MyThing/jobs/0023/update/rejected topic:

```
{
   "clientToken":"client001",
   "timestamp":1476289222841
}
```

The device can combine the two previous requests by calling StartNextPendingJobExecution (p. 786). That gets and starts the next pending job execution and allows the device to update the job execution status. This request also returns the job document when there is a job execution pending.
If the job contains a `TimeoutConfig`, the in-progress timer starts running. You can also set a step timer for a job execution by setting a value for `stepTimeoutInMinutes` when you call `UpdateJobExecution`. The step timer applies only to the job execution that you update. You can set a new value for this timer each time you update a job execution. You can also create a step timer when you call `StartNextPendingJobExecution`. If the job execution remains in the `IN_PROGRESS` status for longer than the step timer interval, it fails and switches to the terminal `TIMED_OUT` status. The step timer has no effect on the in-progress timer that you set when you create a job.

The `status` field can be set to `IN_PROGRESS`, `SUCCEEDED`, or `FAILED`. You cannot update the status of a job execution that is already in a terminal state.

### Report execution completed

When the device is finished executing the job, it calls the `UpdateJobExecution (p. 788)` MQTT API. If the job was successful, set `status` to `SUCCEEDED` and, in the message payload, in `statusDetails`, add other information about the job as name-value pairs. The in-progress and step timers end when the job execution is complete.

For example:

```
{
  "status" : "SUCCEEDED",
  "statusDetails": {
    "progress" : "100%"
  },
  "expectedVersion" : "2",
  "clientToken" : "client-001"
}
```

If the job was not successful, set `status` to `FAILED` and, in `statusDetails`, add information about the error that occurred:

```
{
  "status" : "FAILED",
  "statusDetails": {
    "errorCode" : "101",
    "errorMsg" : "Unable to install update"
  },
  "expectedVersion" : "2",
  "clientToken" : "client-001"
}
```

**Note**

The `statusDetails` attribute can contain any number of name-value pairs.

When the AWS IoT Jobs service receives this update, it publishes a message on the `$aws/things/MyThing/jobs/notify` topic to indicate that the job execution is complete:

```
{
  "timestamp" : 1476290692776,
  "jobs" : {}
}
```

### Additional jobs

If there are other job executions pending for the device, they are included in the message published to `$aws/things/MyThing/jobs/notify`. 762
For example:

```json
{
    "timestamp":1476290692776,
    "jobs":{
        "QUEUED":[
            {
                "jobId":"0002",
                "queuedAt":1476290646230,
                "lastUpdatedAt":1476290646230
            }
        ],
        "IN_PROGRESS":[
            {
                "jobId":"0003",
                "queuedAt":1476290646230,
                "lastUpdatedAt":1476290646230
            }
        ]
    }
}
```

## Jobs notifications

The AWS IoT Jobs service publishes MQTT messages to reserved topics when jobs are pending or when the first job execution in the list changes. Devices can track pending jobs by subscribing to these topics.

### Job notification types

Job notifications are published to MQTT topics as JSON payloads. There are two kinds of notifications:

**ListNotification**

A *ListNotification* contains a list of no more than 15 pending job executions. They are sorted by status (IN_PROGRESS job executions before QUEUED job executions) and then by the times when they were queued.

A *ListNotification* is published whenever one of the following criteria is met.

- A new job execution is queued or changes to a non-terminal status (IN_PROGRESS or QUEUED).
- An old job execution changes to a terminal status (FAILED, SUCCEEDED, CANCELED, TIMED_OUT, REJECTED, or REMOVED).

<table>
<thead>
<tr>
<th>List Notification (Up to 15 pending job executions in QUEUED or IN_PROGRESS)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without</strong> Optional Scheduling Configuration and Recurring Maintenance Window</td>
</tr>
<tr>
<td>(Up to 10 job executions)</td>
</tr>
<tr>
<td>Always appears in the ListNotification.</td>
</tr>
</tbody>
</table>

**NextNotification**

- A *NextNotification* contains summary information about the job execution that's next in the queue.

A *NextNotification* is published whenever the first job execution in the list changes.

- A new job execution is added to the list as QUEUED, and it's the first one in the list.
• The status of an existing job execution that wasn't the first one in the list changes from QUEUED to IN_PROGRESS, and becomes the first one in the list. (This happens when there are no other IN_PROGRESS job executions in the list or when the job execution whose status changes from QUEUED to IN_PROGRESS was queued earlier than any other IN_PROGRESS job execution in the list.)

• The status of the job execution that is first in the list changes to a terminal status and is removed from the list.

For more information about publishing and subscribing to MQTT topics, see the section called "Device communication protocols" (p. 85).

Note
Notifications are not available when you use HTTP Signature Version 4 or HTTP TLS to communicate with jobs.

Job pending
The AWS IoT Jobs service publishes a message on an MQTT topic when a job is added to or removed from the list of pending job executions for a thing or the first job execution in the list changes:

• $aws/things/thingName/jobs/notify
• $aws/things/thingName/jobs/notify-next

The messages contain the following example payloads:

$aws/things/thingName/jobs/notify:

```
{
    "timestamp" : 10011,
    "jobs" : {
        "IN_PROGRESS" : [ {
            "jobId" : "other-job",
            "queuedAt" : 10003,
            "lastUpdatedAt" : 10009,
            "executionNumber" : 1,
            "versionNumber" : 1
        } ],
        "QUEUED" : [ {
            "jobId" : "this-job",
            "queuedAt" : 10011,
            "lastUpdatedAt" : 10011,
            "executionNumber" : 1,
            "versionNumber" : 0
        } ]
    }
}
```

If the job execution called this-job originated from a job with the optional scheduling configuration selected and the job document rollout scheduled to take place during a maintenance window, it'll only appear during a recurring maintenance window. Outside of a maintenance window, the job called this-job will be excluded from the list of pending job executions as shown in the following example.

```
{
    "timestamp" : 10011,
    "jobs" : {
        "IN_PROGRESS" : [ {
            "jobId" : "other-job",
            "queuedAt" : 10003,
        } ]
    }
}
```
Jobs notifications

If the job execution called other-job originated from a job with the optional scheduling configuration selected and the job document rollout scheduled to take place during a maintenance window, it'll only appear during a recurring maintenance window. Outside of a maintenance window, the job called other-job won't be listed as the next job execution as shown in the following example.

//No other pending jobs

Possible job execution status values are QUEUED, IN_PROGRESS, FAILED, SUCCEEDED, CANCELED, TIMED_OUT, REJECTED, and REMOVED.

The following series of examples show the published notifications to each topic as job executions are created and changed from one state to another.

First, one job, called job1, is created. This notification is published to the jobs/notify topic:

```
{  
  "timestamp": 1517016948,  
  "jobs": {  
    "QUEUED": [  
      {  
        "jobId": "job1",  
        "queuedAt": 1517016947,  
        "lastUpdatedAt": 1517016947,  
        "executionNumber": 1,
```
This notification is published to the jobs/notify-next topic:

```
{
  "timestamp": 1517016948,
  "execution": {
    "jobId": "job1",
    "status": "QUEUED",
    "queuedAt": 1517016947,
    "lastUpdatedAt": 1517016947,
    "versionNumber": 1,
    "executionNumber": 1,
    "jobDocument": {
      "operation": "test"
    }
  }
}
```

When another job is created (job2), this notification is published to the jobs/notify topic:

```
{
  "timestamp": 1517017192,
  "jobs": {
    "QUEUED": [
      {
        "jobId": "job1",
        "queuedAt": 1517016947,
        "lastUpdatedAt": 1517016947,
        "executionNumber": 1,
        "versionNumber": 1
      },
      {
        "jobId": "job2",
        "queuedAt": 1517017191,
        "lastUpdatedAt": 1517017191,
        "executionNumber": 1,
        "versionNumber": 1
      }
    ]
  }
}
```

A notification is not published to the jobs/notify-next topic because the next job in the queue (job1) has not changed. When job1 starts to execute, its status changes to IN_PROGRESS. No notifications are published because the list of jobs and the next job in the queue have not changed.

When a third job (job3) is added, this notification is published to the jobs/notify topic:

```
{
  "timestamp": 1517017906,
  "jobs": {
    "IN_PROGRESS": [
      {
        "jobId": "job1",
        "queuedAt": 1517016947,
        "lastUpdatedAt": 1517017472,
```
A notification is not published to the jobs/notify-next topic because the next job in the queue is still job1.

When job1 is complete, its status changes to SUCCEEDED, and this notification is published to the jobs/notify topic:

```
{
  "timestamp": 1517186269,
  "jobs": {
    "QUEUED": [
      {
        "jobId": "job2",
        "queuedAt": 1517017191,
        "lastUpdatedAt": 1517017191,
        "executionNumber": 1,
        "versionNumber": 1
      },
      {
        "jobId": "job3",
        "queuedAt": 1517017905,
        "lastUpdatedAt": 1517017905,
        "executionNumber": 1,
        "versionNumber": 1
      }
    ]
  }
}
```

At this point, job1 has been removed from the queue, and the next job to be executed is job2. This notification is published to the jobs/notify-next topic:

```
{
  "timestamp": 1517186269,
  "execution": {
    "jobId": "job2",
    "status": "QUEUED",
    "queuedAt": 1517017191,
    "lastUpdatedAt": 1517017191,
    "versionNumber": 1,
  }
}
```
If job3 must begin executing before job2 (which is not recommended), the status of job3 can be changed to IN_PROGRESS. If this happens, job2 is no longer next in the queue, and this notification is published to the jobs/notify-next topic:

```json
{
    "timestamp": 1517186779,
    "execution": {
        "jobId": "job3",
        "status": "IN_PROGRESS",
        "queuedAt": 1517017905,
        "startedAt": 1517186779,
        "lastUpdatedAt": 1517186779,
        "versionNumber": 2,
        "executionNumber": 1,
        "jobDocument": {
            "operation": "test"
        }
    }
}
```

No notification is published to the jobs/notify topic because no job has been added or removed.

If the device rejects job2 and updates its status to REJECTED, this notification is published to the jobs/notify topic:

```json
{
    "timestamp": 1517189392,
    "jobs": {
        "IN_PROGRESS": [
            {
                "jobId": "job3",
                "queuedAt": 1517017905,
                "lastUpdatedAt": 1517186779,
                "startedAt": 1517186779,
                "executionNumber": 1,
                "versionNumber": 2
            }
        ]
    }
}
```

If job3 (which is still in progress) is force deleted, this notification is published to the jobs/notify topic:

```json
{
    "timestamp": 1517189551,
    "jobs": {}
}
```

At this point, the queue is empty. This notification is published to the jobs/notify-next topic:

```json
{
    "timestamp": 1517189551
}
```
AWS IoT jobs API operations

AWS IoT Jobs API can be used for either of the following categories:

- Administrative tasks such as management and control of jobs. This is the *control plane*.
- Devices carrying out those jobs. This is the *data plane*, which permits you to send and receive data.

Job management and control uses an HTTPS protocol API. Devices can use either an MQTT or an HTTPS protocol API. The control plane API is designed for a low volume of calls typical when creating and tracking jobs. It usually opens a connection for a single request, and then closes the connection after the response is received. The data plane HTTPS and MQTT API permit long polling. These API operations are designed for large amounts of traffic that can scale to millions of devices.

Each AWS IoT Jobs HTTPS API has a corresponding command that permits you to call the API from the AWS Command Line Interface (AWS CLI). The commands are lowercase, with hyphens between the words that make up the name of the API. For example, you can invoke the `CreateJob` API on the CLI by typing:

```
aws iot create-job ...
```

If an error occurs during an operation, you get an error response that contains information about the error.

**ErrorResponse**

Contains information about an error that occurred during an AWS IoT Jobs service operation.

The following example shows the syntax of this operation:

```
{
  "code": "ErrorCode",
  "message": "string",
  "clientToken": "string",
  "timestamp": timestamp,
  "executionState": JobExecutionState
}
```

The following is a description of this `ErrorResponse`:

**code**

`ErrorCode` can be set to:

- **InvalidTopic**
  
  The request was sent to a topic in the AWS IoT Jobs namespace that doesn't map to any API operation.

- **InvalidJson**
  
  The contents of the request couldn't be interpreted as valid UTF-8-encoded JSON.

- **InvalidRequest**
  
  The contents of the request were not valid. For example, this code is returned when an `UpdateJobExecution` request contains invalid status details. The message contains details about the error.
InvalidStateTransition

An update attempted to change the job execution to a state that is not valid because of the job execution’s current state. For example, an attempt to change a request in state SUCCEEDED to state IN_PROGRESS. In this case, the body of the error message also contains the executionState field.

ResourceNotFound

The JobExecution specified by the request topic doesn’t exist.

VersionMismatch

The expected version specified in the request doesn’t match the version of the job execution in the AWS IoT Jobs service. In this case, the body of the error message also contains the executionState field.

InternalError

There was an internal error during the processing of the request.

RequestThrottled

The request was throttled.

TerminalStateReached

Occurs when a command to describe a job is performed on a job that is in a terminal state.

message

An error message string.

clientToken

An arbitrary string used to correlate a request with its reply.

timestamp

The time, in seconds since the epoch.

executionState

A JobExecutionState object. This field is included only when the code field has the value InvalidStateTransition or VersionMismatch. This makes it unnecessary in these cases to perform a separate DescribeJobExecution request to obtain the current job execution status data.

The following lists the Jobs API operations and data types.

- Jobs management and control API and data types (p. 770)
- Jobs device MQTT and HTTPS API operations and data types (p. 784)

Jobs management and control API and data types

The following commands are available for Job management and control in the CLI and over the HTTPS protocol.

- Job management and control data types (p. 771)
- Job management and control API operations (p. 774)

To determine the endpoint-url parameter for your CLI commands, run this command.

```
aws iot describe-endpoint --endpoint-type=iot:Jobs
```
This command returns the following output.

```
{
  "endpointAddress": "account-specific-prefix.jobs.iot.aws-region.amazonaws.com"
}
```

**Note**
The Jobs endpoint doesn't support ALPN z-amzn-http-ca.

## Job management and control data types

The following data types are used by management and control applications to communicate with AWS IoT Jobs.

### Job

The **Job** object contains details about a job. The following example shows the syntax:

```
{
  "jobArn": "string",
  "jobId": "string",
  "status": "IN_PROGRESS|CANCELED|SUCCEEDED",
  "forceCancled": boolean,
  "targetSelection": "CONTINUOUS|SNAPSHOT",
  "comment": "string",
  "targets": ["string"],
  "description": "string",
  "createdAt": timestamp,
  "lastUpdatedAt": timestamp,
  "completedAt": timestamp,
  "jobProcessDetails": {
    "processingTargets": ["string"],
    "numberOfCanceledThings": long,
    "numberOfSucceededThings": long,
    "numberOfFailedThings": long,
    "numberOfRejectedThings": long,
    "numberOfQueuedThings": long,
    "numberOfInProgressThings": long,
    "numberOfRemovedThings": long,
    "numberOfTimedOutThings": long
  },
  "presignedUrlConfig": {
    "expiresInSec": number,
    "roleArn": "string"
  },
  "jobExecutionsRolloutConfig": {
    "exponentialRate": {
      "baseRatePerMinute": integer,
      "incrementFactor": integer,
      "rateIncreaseCriteria": {
        "numberOfNotifiedThings": integer, // Set one or the other
        "numberOfSucceededThings": integer // of these two values.
      },
      "maximumPerMinute": integer
    }
  },
  "abortConfig": {
    "criteriaList": [{
      "action": "string",
      "failureType": "string",
    }]
  }
}
```
Jobs management and control API and data types

**minNumberOfExecutedThings**: integer,

**thresholdPercentage**: integer

```
}
```

```
"SchedulingConfig": {
  "startTime": string
  "endTime": string
  "timeZone": string
}
```

```
"timeoutConfig": {
  "inProgressTimeoutInMinutes": long
}
```

For more information, see [Job](#) or [job](#).

**JobSummary**

The `JobSummary` object contains a job summary. The following example shows the syntax:

```
{
  "jobArn": "string",
  "jobId": "string",
  "status": "IN_PROGRESS|CANCELED|SUCCEEDED|SCHEDULED",
  "targetSelection": "CONTINUOUS|SNAPSHOT",
  "thingGroupId": "string",
  "createdAt": timestamp,
  "lastUpdatedAt": timestamp,
  "completedAt": timestamp
}
```

For more information, see [JobSummary](#) or [job-summary](#).

**JobExecution**

The `JobExecution` object represents the execution of a job on a device. The following example shows the syntax:

**Note**

When you use the control plane API operations, the `JobExecution` data type doesn't contain a `JobDocument` field. To obtain this information, you can use the [GetJobDocument](#) API operation or the `get-job-document` CLI command.

```
{
  "approximateSecondsBeforeTimedOut": 50,
  "executionNumber": 1234567890,
  "forceCanceled": true|false,
  "jobId": "string",
  "lastUpdatedAt": timestamp,
  "queuedAt": timestamp,
  "startedAt": timestamp,
  "status": "QUEUED|IN_PROGRESS|FAILED|SUCCEEDED|TIMED_OUT|REJECTED|REMOVED",
  "forceCanceled": boolean,
  "statusDetails": {
    "detailsMap": {
      "string": "string" ...
    },
    "status": "string"
  }
}
```
{"thingArn": "string",
"versionNumber": 123
}

For more information, see JobExecution or job-execution.

JobExecutionSummary

The JobExecutionSummary object contains job execution summary information. The following example shows the syntax:

```
{
  "executionNumber": 1234567890,
  "queuedAt": timestamp,
  "lastUpdatedAt": timestamp,
  "startedAt": timestamp,
  "status": "QUEUED|IN_PROGRESS|FAILED|SUCCEEDED|CANCELED|TIMED_OUT|REJECTED|REMOVED"
}
```

For more information, see JobExecutionSummary or job-execution-summary.

JobExecutionSummaryForJob

The JobExecutionSummaryForJob object contains a summary of information about job executions for a specific job. The following example shows the syntax:

```
{
  "executionSummaries": [
    {
      "thingArn": "arn:aws:iot:us-west-2:123456789012:thing/MyThing",
      "jobExecutionSummary": {
        "status": "IN_PROGRESS",
        "lastUpdatedAt": 1549395301.389,
        "queuedAt": 1541526002.609,
        "executionNumber": 1
      }
    },
    ...
  ]
}
```

For more information, see JobExecutionSummaryForJob or job-execution-summary-for-job.

JobExecutionSummaryForThing

The JobExecutionSummaryForThing object contains a summary of information about a job execution on a specific thing. The following example shows the syntax:

```
{
  "executionSummaries": [
    {
      "jobExecutionSummary": {
        "status": "IN_PROGRESS",
        "lastUpdatedAt": 1549395301.389,
        "queuedAt": 1541526002.609,
        "executionNumber": 1
      }
    },
    {
      "jobId": "MyThingJob"
    }
  ]
}
```
For more information, see `JobExecutionSummaryForThing` or `job-execution-summary-for-thing`.

**Job management and control API operations**

Use the following API operations or CLI commands:

**AssociateTargetsWithJob**

Associates a group with a continuous job. The following criteria must be met:

- The job must have been created with the `targetSelection` field set to `CONTINUOUS`.
- The job status must currently be `IN_PROGRESS`.
- The total number of targets associated with a job must not exceed 100.

**HTTPS request**

```
POST /jobs/jobId/targets

{
  "targets": [ "string" ],
  "comment": "string"
}
```

For more information, see `AssociateTargetsWithJob`.

**CLI syntax**

```
aws iot associate-targets-with-job
  --targets <value> \
  --job-id <value> \ 
  [--comment <value>] \ 
  [--cli-input-json <value>] \ 
  [--generate-cli-skeleton]
```

cli-input-json format:

```
{
  "targets": [ "string" ],
  "jobId": "string",
  "comment": "string"
}
```

For more information, see `associate-targets-with-job`.

**CancelJob**

Cancels a job.

**HTTPS request**

```
PUT /jobs/jobId/cancel
```
Jobs management and control API and data types

```json
{
  "force": boolean,
  "comment": "string",
  "reasonCode": "string"
}
```

For more information, see [CancelJob](#).

**CLI syntax**

```bash
aws iot cancel-job \
  --job-id <value> \
  [--force <value>] \
  [--comment <value>] \
  [--reasonCode <value>] \
  [--cli-input-json <value>] \
  [--generate-cli-skeleton]
```

**cli-input-json format:**

```json
{
  "jobId": "string",
  "force": boolean,
  "comment": "string"
}
```

For more information, see [cancel-job](#).

### CancelJobExecution

Cancels a job execution on a device.

**HTTPS request**

```plaintext
PUT /things/thingName/jobs/jobId/cancel
```

```json
{
  "force": boolean,
  "expectedVersion": "string",
  "statusDetails": {
    "string": "string"
  }
}
```

For more information, see [CancelJobExecution](#).

**CLI syntax**

```bash
aws iot cancel-job-execution \
  --job-id <value> \
  --thing-name <value> \
  [--force | --no-force] \
  [--expected-version <value>] \
  [--status-details <value>] \
  [--cli-input-json <value>] \
  [--generate-cli-skeleton]
```

**cli-input-json format:**

```json
{
  "jobId": "string",
  "force": boolean,
  "comment": "string"
}
```
CreateJob

Creates a job. You can provide the job document as a link to a file in an Amazon S3 bucket (documentSource parameter), or in the body of the request (document parameter).

A job can be made continuous by setting the optional targetSelection parameter to CONTINUOUS (the default is SNAPSHOT). A continuous job can be used to onboard or upgrade devices as they are added to a group because it continues to run and is launched on newly added things. This can occur even after the things in the group at the time the job was created have completed the job.

A job can have an optional TimeoutConfig, which sets the value of the in-progress timer. The in-progress timer can't be updated and applies to all executions of the job.

The following validations are performed on arguments to the CreateJob API:

- The targets argument must be a list of valid thing or thing group ARNs. All things and thing groups must be in your AWS account.
- The documentSource argument must be a valid Amazon S3 URL to a job document. Amazon S3 URLs are in the form: https://s3.amazonaws.com/bucketName/objectName.
- The document stored in the URL specified by the documentSource argument must be a UTF-8 encoded JSON document.
- The size of a job document is limited to 32 KB due to the limit on the size of an MQTT message (128 KB) and encryption.
- The jobId must be unique in your AWS account.

HTTPS request

```plaintext
PUT /jobs/jobId
```

```json
{
    "targets": [ "string" ],
    "document": "string",
    "documentSource": "string",
    "description": "string",
    "jobTemplateArn": "string",
    "presignedUrlConfigData": {
        "roleArn": "string",
        "expiresInSec": "integer"
    },
    "targetSelection": "CONTINUOUS|SNAPSHOT",
    "jobExecutionsRolloutConfig": {
        "exponentialRate": {
            "baseRatePerMinute": integer,
            "incrementFactor": integer,
            "rateIncreaseCriteria": {
```
"numberOfNotifiedThings": integer, // Set one or the other
"numberOfSucceededThings": integer // of these two values.
},
"maximumPerMinute": integer
}
},
"abortConfig": {
"criterionList": [{
"action": "string",
"failureType": "string",
"minNumberOfExecutedThings": integer,
"thresholdPercentage": integer
}
]
},
"schedulingConfig": {
"startTime": string
"endTime": string
"timeZone": string
"endTimeBehavior": string
}
"timeoutConfig": {
"inProgressTimeoutInMinutes": long
}
}

For more information, see CreateJob.

CLI syntax

aws iot create-job
--job-id <value>
--targets <value>
[--document-source <value>]
[--document <value>]
[--description <value>]
[--job-template-arn <value>]
[--presigned-url-config <value>]
[--target-selection <value>]
[--job-executions-rollout-config <value>]
[--abort-config <value>]
[--timeout-config <value>]
[--document-parameters <value>]
[--cli-input-json <value>]
[--generate-cli-skeleton]

cli-input-json format:

{
"jobId": "string",
"targets": ["string"],
"documentSource": "string",
"document": "string",
"description": "string",
"jobTemplateArn": "string",
"presignedUrlConfig": {
  "roleArn": "string",
  "expiresInSec": long
},
"targetSelection": "string"}
"jobExecutionsRolloutConfig": {
  "exponentialRate": {
    "baseRatePerMinute": integer,
    "incrementFactor": integer,
    "rateIncreaseCriteria": {
      "numberOfNotifiedThings": integer, // Set one or the other
      "numberOfSucceededThings": integer // of these two values.
    },
    "maximumPerMinute": integer
  }
},
"abortConfig": {
  "criteriaList": [
    {
      "action": "string",
      "failureType": "string",
      "minNumberOfExecutedThings": integer,
      "thresholdPercentage": integer
    }
  ],
  "timeoutConfig": {
    "inProgressTimeoutInMinutes": long
  },
  "documentParameters": {
    "string": "string"
  }
}

For more information, see [create-job](https://aws.amazon.com/).

### DeleteJob

Deletes a job and its related job executions.

Deleting a job can take time, depending on the number of job executions created for the job and various other factors. While the job is being deleted, the status of the job is shown as "DELETION_IN_PROGRESS". Attempting to delete or cancel a job whose status is already "DELETION_IN_PROGRESS" results in an error.

**HTTPS request**

```
DELETE /jobs/jobId?force=force
```

For more information, see [DeleteJob](https://aws.amazon.com/).

**CLI syntax**

```
aws iot delete-job \
  --job-id <value> \n  [ --force | --no-force ] \n  [ --cli-input-json <value> ] \n  [ --generate-cli-skeleton ]
```

**cli-input-json format:**

```
{
  "jobId": "string",
  "force": boolean
}
```
For more information, see `delete-job`.

**DeleteJobExecution**

Deletes a job execution.

**HTTPS request**

```
DELETE /things/thingName/jobs/jobId/executionsNumber?force=force
```

For more information, see `DeleteJobExecution`.

**CLI syntax**

```
aws iot  delete-job-execution \
  --job-id <value> \
  --thing-name <value> \
  --execution-number <value> \
  [--force | --no-force] \
  [--cli-input-json <value>] \
  [--generate-cli-skeleton]
```

**cli-input-json format:**

```
{
  "jobId": "string",
  "thingName": "string",
  "executionNumber": long,
  "force": boolean
}
```

For more information, see `delete-job-execution`.

**DescribeJob**

Gets the details of the job execution.

**HTTPS request**

```
GET /jobs/jobId
```

For more information, see `DescribeJob`.

**CLI syntax**

```
aws iot describe-job \
  --job-id <value> \
  [--cli-input-json <value>] \
  [--generate-cli-skeleton]
```

**cli-input-json format:**

```
{
  "jobId": "string"
}
```

For more information, see `describe-job`.
DescribeJobExecution

Gets details of a job execution. The job's execution status must be SUCCEEDED or FAILED.

HTTPS request

GET /things/thingName/jobs/jobId?executionNumber=executionNumber

For more information, see DescribeJobExecution.

CLI syntax

aws iot describe-job-execution
   --job-id <value> \
   --thing-name <value> \n   [--execution-number <value>] \n   [--cli-input-json <value>] \
   [--generate-cli-skeleton]

cli-input-json format:

{  
  "jobId": "string",  
  "thingName": "string",  
  "executionNumber": long
}

For more information, see describe-job-execution.

GetJobDocument

Gets the job document for a job.

Note

Placeholder URLs are not replaced with presigned Amazon S3 URLs in the document returned. Presigned URLs are generated only when the AWS IoT Jobs service receives a request over MQTT.

HTTPS request

GET /jobs/jobId/job-document

For more information, see GetJobDocument.

CLI syntax

aws iot get-job-document
   --job-id <value> \
   [--cli-input-json <value>] \
   [--generate-cli-skeleton]

cli-input-json format:

{
  "jobId": "string"
}

For more information, see get-job-document.
ListJobExecutionsForJob

Gets a list of job executions for a job.

HTTPS request

```
GET /jobs/jobId/things?status=status&maxResults=maxResults&nextToken=nextToken
```

For more information, see [ListJobExecutionsForJob](#).

CLI syntax

```
aws iot list-job-executions-for-job \
--job-id <value> \
[--status <value>] \
[--max-results <value>] \
[--next-token <value>] \
[--cli-input-json <value>] \
[--generate-cli-skeleton]
```

cli-input-json format:

```
{
"jobId": "string",
"status": "string",
"maxResults": "integer",
"nextToken": "string"
}
```

For more information, see [list-job-executions-for-job](#).

ListJobExecutionsForThing

Gets a list of job executions for a thing.

HTTPS request

```
GET /things/thingName/jobs?status=status&maxResults=maxResults&nextToken=nextToken
```

For more information, see [ListJobExecutionsForThing](#).

CLI syntax

```
aws iot list-job-executions-for-thing \
--thing-name <value> \
[--status <value>] \
[--max-results <value>] \
[--next-token <value>] \
[--cli-input-json <value>] \
[--generate-cli-skeleton]
```

cli-input-json format:

```
{
"thingName": "string",
"status": "string",
"maxResults": "integer",
"nextToken": "string"
}````
ListJobs

Gets a list of jobs in your AWS account.

HTTPS request

GET /jobs?
status=status&targetSelection=targetSelection&thingGroupName=thingGroupName&thingGroupId=thingGroupId&maxResults=maxResults&nextToken=nextToken

For more information, see ListJobs.

CLI syntax

```
aws iot list-jobs
[--status <value>]
[--target-selection <value>]
[--max-results <value>]
[--next-token <value>]
[--thing-group-name <value>]
[--thing-group-id <value>]
[--cli-input-json <value>]
[--generate-cli-skeleton]
```

cli-input-json format:

```json
{
  "status": "string",
  "targetSelection": "string",
  "maxResults": "integer",
  "nextToken": "string",
  "thingGroupName": "string",
  "thingGroupId": "string"
}
```

For more information, see list-jobs.

UpdateJob

Updates supported fields of the specified job. Updated values for timeoutConfig take effect for only newly in-progress launches. Currently, in-progress launches continue to launch with the previous timeout configuration.

HTTPS request

```
PATCH /jobs/jobId
{
  "description": "string",
  "presignedUrlConfig": {
    "expiresInSec": number,
    "roleArn": "string"
  },
  "jobExecutionsRolloutConfig": {
    "exponentialRate": {
      "baseRatePerMinute": number,
      "rateCoefficient": number
    }
  }
}
```
"incrementFactor": number,
"rateIncreaseCriteria": {
    "numberOfNotifiedThings": number,
    "numberOfSucceededThings": number
},
"maximumPerMinute": number
},
"abortConfig": {
    "criteriaList": [
        {
            "action": "string",
            "failureType": "string",
            "minNumberOfExecutedThings": number,
            "thresholdPercentage": number
        }
    ],
"timeoutConfig": {
        "inProgressTimeoutInMinutes": number
    }
}
}

For more information, see `UpdateJob`.

CLI syntax

```
aws iot  update-job \
  --job-id <value> \ 
  [--description <value>] \ 
  [--presigned-url-config <value>] \ 
  [--job-executions-rollout-config <value>] \ 
  [--abort-config <value>] \ 
  [--timeout-config <value>] \ 
  [--cli-input-json <value>] \ 
  [--generate-cli-skeleton]
```

cli-input-json format:

```
{
    "description": "string",
    "presignedUrlConfig": {
        "expiresInSec": number,
        "roleArn": "string"
    },
    "jobExecutionsRolloutConfig": {
        "exponentialRate": {
            "baseRatePerMinute": number,
            "incrementFactor": number,
            "rateIncreaseCriteria": {
                "numberOfNotifiedThings": number,
                "numberOfSucceededThings": number
            }
        },
        "maximumPerMinute": number
    },
    "abortConfig": {
        "criteriaList": [
            {
                "action": "string",
                "failureType": "string",
                "minNumberOfExecutedThings": number,
                "thresholdPercentage": number
            }
        ]
    }
}
```
Jobs device MQTT and HTTPS API operations and data types

The following commands are available over the MQTT and HTTPS protocols. Use these API operations on the data plane for devices executing the jobs.

Jobs device MQTT and HTTPS data types

The following data types are used to communicate with the AWS IoT Jobs service over the MQTT and HTTPS protocols.

JobExecution

The JobExecution object represents the execution of a job on a device. The following example shows the syntax:

```
Note
When you use the MQTT and HTTP data plane API operations, the JobExecution data type contains a JobDocument field. Your devices can use this information to retrieve the job document from a job execution.
```

```
{
   "jobId" : "string",
   "thingName" : "string",
   "jobDocument" : "string",
   "status": "QUEUED|IN_PROGRESS|FAILED|SUCCEEDED|CANCELED|TIMED_OUT|REJECTED|REMOVED",
   "statusDetails": {
      "string": "string"
   },
   "queuedAt" : "timestamp",
   "startedAt" : "timestamp",
   "lastUpdatedAt" : "timestamp",
   "versionNumber" : "number",
   "executionNumber": long
}
```

For more information, see JobExecution or job-execution.

JobExecutionState

The JobExecutionState contains information about the state of a job execution. The following example shows the syntax:

```
{
   "status": "QUEUED|IN_PROGRESS|FAILED|SUCCEEDED|CANCELED|TIMED_OUT|REJECTED|REMOVED",
   "statusDetails": {
      "string": "string"
   },
   "versionNumber": "number"
}```
For more information, see JobExecutionState or job-execution-state.

JobExecutionSummary

Contains a subset of information about a job execution. The following example shows the syntax:

```
{
   "jobId": "string",
   "queuedAt": timestamp,
   "startedAt": timestamp,
   "lastUpdatedAt": timestamp,
   "versionNumber": "number",
   "executionNumber": long
}
```

For more information, see JobExecutionSummary or job-execution-summary.

Learn more about the MQTT and HTTPS API operations in the following sections:

- Jobs device MQTT API operations (p. 785)
- Jobs device HTTP API (p. 790)

Jobs device MQTT API operations

You can issue jobs device commands by publishing MQTT messages to the Reserved topics used for Jobs commands (p. 117).

Your device-side client must be subscribed to the response message topics of these commands. If you use the AWS IoT Device Client, your device will automatically subscribe to the response topics. This means that the message broker will publish response message topics to the client that published the command message, whether or not your client has subscribed to the response message topics. These response messages don't pass through the message broker and can't be subscribed to by other clients or rules.

When subscribing to the job and jobExecution event topics for your fleet-monitoring solution, first enable job and job execution events (p. 1205) to receive any events on the cloud side. Job progress messages that are processed through the message broker and can be used by AWS IoT rules are published as Jobs events (p. 1216). Because the message broker publishes response messages, even without an explicit subscription to them, your client must be configured to receive and identify the messages it receives. Your client must also confirm that the thingName in the incoming message topic applies to the client's thing name before the client acts on the message.

**Note**

Messages that AWS IoT sends in response to MQTT Jobs API command messages are charged to your account, whether or not you subscribed to them explicitly.

The following shows the MQTT API operations and their request and response syntax. All MQTT API operations have the following parameters:

- **clientToken**
  
  An optional client token used to correlate requests and responses. Enter an arbitrary value here and it's reflected in the response.

- **timestamp**
  
  The time in seconds since the epoch, when the message was sent.
**GetPendingJobExecutions**

Gets the list of all jobs that are not in a terminal state, for a specified thing.

To invoke this API, publish a message on `$aws/things/thingName/jobs/get`.

Request payload:

```
{ "clientToken": "string" }
```

The message broker will publish `$aws/things/thingName/jobs/get/accepted` and `$aws/things/thingName/jobs/get/rejected` even without a specific subscription to them. However, for your client to receive the messages, it must be listening for them. For more information, see the note about Jobs API messages (p. 785).

Response payload:

```
{
  "inProgressJobs": [ JobExecutionSummary ... ],
  "queuedJobs": [ JobExecutionSummary ... ],
  "timestamp": 1489096425069,
  "clientToken": "client-001"
}
```

Where `inProgressJobs` and `queuedJobs` return a list of `JobExecutionSummary` (p. 785) objects that have status of `IN_PROGRESS` or `QUEUED`.

**StartNextPendingJobExecution**

Gets and starts the next pending job execution for a thing (status `IN_PROGRESS` or `QUEUED`).

- Any job executions with status `IN_PROGRESS` are returned first.
- Job executions are returned in the order in which they were queued. When a thing is added or removed from the target group for your job, confirm the rollout order of any new job executions compared to existing job executions.
- If the next pending job execution is `QUEUED`, its state changes to `IN_PROGRESS` and the job execution's status details are set as specified.
- If the next pending job execution is already `IN_PROGRESS`, its status details aren't changed.
- If no job executions are pending, the response doesn't include the execution field.
- Optionally, you can create a step timer by setting a value for the `stepTimeoutInMinutes` property. If you don't update the value of this property by running `UpdateJobExecution`, the job execution times out when the step timer expires.

To invoke this API, publish a message on `$aws/things/thingName/jobs/start-next`.

Request payload:

```
{
  "statusDetails": {
    "string": "job-execution-state"
  },
  "stepTimeoutInMinutes": long,
  "clientToken": "string"
}
```
statusDetails

A collection of name-value pairs that describe the status of the job execution. If not specified, the statusDetails are unchanged.

stepTimeOutInMinutes

Specifies the amount of time this device has to finish execution of this job. If the job execution status isn’t set to a terminal state before this timer expires, or before the timer is reset, (by calling UpdateJobExecution, setting the status to IN_PROGRESS and specifying a new timeout value in field stepTimeOutInMinutes) the job execution status is set to TIMED_OUT. Setting this timeout has no effect on that job execution timeout that might have been specified when the job was created (CreateJob using the timeoutConfig field).

The message broker will publish $aws/things/thingName/jobs/start-next/accepted and $aws/things/thingName/jobs/start-next/rejected even without a specific subscription to them. However, for your client to receive the messages, it must be listening for them. For more information, see the note about Jobs API messages (p. 785).

Response payload:

```
{
  "execution" : JobExecutionData,
  "timestamp" : timestamp,
  "clientToken" : "string"
}
```

Where execution is a JobExecution (p. 784) object. For example:

```
{
  "execution" : {
    "jobId" : "022",
    "thingName" : "MyThing",
    "jobDocument" : "< contents of job document >",
    "status" : "IN_PROGRESS",
    "queuedAt" : 1489096123309,
    "lastUpdatedAt" : 1489096123309,
    "versionNumber" : 1,
    "executionNumber" : 1234567890
  },
  "clientToken" : "client-1",
  "timestamp" : 1489088524284,
}
```

DescribeJobExecution

Gets detailed information about a job execution.

You can set the jobId to $next to return the next pending job execution for a thing (with a status of IN_PROGRESS or QUEUED).

To invoke this API, publish a message on $aws/things/thingName/jobs/jobId/get.

Request payload:

```
{
  "jobId" : "022",
  "thingName" : "MyThing",
  "executionNumber": long,
  "includeJobDocument": boolean,
}
```
"clientToken": "string"
}

thingName

The name of the thing associated with the device.

jobId

The unique identifier assigned to this job when it was created.

Or use $next to return the next pending job execution for a thing (with a status of IN_PROGRESS or QUEUED). In this case, any job executions with status IN_PROGRESS are returned first. Job executions are returned in the order in which they were created.

executionNumber

(Optional) A number that identifies a job execution on a device. If not specified, the latest job execution is returned.

includeJobDocument

(Optional) Unless set to false, the response contains the job document. The default is true.

The message broker will publish $aws/things/thingName/jobs/jobId/get/accepted and $aws/things/thingName/jobs/jobId/get/rejected even without a specific subscription to them. However, for your client to receive the messages, it must be listening for them. For more information, see the note about Jobs API messages (p. 785).

Response payload:

```
{
  "execution": JobExecutionData,
  "timestamp": "timestamp",
  "clientToken": "string"
}
```
Where execution is a JobExecution (p. 784) object.

UpdateJobExecution

Updates the status of a job execution. You can optionally create a step timer by setting a value for the stepTimeoutInMinutes property. If you don't update the value of this property by running UpdateJobExecution again, the job execution times out when the step timer expires.

To invoke this API, publish a message on $aws/things/thingName/jobs/jobId/update.

Request payload:

```
{
  "status": "job-execution-state",
  "statusDetails": {
    "string": "string"
  },
  "expectedVersion": "number",
  "executionNumber": long,
  "includeJobExecutionState": boolean,
  "includeJobDocument": boolean,
  "stepTimeoutInMinutes": long,
  "clientToken": "string"
}
```
status

The new status for the job execution (IN_PROGRESS, FAILED, SUCCEEDED, or REJECTED). This must be specified on every update.

statusDetails

A collection of name-value pairs that describe the status of the job execution. If not specified, the statusDetails are unchanged.

expectedVersion

The expected current version of the job execution. Each time you update the job execution, its version is incremented. If the version of the job execution stored in the AWS IoT Jobs service doesn't match, the update is rejected with a VersionMismatch error. An ErrorResponse (p. 769) that contains the current job execution status data is also returned. (This makes it unnecessary to perform a separate DescribeJobExecution request to obtain the job execution status data.)

executionNumber

(Optional) A number that identifies a job execution on a device. If not specified, the latest job execution is used.

includeJobExecutionState

(Optional) When included and set to true, the response contains the JobExecutionState field. The default is false.

includeJobDocument

(Optional) When included and set to true, the response contains the JobDocument. The default is false.

stepTimeoutInMinutes

Specifies the amount of time this device has to finish execution of this job. If the job execution status is not set to a terminal state before this timer expires, or before the timer is reset, the job execution status is set to TIMED_OUT. Setting or resetting this timeout has no effect on the job execution timeout that might have been specified when the job was created.

The message broker will publish $aws/things/thingName/jobs/jobId/update/accepted and $aws/things/thingName/jobs/jobId/update/rejected even without a specific subscription to them. However, for your client to receive the messages, it must be listening for them. For more information, see the note about Jobs API messages (p. 785).

Response payload:

```
{
  "executionState": JobExecutionState,
  "jobDocument": "string",
  "timestamp": timestamp,
  "clientToken": "string"
}
```

executionState

A JobExecutionState (p. 784) object.

jobDocument

A job document (p. 705) object.

timestamp

The time in seconds since the epoch, when the message was sent.
clientToken

A client token used to correlate requests and responses.

When you use the MQTT protocol, you can also perform the following updates:

**JobExecutionsChanged**

Sent whenever a job execution is added to or removed from the list of pending job executions for a thing.

Use the topic:

$aws/things/thingName/jobs/notify

Message payload:

```json
{
  "jobs": {
    "JobExecutionState": [ JobExecutionSummary ... ],
    "timestamp": timestamp
  }
}
```

**NextJobExecutionChanged**

Sent whenever there is a change to which job execution is next on the list of pending job executions for a thing, as defined for DescribeJobExecution with jobId $next. This message is not sent when the next job's execution details change, only when the next job that would be returned by DescribeJobExecution with jobId $next has changed. Consider job executions J1 and J2 with a status of QUEUED. J1 is next on the list of pending job executions. If the status of J2 is changed to IN_PROGRESS while the state of J1 remains unchanged, then this notification is sent and contains details of J2.

Use the topic:

$aws/things/thingName/jobs/notify-next

Message payload:

```json
{
  "execution": JobExecution,
  "timestamp": timestamp,
}
```

**Jobs device HTTP API**

Devices can communicate with AWS IoT Jobs using HTTP Signature Version 4 on port 443. This is the method used by the AWS SDKs and CLI. For more information about those tools, see AWS CLI Command Reference:iot-jobs-data or AWS SDKs and Tools.

The following commands are available for devices executing the jobs. For information about using API operations with the MQTT protocol, see Jobs device MQTT API operations (p. 785).

**GetPendingJobExecutions**

Gets the list of all jobs that aren't in a terminal state, for a specified thing.
HTTPS request

GET /things/thingName/jobs

Response:

```json
{
    "inProgressJobs": [ JobExecutionSummary ... ],
    "queuedJobs": [ JobExecutionSummary ... ]
}
```

For more information, see [GetPendingJobExecutions](#).

CLI syntax

```sh
aws iot-jobs-data get-pending-job-executions \\
--thing-name <value> \\
[--cli-input-json <value>] \\
[--generate-cli-skeleton]
```

cli-input-json format:

```json
{
    "thingName": "string"
}
```

For more information, see [get-pending-job-executions](#).

### StartNextPendingJobExecution

Gets and starts the next pending job execution for a thing (with a status of IN_PROGRESS or QUEUED).

- Any job executions with status IN_PROGRESS are returned first.
- Job executions are returned in the order in which they were created.
- If the next pending job execution is QUEUED, its status changes to IN_PROGRESS and the job execution's status details are set as specified.
- If the next pending job execution is already IN_PROGRESS, its status details don't change.
- If no job executions are pending, the response doesn't include the execution field.
- Optionally, you can create a step timer by setting a value for the stepTimeoutInMinutes property. If you don't update the value of this property by running UpdateJobExecution, the job execution times out when the step timer expires.

HTTPS request

The following example shows the request syntax:

```http
PUT /things/thingName/jobs/$next
{
    "statusDetails": {
        "string": "string"
    },
    "stepTimeoutInMinutes": long
}
```
For more information, see `StartNextPendingJobExecution`

**CLI syntax**

**Synopsis:**

```bash
aws iot-jobs-data start-next-pending-job-execution \ 
--thing-name <value> \ 
[--step-timeout-in-minutes <value>] \ 
[--status-details <value>] \ 
[--cli-input-json <value>] \ 
[--generate-cli-skeleton]
```

cli-input-json format:

```json
{
 "thingName": "string",
 "statusDetails": {
 "string": "string"
 },
 "stepTimeoutInMinutes": long
}
```

For more information, see `start-next-pending-job-execution`.

**DescribeJobExecution**

Gets detailed information about a job execution.

You can set the `jobId` to `$next` to return the next pending job execution for a thing. The job's execution status must be `QUEUED` or `IN_PROGRESS`.

**HTTPS request**

Request:

```plaintext
GET /things/thingName/jobs/jobId?executionNumber=executionNumber&includeJobDocument=includeJobDocument
```

Response:

```json
{
 "execution": JobExecution,
}
```

For more information, see `DescribeJobExecution`.

**CLI syntax**

**Synopsis:**

```bash
aws iot-jobs-data describe-job-execution \ 
--job-id <value> \ 
--thing-name <value> \ 
[--include-job-document | --no-include-job-document] \ 
[--execution-number <value>] \ 
[--cli-input-json <value>] \ 
[--generate-cli-skeleton]
```
cli-input-json format:

```
{
    "jobId": "string",
    "thingName": "string",
    "includeJobDocument": boolean,
    "executionNumber": long
}
```

For more information, see [describe-job-execution](#).

**UpdateJobExecution**

Updates the status of a job execution. Optionally, you can create a step timer by setting a value for the `stepTimeoutInMinutes` property. If you don't update the value of this property by running `UpdateJobExecution` again, the job execution times out when the step timer expires.

**HTTPS request**

Request:

```
POST /things/thingName/jobs/jobId
{
    "status": "job-execution-state",
    "statusDetails": {
        "string": "string"
    },
    "expectedVersion": "number",
    "includeJobExecutionState": boolean,
    "includeJobDocument": boolean,
    "stepTimeoutInMinutes": long,
    "executionNumber": long
}
```

For more information, see [UpdateJobExecution](#).

**CLI syntax**

**Synopsis:**

```
aws iot-jobs-data update-job-execution \
    --job-id <value> \ 
    --thing-name <value> \ 
    --status <value> \ 
    [--status-details <value>] \ 
    [--expected-version <value>] \ 
    [--include-job-execution-state] \ 
    [--include-job-document] \ 
    [--execution-number <value>] \ 
    [--cli-input-json <value>] \ 
    [--step-timeout-in-minutes <value>] \ 
    [--generate-cli-skeleton]
```

cli-input-json format:

```
{
    "jobId": "string",
    "thingName": "string",
    "status": "string",
    "statusDetails": {
```

793
Securing users and devices with AWS IoT Jobs

To authorize users to use AWS IoT Jobs with their devices, you must grant them permissions by using IAM policies. The devices must then be authorized by using AWS IoT Core policies to connect securely to AWS IoT, receive job executions, and update the execution status.

Required policy type for AWS IoT Jobs

The following table shows the different types of policies that you must use for authorization. For more information about the required policy to use, see Authorization (p. 334).

<table>
<thead>
<tr>
<th>Required policy type</th>
<th>Use case</th>
<th>Protocol</th>
<th>Authentication</th>
<th>Control plane/data plane</th>
<th>Identity type</th>
<th>Required policy type</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAM policy</td>
<td>Authorize an administrator, operator, or Cloud Service to work securely with Jobs</td>
<td>HTTPS</td>
<td>AWS Signature Version 4 authentication (port 443)</td>
<td>Both control plane and data plane</td>
<td>Amazon Cognito Identity, IAM, or federated user</td>
<td>IAM policy</td>
</tr>
<tr>
<td>AWS IoT Core policy</td>
<td>Authorize your IoT device to work securely with Jobs</td>
<td>MQTT/HTTPS</td>
<td>TCP or TLS mutual authentication (port 8883 or 443)</td>
<td>Data plane</td>
<td>X.509 certificates</td>
<td>AWS IoT Core policy</td>
</tr>
</tbody>
</table>

To authorize AWS IoT Jobs operations that can be performed both on the control plane and data plane, you must use IAM policies. The identities must have been authenticated with AWS IoT to perform these operations, which must be Amazon Cognito identities (p. 322) or IAM users, groups, and roles (p. 321). For more information about authentication, see Authentication (p. 297).

The devices must now be authorized on the data plane by using AWS IoT Core policies to connect securely to the device gateway. The device gateway enables devices to securely communicate with AWS IoT, receive job executions, and update the job execution status. Device communication is secured by using secure MQTT (p. 88) or HTTPS (p. 106) communication protocols. These protocols use X.509 client certificates (p. 300) that are provided by AWS IoT to authenticate the device connections.

The following shows how you authorize your users, cloud services, and devices to use AWS IoT Jobs. For information about control plane and data plane API operations, see AWS IoT Jobs API operations (p. 769).

Topics
Authorizing users and cloud services to use AWS IoT Jobs

To authorize your users and cloud services, you must use IAM policies on both the control plane and data plane. The policies must be used with HTTPS protocol and must use AWS Signature Version 4 authentication (port 443) to authenticate users.

**Note**
AWS IoT Core policies must not be used on the control plane. Only IAM policies are used for authorizing users or Cloud Services. For more information about using the required policy type, see [Required policy type for AWS IoT Jobs](#).

IAM policies are JSON documents that contain policy statements. Policy statements use *Effect*, *Action*, and *Resource* elements to specify resources, allowed or denied actions, and conditions under which actions are allowed or denied. For more information, see [IAM JSON Policy Elements Reference](#) in the [IAM user Guide](#).

**Warning**
We recommend that you don’t use wildcard permissions, such as "Action": ["iot:*"] in your IAM policies or AWS IoT Core policies. Using wildcard permissions is not a recommended security best practice. For more information, see [AWS IoT policies overly permissive](#).

### IAM policies on the control plane

On the control plane, IAM policies use the `iot:` prefix with the action to authorize the corresponding jobs API operation. For example, the `iot:CreateJob` policy action grants the user permission to use the [CreateJob API](#).

**Policy actions**

The following table shows a list of IAM policy actions and permissions to use the API actions. For information about resource types, see [Resource types defined by AWS IoT](#). For more information about AWS IoT actions, see [Actions defined by AWS IoT](#).

<table>
<thead>
<tr>
<th>Policy action</th>
<th>API operation</th>
<th>Resource types</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>iot:AssociateTargets_withJob</code></td>
<td>AssociateTargets_withJob</td>
<td>• thing • thinggroup</td>
<td>Represents the permission to associate a group with a continuous job. The <code>iot:AssociateTargets_withJob</code> permission is checked every time a request is made to associate targets.</td>
</tr>
<tr>
<td><code>iot:CancelJob</code></td>
<td>CancelJob</td>
<td>job</td>
<td>Represents the permission to cancel a job. The <code>iot:CancelJob</code> permission is checked every time a request is made to cancel a job.</td>
</tr>
<tr>
<td><code>iot:CancelJobExecution</code></td>
<td>CancelJobExecution</td>
<td>• thing</td>
<td>Represents the permission to cancel a job execution. The <code>iot:CancelJobExecution</code> permission is checked every time a request is made to cancel a job execution.</td>
</tr>
<tr>
<td>Policy action</td>
<td>API operation</td>
<td>Resource types</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------</td>
<td>----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>iot:CreateJob</td>
<td>CreateJob</td>
<td>• job</td>
<td>Represents the permission to create a job. The iot: CreateJob permission is checked every time a request is made to create a job.</td>
</tr>
<tr>
<td>iot:CreateJobTemplate</td>
<td>CreateJobTemplate</td>
<td>• jobtemplate</td>
<td>Represents the permission to create a job template. The iot: CreateJobTemplate permission is checked every time a request is made to create a job template.</td>
</tr>
<tr>
<td>iot:DeleteJob</td>
<td>DeleteJob</td>
<td>job</td>
<td>Represents the permission to delete a job. The iot: DeleteJob permission is checked every time a request is made to delete a job.</td>
</tr>
<tr>
<td>iot:DeleteJobTemplate</td>
<td>DeleteJobTemplate</td>
<td>jobtemplate</td>
<td>Represents the permission to delete a job template. The iot: CreateJobTemplate permission is checked every time a request is made to delete a job template.</td>
</tr>
<tr>
<td>iot:DeleteJobExecution</td>
<td>DeleteJobExecution</td>
<td>• job</td>
<td>Represents the permission to delete a job execution. The iot: DeleteJobExecution permission is checked every time a request is made to delete a job execution.</td>
</tr>
<tr>
<td>iot:DescribeJob</td>
<td>DescribeJob</td>
<td>job</td>
<td>Represents the permission to describe a job. The iot: DescribeJob permission is checked every time a request is made to describe a job.</td>
</tr>
<tr>
<td>iot:DescribeJobExecution</td>
<td>DescribeJobExecution</td>
<td>• job</td>
<td>Represents the permission to describe a job execution. The iot: DescribeJobExecution permission is checked every time a request is made to describe a job execution.</td>
</tr>
<tr>
<td>iot:DescribeJobTemplate</td>
<td>DescribeJobTemplate</td>
<td>jobtemplate</td>
<td>Represents the permission to describe a job template. The iot: DescribeJobTemplate permission is checked every time a request is made to describe a job template.</td>
</tr>
<tr>
<td>iot:DescribeManagedJobTemplate</td>
<td>DescribeManagedJobTemplate</td>
<td>jobtemplate</td>
<td>Represents the permission to describe a managed job template. The iot: DescribeManagedJobTemplate permission is checked every time a request is made to describe a managed job template.</td>
</tr>
<tr>
<td>iot:GetJobDocument</td>
<td>GetJobDocument</td>
<td>job</td>
<td>Represents the permission to get the job document for a job. The iot:GetJobDocument permission is checked every time a request is made to get a job document.</td>
</tr>
<tr>
<td>Policy action</td>
<td>API operation</td>
<td>Resource types</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>iot:ListJobExecutionsForJob</code></td>
<td><code>ListJobExecutionsForJob</code></td>
<td>job</td>
<td>Represents the permission to list the job executions for a job. The <code>iot:ListJobExecutionsForJob</code> permission is checked every time a request is made to list the job executions for a job.</td>
</tr>
<tr>
<td><code>iot:ListJobExecutionsForThing</code></td>
<td><code>ListJobExecutionsForThing</code></td>
<td>thing</td>
<td>Represents the permission to list the job executions for a job. The <code>iot:ListJobExecutionsForThing</code> permission is checked every time a request is made to list the job executions for a thing.</td>
</tr>
<tr>
<td><code>iot:ListJobs</code></td>
<td><code>ListJobs</code></td>
<td>none</td>
<td>Represents the permission to list the jobs. The <code>iot:ListJobs</code> permission is checked every time a request is made to list the jobs.</td>
</tr>
<tr>
<td><code>iot:ListJobTemplates</code></td>
<td><code>ListJobTemplates</code></td>
<td>none</td>
<td>Represents the permission to list the job templates. The <code>iot:ListJobTemplates</code> permission is checked every time a request is made to list the job templates.</td>
</tr>
<tr>
<td><code>iot:ListManagedJobTemplates</code></td>
<td><code>ListManagedJobTemplates</code></td>
<td>none</td>
<td>Represents the permission to list the managed job templates. The <code>iot:ListManagedJobTemplates</code> permission is checked every time a request is made to list the managed job templates.</td>
</tr>
<tr>
<td><code>iot:UpdateJob</code></td>
<td><code>UpdateJob</code></td>
<td>job</td>
<td>Represents the permission to update a job. The <code>iot:UpdateJob</code> permission is checked every time a request is made to update a job.</td>
</tr>
<tr>
<td><code>iot:TagResource</code></td>
<td><code>TagResource</code></td>
<td>job</td>
<td>Grants permission to tag a specific resource.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>jobtemplate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>thing</td>
<td></td>
</tr>
<tr>
<td><code>iot:UntagResource</code></td>
<td><code>UntagResource</code></td>
<td>job</td>
<td>Grants permission to untag a specific resource.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>jobtemplate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>thing</td>
<td></td>
</tr>
</tbody>
</table>

**Basic IAM policy example**

The following example shows an IAM policy that allows the user permission to perform the following actions for your IoT thing and thing group.

In the example, replace:

- **region** with your AWS Region, such as `us-east-1`.
- **account-id** with your AWS account number, such as `57EXAMPLE833`.
- **thing-group-name** with the name of your IoT thing group for which you're targeting jobs, such as `FirmwareUpdateGroup`.
- **thing-name** with the name of your IoT thing for which you're targeting jobs, such as `MyIoTThing`.
IAM policy example for IP based authorization

You can restrict principals from making API calls to your control plane endpoint from specific IP addresses. To specify the IP addresses that can be allowed, in the Condition element of your IAM policy, use the aws:SourceIp global condition key.

Using this condition key can also deny access to other AWS services from making these API calls on your behalf, such as AWS CloudFormation. To allow access to these services, use the aws:ViaAWSService global condition key with the aws:SourceIp key. This makes sure that the source IP address access restriction applies only to requests that are made directly by a principal. For more information, see AWS: Denies access to AWS based on the source IP.

The following example shows how to allow only a specific IP address that can make API calls to the control plane endpoint. The aws:ViaAWSService key is set to true, which allows other services to make API calls on your behalf.

```json
{
  "Version": "2012-10-17",
  "Statement": [  
    {  
      "Effect": "Allow",
      "Action": [
        "iot:CreateJobTemplate",
        "iot:CreateJob"
      ],
      "Resource": ["arn:aws:iot:::thinggroup/thing-group-name"]
    },  
    {  
      "Action": [  
        "iot:DescribeJob",
        "iot:CancelJob",
        "iot:DeleteJob"
      ],
      "Effect": "Allow",
      "Resource": ["arn:aws:iot:::job/*"]
    },  
    {  
      "Action": [  
        "iot:DescribeJobExecution",
        "iot:CancelJobExecution",
        "iot:DeleteJobExecution"
      ],
      "Effect": "Allow",
      "Resource": [  
        "arn:aws:iot:::thing/thing-name",
        "arn:aws:iot:::job/*"
      ]
    }  
  ]
}
```
IAM policies on the data plane

IAM policies on the data plane use the `iotjobsdata:` prefix to authorize jobs API operations that users can perform. On the data plane, you can grant a user permission to use the `DescribeJobExecution` API by using the `iotjobsdata:DescribeJobExecution` policy action.

**Warning**

Using IAM policies on the data plane is not recommended when targeting AWS IoT Jobs for your devices. We recommend that you use IAM policies on the control plane for users to create and manage jobs. On the data plane, for authorizing devices to retrieve job executions and update the execution status, use AWS IoT Core policies for HTTPS protocol (p. 803).

Basic IAM policy example

The API operations that must be authorized are usually performed by you typing CLI commands. The following shows an example of a user performing a `DescribeJobExecution` operation.

In the example, replace:

- **region** with your AWS Region, such as `us-east-1`.
- **account-id** with your AWS account number, such as `57EXAMPLE833`.
- **thing-name** with the name of your IoT thing for which you're targeting jobs, such as `myRegisteredThing`.
- **job-id** is the unique identifier for the job that's targeted using the API.

```bash
aws iot-jobs-data describe-job-execution \
   --endpoint-url "https://account-id.jobs.iot.region.amazonaws.com" \
   --job-id jobID --thing-name thing-name
```

The following shows a sample IAM policy that authorizes this action:

```json
{
   "Version": "2012-10-17",
   "Statement":
   {
      "Action": ["iotjobsdata:DescribeJobExecution"],
      "Effect": "Allow",
   }
}
```

IAM policy examples for IP based authorization

You can restrict **principals** from making API calls to your data plane endpoint from specific IP addresses. To specify the IP addresses that can be allowed, in the Condition element of your IAM policy, use the `aws:SourceIp` global condition key.
Using this condition key can also deny access to other AWS services from making these API calls on your behalf, such as AWS CloudFormation. To allow access to these services, use the `aws:ViaAWSService` global condition key with the `aws:SourceIp` condition key. This makes sure that the IP address access restriction only applies to requests that are directly made by the principal. For more information, see AWS: Denies access to AWS based on the source IP.

The following example shows how to allow only a specific IP address that can make API calls to the data plane endpoint.

```json
{
"Version": "2012-10-17",
"Statement": [
{
"Effect": "Allow",
"Action": ["iotjobsdata:*"],
"Resource": ["*"],
"Condition": {
"IpAddress": {
"aws:SourceIp": "123.45.167.89"
}
},
"Bool": {"aws:ViaAWSService": "false"}
},
]
}
```

The following example shows how to restrict specific IP addresses or address ranges from making API calls to the data plane endpoint.

```json
{
"Version": "2012-10-17",
"Statement": [
{
"Effect": "Deny",
"Action": ["iotjobsdata:*"],
"Condition": {
"IpAddress": {
"aws:SourceIp": [
"123.45.167.89",
"192.0.2.0/24",
"203.0.113.0/24"
]
}
},
"Resource": ["*"],
]
}
```

IAM policy example for both control plane and data plane

If you perform an API operation on both the control plane and data plane, your control plane policy action must use the `iot:` prefix, and your data plane policy action must use the `iotjobsdata:` prefix.

For example, the `DescribeJobExecution` API can be used in both the control plane and data plane. On the control plane, the `DescribeJobExecution` API is used to describe a job execution. On the data plane, the `DescribeJobExecution` API is used to get details of a job execution.

The following IAM policy authorizes a user permission to use the `DescribeJobExecution` API on both the control plane and data plane.

In the example, replace:
• **region** with your AWS Region, such as `us-east-1`.
• **account-id** with your AWS account number, such as `57EXAMPLE833`.
• **thing-name** with the name of your IoT thing for which you're targeting jobs, such as `MyIoTThing`.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": ["iotjobsdata:DescribeJobExecution"],
      "Effect": "Allow",
      "Resource": "arn:aws:iot::region:account-id:thing/thing-name"
    },
    {
      "Action": ["iot:DescribeJobExecution", "iot:CancelJobExecution", "iot:DeleteJobExecution"],
      "Effect": "Allow",
    }
  ]
}
```

### Authorize tagging of IoT resources

For better control over jobs and job templates that you can create, modify, or use, you can attach tags to the jobs or job templates. Tags also help you discern ownership and assign and allocate costs by placing them in billing groups and attaching tags to them.

When a user wants to tag their jobs or job templates that they created by using the AWS Management Console or the AWS CLI, your IAM policy must grant the user permissions to tag them. To grant permissions, your IAM policy must use the `iot:TagResource` action.

**Note**

If your IAM policy doesn't include the `iot:TagResource` action, then any `CreateJob` or `CreateJobTemplate` with a tag will return an `AccessDeniedException` error.

When you want to tag your jobs or job templates that you created by using the AWS Management Console or the AWS CLI, your IAM policy must grant permission to tag them. To grant permissions, your IAM policy must use the `iot:TagResource` action.

For general information about tagging your resources, see [Tagging your AWS IoT resources](p. 291).

### IAM policy example

Refer to the following IAM policy examples granting tagging permissions:

**Example 1**

A user that runs the following command to create a job and tag it to a specific environment.

In this example, replace:

• **region** with your AWS Region, such as `us-east-1`.
• **account-id** with your AWS account number, such as `57EXAMPLE833`.
• **thing-name** with the name of your IoT thing for which you're targeting jobs, such as `MyIoTThing`.  

801
Authorizing devices to use jobs

For this example, you must use the following IAM policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Action": ["iot:CreateJob", "iot:CreateJobTemplate", "iot:TagResource"],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:iot:aws-region:account-id:jobtemplate/*"
            ]
        }
    ]
}
```

Authorizing your devices to securely use AWS IoT Jobs on the data plane

To authorize your devices to interact securely with AWS IoT Jobs on the data plane, you must use AWS IoT Core policies. AWS IoT Core policies for jobs are JSON documents containing policy statements. These policies also use `Effect`, `Action`, and `Resource` elements, and follow a similar convention to IAM policies. For more information about the elements, see IAM JSON Policy Elements Reference in the IAM user Guide.

The policies can be used with both MQTT and HTTPS protocols and must use TCP or TLS mutual authentication to authenticate the devices. The following shows how to use these policies across the different communication protocols.

**Warning**

We recommend that you don't use wildcard permissions, such as "Action": ["iot:*"] in your IAM policies or AWS IoT Core policies. Using wildcard permissions is not a recommended security best practice. For more information, see AWS IoT policies overly permissive (p. 984).

AWS IoT Core policies for MQTT protocol

AWS IoT Core policies for MQTT protocol grant you permissions to use the jobs device MQTT API actions. The MQTT API operations are used to work with MQTT topics that are reserved for jobs commands. For more information about these API operations, see Jobs device MQTT API operations (p. 785).

MQTT policies use policy actions such as `iot:Connect`, `iot:Publish`, `iot:Subscribe`, and `iot:Receive` to work with the jobs topics. These policies allow you to connect to the message broker, subscribe to the jobs MQTT topics, and send and receive MQTT messages between your devices and the cloud. For more information about these actions, see AWS IoT Core policy actions (p. 337).

For information about topics for AWS IoT Jobs, see Job topics (p. 117).

Basic MQTT policy example

The following example shows how you can use `iot:Publish` and `iot:Subscribe` to publish and subscribe to jobs and job executions.
In the example, replace:

- **region** with your AWS Region, such as us-east-1.
- **account-id** with your AWS account number, such as 57EXAMPLE833.
- **thing-name** with the name of your IoT thing for which you're targeting jobs, such as MyIoTThing.

```json
{
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:Publish",
                "iot:Subscribe"
            ],
            "Resource": [
                "arn:aws:iot:region:account-id:topic/$aws/events/job/*",
                "arn:aws:iot:region:account-id:topic/$aws/events/jobExecution/*",
            ]
        }
    ],
    "Version": "2012-10-17"
}
```

**AWS IoT Core policies for HTTPS protocol**

AWS IoT Core policies on the data plane can also use the HTTPS protocol with the TLS authentication mechanism to authorize your devices. On the data plane, policies use the `iotjobsdata:` prefix to authorize jobs API operations that your devices can perform. For example, the `iotjobsdata:DescribeJobExecution` policy action grants the user permission to use the `DescribeJobExecution` API.

**Note**

The data plane policy actions must use the `iotjobsdata:` prefix. On the control plane, the actions must use the `iot:` prefix. For an example IAM policy when both control plane and data plane policy actions are used, see [IAM policy example for both control plane and data plane](p. 800).

**Policy actions**

The following table shows a list of AWS IoT Core policy actions and permissions for authorizing devices to use the API actions. For a list of API operations that you can perform in the data plane, see [Jobs device HTTP API](p. 790).

**Note**

These job execution policy actions apply only to the HTTP TLS endpoint. If you use the MQTT endpoint, you must use the MQTT policy actions defined previously.

**AWS IoT Core policy actions on data plane**

<table>
<thead>
<tr>
<th>Policy action</th>
<th>API operation</th>
<th>Resource types</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>iotjobsdata:DescribeJobExecution</code></td>
<td><code>DescribeJobExecution</code></td>
<td>job • thing</td>
<td>Represents the permission to retrieve a job execution. The <code>iotjobsdata:DescribeJobExecution</code> permission is checked every time a request is made to retrieve a job execution.</td>
</tr>
<tr>
<td>Policy action</td>
<td>API operation</td>
<td>Resource types</td>
<td>Description</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>iotjobsdata:GetPendingJobExecutions</td>
<td>GetPendingJobExecutions</td>
<td>thing</td>
<td>Represents the permission to retrieve the list of jobs that are not in a terminal status for a thing. The iotjobsdata:GetPendingJobExecutions permission is checked every time a request is made to retrieve the list.</td>
</tr>
<tr>
<td>iotjobsdata:StartNextPendingJobExecution</td>
<td>StartNextPendingJobExecution</td>
<td>thing</td>
<td>Represents the permission to get and start the next pending job execution for a thing. That is, to update a job execution with status QUEUED to IN_PROGRESS. The iot:StartNextPendingJobExecution permission is checked every time a request is made to start the next pending job execution.</td>
</tr>
<tr>
<td>iotjobsdata:UpdateJobExecution</td>
<td>UpdateJobExecution</td>
<td>thing</td>
<td>Represents the permission to update a job execution. The iot:UpdateJobExecution permission is checked every time a request is made to update the state of a job execution.</td>
</tr>
</tbody>
</table>

**Basic policy example**

The following shows an example of an AWS IoT Core policy that grants permission to perform the actions on the data plane API operations for any resource. You can scope your policy to a specific resource, such as an IoT thing. In your example, replace:

- `region` with your AWS Region such as us-east-1.
- `account-id` with your AWS account number, such as 57EXAMPLE833.
- `thing-name` with the name of the IoT thing, such as MyIoTthing.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Action": [
        "iotjobsdata:GetPendingJobExecutions",
        "iotjobsdata:StartNextPendingJobExecution",
        "iotjobsdata:DescribeJobExecution",
        "iotjobsdata:UpdateJobExecution"
      ],
      "Effect": "Allow",
      "Resource": "arn:aws:iot:region:account-id:thing/thing-name"
    }
  ]
}
```

An example of when you must use these policies can be when your IoT devices use an AWS IoT Core policy to access one of these API operations, such as the following example of the DescribeJobExecution API:
Job limits

AWS IoT Jobs has Service quotas, or limits, that correspond to the maximum number of service resources or operations for your AWS account.

Active and concurrent job limits

This section will help you learn more about active and concurrent jobs and the limits that apply to them.

Active jobs and active job limit

When you create a job by using the AWS IoT console or the CreateJob API, the job status changes to IN_PROGRESS. All in-progress jobs are active jobs and count towards the active jobs limit. This includes jobs that are either rolling out new job executions, or jobs that are waiting for devices to complete their job executions. This limit applies to both continuous and snapshot jobs.

Concurrent jobs and job concurrency limit

In-progress jobs that are either rolling out new job executions, or jobs that are canceling previously created job executions are concurrent jobs and count towards the job concurrency limit. AWS IoT Jobs can roll out and cancel job executions swiftly at a rate of 1000 devices per minute. Each job is concurrent and counts towards the job concurrency limit only for a short time. After the job executions have been rolled out or canceled, the job is no longer concurrent and does not count towards the job concurrency limit. You can use the job concurrency to create a large number of jobs while waiting for devices to complete the job execution.

Note

If a job with the optional scheduling configuration and job document rollout scheduled to take place during a maintenance window reaches the selected startTime and you're at your maximum job concurrency limit, then that scheduled job will move to a status state of CANCELED.

To determine whether a job is concurrent, you can use the IsConcurrent property of a job from the AWS IoT console, or by using the DescribeJob or ListJob API. This limit applies to both continuous and snapshot jobs.

To view the active jobs and job concurrency limits and other AWS IoT Jobs quotas for your AWS account and to request a limit increase, see AWS IoT Device Management endpoints and quotas in the AWS General Reference.

The following diagram shows how the job concurrency applies to in-progress jobs and jobs that are being canceled.
Note
New jobs with the optional SchedulingConfig will maintain an initial status state of SCHEDULED and update to IN_PROGRESS upon reaching the selected startTime. After the new job with the optional SchedulingConfig reaches the selected startTime and updates to IN_PROGRESS, it will count towards the active jobs limit and job concurrency limit. Jobs with a status state of SCHEDULED will count towards the active jobs limit, but will not count towards the job concurrency limit.

The following table shows the limits that apply to active and concurrent jobs and the concurrent and non-concurrent phases of the job states.

### Active and concurrent job limits

<table>
<thead>
<tr>
<th>Job status</th>
<th>Phase</th>
<th>Active jobs limit</th>
<th>Job concurrency limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCHEDULED</td>
<td>Non-concurrent phase: AWS IoT Jobs waits for the scheduled startTime of the job to begin job execution notifications to your devices. Jobs in this phase only count towards the active jobs limit and will have the IsConcurrent property set to false.</td>
<td>Applies</td>
<td>Does not apply</td>
</tr>
<tr>
<td>IN_PROGRESS</td>
<td>Concurrent phase: AWS IoT Jobs accepts the request for creating the job and starts rolling out job execution notifications to your devices. Jobs in this phase are concurrent, as denoted by the IsConcurrent property set to true, and count towards both the active jobs and the job concurrency limits. Non-concurrent phase: AWS IoT Jobs waits for devices to report the results of their job executions. Jobs in this phase only count towards the active jobs limit and will have the IsConcurrent property set to false.</td>
<td>Applies</td>
<td>Applies</td>
</tr>
<tr>
<td>Canceled</td>
<td>Concurrent phase: AWS IoT Jobs accepts the request for canceling the job and starts canceling job executions previously created for your devices. Jobs in this phase are concurrent and will have the IsConcurrent property set to true. Once the job and job executions have been canceled, the job is no longer concurrent.</td>
<td>Does not apply</td>
<td>Applies</td>
</tr>
</tbody>
</table>
### Active and concurrent job limits

<table>
<thead>
<tr>
<th>Job status</th>
<th>Phase</th>
<th>Active jobs limit</th>
<th>Job concurrency limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>and does not count towards the job concurrency limit.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note**
The max duration of a recurring maintenance window is 23 hours, 50 minutes.
AWS IoT secure tunneling

When devices are deployed behind restricted firewalls at remote sites, you need a way to gain access to those devices for troubleshooting, configuration updates, and other operational tasks. Use secure tunneling to establish bidirectional communication to remote devices over a secure connection that is managed by AWS IoT. Secure tunneling does not require updates to your existing inbound firewall rules, so you can keep the same security level provided by firewall rules at a remote site.

For example, a sensor device located at a factory that is a couple hundred miles away is having trouble measuring the factory temperature. You can use secure tunneling to open and quickly start a session to that sensor device. After you have identified the problem (for example, a bad configuration file), you can reset the file and restart the sensor device through the same session. Compared to a more traditional troubleshooting (for example, sending a technician to the factory to investigate the sensor device), secure tunneling decreases incident response and recovery time and operational costs.

What is secure tunneling?

Use secure tunneling to access devices that are deployed behind port-restricted firewalls at remote sites. You can connect to the destination device from your laptop or desktop computer as the source device by using the AWS Cloud. The source and destination communicate by using an open source local proxy that runs on each device. The local proxy communicates with the AWS Cloud by using an open port that is allowed by firewall, typically 443. Data that is transmitted through the tunnel is encrypted using Transported Layer Security (TLS).

Topics

• Secure tunneling concepts (p. 808)
• How secure tunneling works (p. 809)
• Secure tunnel lifecycle (p. 810)

Secure tunneling concepts

The following terms are used by secure tunneling when establishing communication with remote devices. For information about how secure tunneling works, see How secure tunneling works (p. 809).

Client access token (CAT)

A pair of tokens generated by secure tunneling when a new tunnel is created. The CAT is used by the source and destination devices to connect to the secure tunneling service. The CAT can only be used once to connect to the tunnel. To reconnect to the tunnel, rotate the client access tokens using the RotateTunnelAccessToken API operation or the rotate-tunnel-access-token CLI command.

Client token

A unique value generated by the client that AWS IoT secure tunneling can use for all subsequent retry connections to the same tunnel. This field is optional. If the client token is not provided, then the client access token (CAT) can only be used once for the same tunnel. Subsequent connection attempts using the same CAT will be rejected. For more information about using client tokens, see the local proxy reference implementation in GitHub.
Destination application

The application that runs on the destination device. For example, the destination application can be an SSH daemon for establishing an SSH session using secure tunneling.

Destination device

The remote device you want to access.

Device agent

An IoT application that connects to the AWS IoT device gateway and listens for new tunnel notifications over MQTT. For more information, see IoT agent snippet (p. 841).

Local proxy

A software proxy that runs on the source and destination devices and relays a data stream between secure tunneling and the device application. The local proxy can be run in source mode or destination mode. For more information, see Local proxy (p. 826).

Source device

The device an operator uses to initiate a session to the destination device, usually a laptop or desktop computer.

Tunnel

A logical pathway through AWS IoT that enables bidirectional communication between a source device and destination device.

How secure tunneling works

The following shows how secure tunneling establishes a connection between your source and destination device. For information about the different terms such as client access token (CAT), see Secure tunneling concepts (p. 808).

1. **Open a tunnel**

   To open a tunnel for initiating a session with your remote destination device, you can use the AWS Management Console, the AWS CLI open-tunnel command, or the OpenTunnel API.

2. **Download the client access token pair**

   After you've opened a tunnel, you can download the client access token (CAT) for your source and destination and save it on your source device. You must retrieve the CAT and save it now before starting the local proxy.

3. **Start local proxy in destination mode**

   The IoT agent that has been installed and is running on your destination device will be subscribed to the reserved MQTT topic $aws/things/thing-name/tunnels/notify and will receive the CAT. Here, thing-name is the name of the AWS IoT thing you create for your destination. For more information, see Secure tunneling topics (p. 120).

   The IoT agent then uses the CAT to start the local proxy in destination mode and set up a connection on the destination side of the tunnel. For more information, see IoT agent snippet (p. 841).

4. **Start local proxy in source mode**

   After the tunnel has been opened, AWS IoT Device Management provides the CAT for the source that you can download on the source device. You can use the CAT to start the local proxy in source mode, which then connects the source side of the tunnel. For more information about local proxy, see Local proxy (p. 826).
Open an SSH session

As both sides of the tunnel are connected, you can start an SSH session by using the local proxy on the source side.

For more information about how to use the AWS Management Console to open a tunnel and start an SSH session, see Open a tunnel and start SSH session to remote device (p. 811).

The following video describes how secure tunneling works and walks you through the process of setting up an SSH session to a Raspberry Pi device.

Secure tunnel lifecycle

Tunnels can have the status OPEN or CLOSED. Connections to the tunnel can have the status CONNECTED or DISCONNECTED. The following shows how the different tunnel and connection statuses work.

1. When you open a tunnel, it has a status of OPEN. The tunnel's source and destination connection status is set to DISCONNECTED.

2. When a device (source or destination) connects to the tunnel, the corresponding connection status changes to CONNECTED.

3. When a device disconnects from the tunnel while the tunnel status remains OPEN, the corresponding connection status changes back to DISCONNECTED. A device can connect to and disconnect from a tunnel repeatedly as long as the tunnel remains OPEN.

Note
The client access tokens (CAT) can only be used once to connect to a tunnel. To reconnect to the tunnel, rotate the client access tokens using the RotateTunnelAccessToken API operation or the rotate-tunnel-access-token CLI command. For examples, see Resolving AWS IoT secure tunneling connectivity issues by rotating client access tokens (p. 848).

4. When you call CloseTunnel or the tunnel remains OPEN for longer than the MaxLifetimeTimeout value, a tunnel's status becomes CLOSED. You can configure MaxLifetimeTimeout when calling OpenTunnel. MaxLifetimeTimeout defaults to 12 hours if you do not specify a value.

Note
A tunnel cannot be reopened when it is CLOSED.

5. You can call DescribeTunnel and ListTunnels to view tunnel metadata while the tunnel is visible. The tunnel can be visible in the AWS IoT console for at least three hours before it is deleted.

AWS IoT secure tunneling tutorials

AWS IoT secure tunneling helps customers establish bidirectional communication to remote devices that are behind a firewall over a secure connection managed by AWS IoT.

To demo AWS IoT secure tunneling, use our AWS IoT secure tunneling demo on GitHub.

The following tutorials will help you learn how to get started and use secure tunneling. You'll learn how to:

1. Create a secure tunnel using the quick setup and manual setup methods for accessing the remote device.

2. Configure the local proxy when using the manual setup method and connect to the tunnel to access the destination device.

3. SSH into the remote device from a browser without having to configure the local proxy.
4. Convert a tunnel created using the AWS CLI or using the manual setup method to use the quick setup method.

Tutorials in this section

The tutorials in this section focus on creating a tunnel using the AWS Management Console and the AWS IoT API Reference. In the AWS IoT console, you can create a tunnel from the Tunnels hub page or from the details page of a thing that you created. For more information, see Tunnel creation methods in AWS IoT console (p. 812).

Following shows the tutorials in this section:

- **Open a tunnel and use browser-based SSH to access remote device (p. 813)**
  
  This tutorial shows how to open a tunnel from the Tunnels hub page using the quick setup method. You'll also learn how to use browser-based SSH to access the remote device using an in-context command line interface within the AWS IoT console.

- **Open a tunnel using manual setup and connect to remote device (p. 818)**
  
  This tutorial shows how to open a tunnel from the Tunnels hub page using the manual setup method. You'll also learn how to configure and start the local proxy from a terminal in your source device and connect to the tunnel.

- **Open a tunnel for remote device and use browser-based SSH (p. 823)**
  
  This tutorial shows how to open a tunnel from the details page of a thing that you created. You'll learn how to create a new tunnel and use an existing tunnel. The existing tunnel corresponds to the most recent, open tunnel that was created for the device. You can also use the browser-based SSH to access the remote device.

AWS IoT secure tunneling tutorials

- **Open a tunnel and start SSH session to remote device (p. 811)**
- **Open a tunnel for remote device and use browser-based SSH (p. 823)**

Open a tunnel and start SSH session to remote device

In these tutorials, you'll learn how to remotely access a device that's behind a firewall. You can't start a direct SSH session into the device because the firewall blocks all inbound traffic. The tutorials show you how you can open a tunnel and then use that tunnel to start an SSH session to a remote device.

Prerequisites for the tutorials

The prerequisites for running the tutorial can vary depending on whether you use the manual or quick setup methods for opening a tunnel and accessing the remote device.

**Note**

For both setup methods, you must allow outbound traffic on port 443.

- For information about prerequisites for the quick setup method tutorial, see Prerequisites for quick setup method (p. 813).
- For information about prerequisites for the manual setup method tutorial, see Prerequisites for manual setup method (p. 818). If you use this setup method, you must configure the local
proxy on your source device. To download the local proxy source code, see Local proxy reference implementation on GitHub.

Tunnel setup methods

In these tutorials, you'll learn about the manual and quick setup methods for opening a tunnel and connecting to the remote device. The following table shows the difference between the setup methods. After you create the tunnel, you can use an in-browser command line interface to SSH into the remote device. If you misplace the tokens or the tunnel gets disconnected, you can send new access tokens to reconnect to the tunnel.

Quick and manual setup methods

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Quick setup</th>
<th>Manual setup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunnel creation</td>
<td>Create a new tunnel with default, editable configurations. To access your remote device, you can only use SSH as the destination service.</td>
<td>Create a tunnel by manually specifying the tunnel configurations. You can use this method to connect to the remote device using services other than SSH.</td>
</tr>
<tr>
<td>Access tokens</td>
<td>The destination access token will be automatically delivered to your device on the reserved MQTT topic, if a thing name is specified when creating the tunnel. You don't have to download or manage the token on your source device.</td>
<td>You'll have to manually download and manage the token on your source device. The destination access token is automatically delivered to the remote device on the reserved MQTT topic, if a thing name is specified when creating the tunnel.</td>
</tr>
<tr>
<td>Local proxy</td>
<td>A web-based local proxy is automatically configured for you for interacting with the device. You don't have to manually configure the local proxy.</td>
<td>You'll have to manually configure and launch the local proxy. To configure the local proxy, you can either use the AWS IoT Device Client or download the Local proxy reference implementation on GitHub.</td>
</tr>
</tbody>
</table>

Tunnel creation methods in AWS IoT console

The tutorials in this section show you how to create a tunnel using the AWS Management Console and the OpenTunnel API. If you configure the destination when creating a tunnel, AWS IoT secure tunneling delivers the destination client access token to the remote device over MQTT and the reserved MQTT topic, $aws/things/RemoteDeviceA/tunnels/notify. On receiving the MQTT message, the IoT agent on the remote device starts the local proxy in destination mode. For more information, see Reserved topics (p. 111).

Note
You can omit the destination configuration if you want to deliver the destination client access token to the remote device through another method. For more information, see Configuring a remote device and using IoT agent (p. 841).

In the AWS IoT console, you can create a tunnel using either of the following methods. For information about tutorials that will help you learn to create a tunnel using these methods, see Tutorials in this section (p. 811).

- **Tunnels hub**

  When you create the tunnel, you'll be able to specify whether to use the quick setup or the manual setup methods for creating the tunnel and provide the optional tunnel configuration details. The
configuration details also include the name of the destination device and the service that you want to use for connecting to the device. After you create a tunnel, you can either SSH within the browser or open a terminal outside the AWS IoT console to access your remote device.

- **Thing details page**

  When you create the tunnel, you'll also be able to specify whether to use the most recent, open tunnel or create a new tunnel for the device, in addition to choosing the setup methods and providing any optional tunnel configuration details. You can't edit the configuration details of an existing tunnel. You can use the quick setup method to rotate the access tokens and SSH into the remote device within the browser. To open a tunnel using this method, you must have created an IoT thing (for example, RemoteDeviceA) in the AWS IoT registry. For more information, see Register a device in the AWS IoT registry.

**Tutorials in this section**

- Open a tunnel and use browser-based SSH to access remote device (p. 813)
- Open a tunnel using manual setup and connect to remote device (p. 818)

**Open a tunnel and use browser-based SSH to access remote device**

You can use the quick setup or the manual setup method for creating a tunnel. This tutorial shows how to open a tunnel using the quick setup method and use the browser-based SSH to connect to the remote device. For an example that shows how to open a tunnel using the manual setup method, see Open a tunnel using manual setup and connect to remote device (p. 818).

Using the quick setup method, you can create a new tunnel with default configurations that can be edited. A web-based local proxy is configured for you and the access token is automatically delivered to your remote destination device using MQTT. After creating a tunnel, you can start interacting with your remote device using a command line interface within the console.

With the quick setup method, you must use SSH as the destination service to access the remote device. For more information about the different setup methods, see Tunnel setup methods (p. 812).

**Prerequisites for quick setup method**

- The firewalls that the remote device is behind must allow outbound traffic on port 443. The tunnel that you create will use this port to connect to the remote device.
- You have an IoT device agent (see IoT agent snippet (p. 841)) running on the remote device that connects to the AWS IoT device gateway and is configured with an MQTT topic subscription. For more information, see connect a device to the AWS IoT device gateway.
- You must have an SSH daemon running on the remote device.

**Open a tunnel**

You can open a secure tunnel using the AWS Management Console, the AWS IoT API Reference, or the AWS CLI. You can optionally configure a destination name but it's not required for this tutorial. If you configure the destination, secure tunneling will automatically deliver the access token to the remote device using MQTT. For more information, see Tunnel creation methods in AWS IoT console (p. 812).

**To open a tunnel using the console**

1. Go to the Tunnels hub of the AWS IoT console and choose Create tunnel.
2. For this tutorial, choose **Quick setup** as the tunnel creation method and then choose **Next**.

   **Note**
   If you create a secure tunnel from the details page of a thing you created, you can choose whether to create a new tunnel or use an existing one. For more information, see *Open a tunnel for remote device and use browser-based SSH* (p. 823).

3. Review and confirm the tunnel configuration details. To create a tunnel, choose **Confirm and create**. If you want to edit these details, choose **Previous** to go back to the previous page and then confirm and create the tunnel.

   **Note**
   When using quick setup, the service name can't be edited. You must use **SSH** as the **Service**.

4. To create the tunnel, choose **Done**.

   For this tutorial, you don't have to download the source or destination access tokens. These tokens can only be used once to connect to the tunnel. If your tunnel gets disconnected, you can generate and send new tokens to your remote device for reconnecting to the tunnel. For more information, see *Resend tunnel access tokens* (p. 821).
Open a tunnel and start SSH session to remote device

To open a tunnel using the API

To open a new tunnel, you can use the OpenTunnel API operation.

**Note**
You can create a tunnel using the quick setup method only from the AWS IoT console. When you use the AWS IoT API Reference API or the AWS CLI, it will use the manual setup method. You can open the existing tunnel that you created and then change the setup method of the tunnel to use the quick setup. For more information, see Open an existing tunnel and use browser-based SSH (p. 825).

The following shows an example of how to run this API operation. Optionally, if you want to specify the thing name and the destination service, use the DestinationConfig parameter. For an example that shows how to use this parameter, see Open a new tunnel for the remote device (p. 824).

```
aws iotsecuretunneling open-tunnel
```

Running this command creates a new tunnel and provides you the source and destination access tokens.

```
{
    "tunnelId": "01234567-89ab-0123-4c56-789a01234bcd",
    "tunnelArn": "arn:aws:iot:us-east-1:123456789012:tunnel/01234567-89ab-0123-4c56-789a01234bcd",
    "sourceAccessToken": "<SOURCE_ACCESS_TOKEN>",
    "destinationAccessToken": "<DESTINATION_ACCESS_TOKEN>"
}
```

**Using the browser-based SSH**

After you create a tunnel using the quick setup method, and your destination device has connected to the tunnel, you can access the remote device using a browser-based SSH. Using the browser-based
SSH, you can directly communicate with the remote device by entering commands into an in-context command line interface within the console. This feature makes it easier for you to interact with the remote device because you don't have to open a terminal outside the console or configure the local proxy.

**To use the browser-based SSH**

1. Go to the [Tunnels hub of the AWS IoT console](#) and choose the tunnel that you created to view its details.
2. Expand the Secure Shell (SSH) section and then choose Connect.
3. Choose whether you want to authenticate into the SSH connection by providing your username and password, or, for more secure authentication, you can use your device's private key. If you're authenticating using the private key, you can use RSA, DSA, ECDSA (nistp-*), and ED25519 key types, in PEM (PKCS#1, PKCS#8) and OpenSSH formats.
   - To connect using your username and password, choose Use password. You can then enter your username and password and start using the in-browser CLI.
   - To connect using your destination device's private key, choose Use private key. Specify your username and upload the device's private key file, and then choose Connect to start using the in-browser CLI.

After you've authenticated into the SSH connection, you can quickly get started with entering commands and interact with the device using the browser CLI, as the local proxy has already been configured for you.
Open a tunnel and start SSH session to remote device

If the browser CLI stays open after the tunnel duration, it might time out, causing the command line interface to get disconnected. You can duplicate the tunnel and start another session to interact with the remote device within the console itself.

Troubleshooting issues when using the browser-based SSH

The following shows how to troubleshoot some issues that you might run into when using the browser-based SSH.

- **You see an error instead of the command line interface**
  
  You might be seeing the error because your destination device got disconnected. You can choose Generate new access tokens to generate new access tokens and send the tokens to your remote device using MQTT. The new tokens can be used to reconnect to the tunnel. Reconnecting to the tunnel clears the history and refreshes the command line session.

- **You see a tunnel disconnected error when authenticating using private key**
  
  You might be seeing the error because your private key might not have been accepted by the destination device. To troubleshoot this error, check the private key file that you uploaded for authentication. If you still see an error, check your device logs. You can also try reconnecting to the tunnel by sending new access tokens to your remote device.

- **Your tunnel was closed when using the session**
  
  If your tunnel was closed because it stayed open for more than the specified duration, your command line session might get disconnected. A tunnel cannot be reopened once closed. To reconnect, you must open another tunnel to the device.

  You can duplicate a tunnel to create a new tunnel with the same configurations as the closed tunnel. You can duplicate a closed tunnel from the AWS IoT console. To duplicate the tunnel, choose the tunnel that was closed to view its details, and then choose Duplicate tunnel. Specify the tunnel duration that you want to use and then create the new tunnel.
Cleaning up

- **Close tunnel**

  We recommend that you close the tunnel after you’ve finished using it. A tunnel can also become closed if it stayed open for longer than the specified tunnel duration. A tunnel cannot be reopened once closed. You can still duplicate a tunnel by choosing the closed tunnel and then choosing **Duplicate tunnel**. Specify the tunnel duration that you want to use and then create the new tunnel.

  - To close an individual tunnel or multiple tunnels from the AWS IoT console, go to the Tunnels hub, choose the tunnels that you want to close, and then choose **Close tunnel**.
  - To close an individual tunnel or multiple tunnels using the AWS IoT API Reference API, use the **CloseTunnel** API.

    ```bash
    aws iotsecuretunneling close-tunnel
    --tunnel-id "01234567-89ab-0123-4c56-789a01234bcd"
    ```

- **Delete tunnel**

  You can delete a tunnel permanently from your AWS account.

  **Warning**
  Deletion actions are permanent and can't be undone.

  - To delete an individual tunnel or multiple tunnels from the AWS IoT console, go to the Tunnels hub, choose the tunnels that you want to delete, and then choose **Delete tunnel**.
  - To delete an individual tunnel or multiple tunnels using the AWS IoT API Reference API, use the **CloseTunnel** API. When using the API, set the delete flag to True.

    ```bash
    aws iotsecuretunneling close-tunnel
    --tunnel-id "01234567-89ab-0123-4c56-789a01234bcd"
    --delete true
    ```

Open a tunnel using manual setup and connect to remote device

When you open a tunnel, you can choose the quick setup or the manual setup method for opening a tunnel into the remote device. This tutorial shows how to open a tunnel using the manual setup method and configure and start the local proxy to connect to the remote device.

When you use the manual setup method, you must manually specify the tunnel configurations when creating the tunnel. After creating the tunnel, you can SSH within the browser or open a terminal outside the AWS IoT console. This tutorial shows how to use the terminal outside the console to access the remote device. You’ll also learn how to configure the local proxy and then connect to the local proxy to interact with the remote device. To connect to the local proxy, you must download the source access token when creating the tunnel.

With this setup method, you can use services other than SSH, such as FTP to connect to the remote device. For more information about the different setup methods, see **Tunnel setup methods** (p. 812).

**Prerequisites for manual setup method**

- The firewalls that the remote device is behind must allow outbound traffic on port 443. The tunnel that you create will use this port to connect to the remote device.

- You have an IoT device agent (see **IoT agent snippet** (p. 841)) running on the remote device that connects to the AWS IoT device gateway and is configured with an MQTT topic subscription. For more information, see **connect a device to the AWS IoT device gateway**.
• You must have an SSH daemon running on the remote device.
• You have downloaded the local proxy source code from GitHub and built it for the platform of your choice. We'll refer to the built local proxy executable file as `localproxy` in this tutorial.

Open a tunnel

You can open a secure tunnel using the AWS Management Console, the AWS IoT API Reference, or the AWS CLI. You can optionally configure a destination name but it's not required for this tutorial. If you configure the destination, secure tunneling will automatically deliver the access token to the remote device using MQTT. For more information, see Tunnel creation methods in AWS IoT console (p. 812).

To open a tunnel in the console

1. Go to the Tunnels hub of the AWS IoT console and choose Create tunnel.

2. For this tutorial, choose Manual setup as the tunnel creation method and then choose Next. For information about using the quick setup method to create a tunnel, see Open a tunnel and use browser-based SSH to access remote device (p. 813).

   Note
   If you create a secure tunnel from the details page of a thing, you can choose whether to create a new tunnel or use an existing one. For more information, see Open a tunnel for remote device and use browser-based SSH (p. 823).

3. (Optional) Enter the configuration settings for your tunnel. You can also skip this step and proceed to the next step to create a tunnel.
Enter a tunnel description, a tunnel timeout duration, and resource tags as key-value pairs to help you identify your resource. For this tutorial, you can skip the destination configuration.

**Note**
You won’t be charged based on the duration for which you keep a tunnel open. You only incur charges when creating a new tunnel. For pricing information, see Secure Tunneling in AWS IoT Device Management pricing.

4. Download the client access tokens and then choose **Done**. The tokens will not be available to download after you choose **Done**.

These tokens can only be used once to connect to the tunnel. If you misplace the tokens or the tunnel gets disconnected, you can generate and send new tokens to your remote device for reconnecting to the tunnel.

To open a tunnel using the API

To open a new tunnel, you can use the OpenTunnel API operation. You can also specify additional configurations using the API, such as the tunnel duration and the destination configuration.

```bash
aws iotsecuretunneling open-tunnel \
  --region us-east-1 \
  --endpoint https://api.us-east-1.tunneling.iot.amazonaws.com
```

Running this command creates a new tunnel and provides you the source and destination access tokens.

```json
{
    "tunnelId": "01234567-89ab-0123-4c56-789a01234bcd",
    "tunnelArn": "arn:aws:iot:us-east-1:123456789012:tunnel/01234567-89ab-0123-4c56-789a01234bcd",
    "sourceAccessToken": "<SOURCE_ACCESS_TOKEN>",
    "destinationAccessToken": "<DESTINATION_ACCESS_TOKEN>"
}
```
Resend tunnel access tokens

The tokens that you obtained when creating a tunnel can only be used once to connect to the tunnel. If you misplace the access token or the tunnel gets disconnected, you can resend new access tokens to the remote device using MQTT at no additional charge. AWS IoT secure tunneling will revoke the current tokens and return new access tokens for reconnecting to the tunnel.

To rotate the tokens from the console

1. Go to the Tunnels hub of the AWS IoT console and choose the tunnel that you created.
2. In the tunnel details page, choose Generate new access tokens and then choose Next.
3. Download the new access tokens for your tunnel and choose Done. These tokens can be used only once. If you misplace these tokens or the tunnel gets disconnected, you can resend new access tokens.

To rotate access tokens using the API

To rotate the tunnel access tokens, you can use the RotateTunnelAccessToken API operation to revoke the current tokens and return new access tokens for reconnecting to the tunnel. For example, the following command rotates the access tokens for the destination device, RemoteThing1.

```
aws iotsecuretunneling rotate-tunnel-access-token
  --tunnel-id <tunnel-id>
  --client-mode DESTINATION
  --destination-config thingName=<RemoteThing1>,services=SSH
  --region <region>
```

Running this command generates the new access token as shown in the following example. The token is then delivered to the device using MQTT to connect to the tunnel, if the device agent is set up correctly.
Open a tunnel and start SSH session to remote device

```json
{
    "destinationAccessToken": "destination-access-token",
    "tunnelArn": "arn:aws:iot:region:account-id:tunnel/tunnel-id"
}
```

For examples that show how and when to rotate the access tokens, see Resolving AWS IoT secure tunneling connectivity issues by rotating client access tokens (p. 848).

### Configure and start the local proxy

To connect to the remote device, open a terminal on your laptop and configure and start the local proxy. The local proxy transmits data sent by the application running on the source device by using secure tunneling over a WebSocket secure connection. You can download the local proxy source from GitHub.

After you configure the local proxy, copy the source client access token, and use it to start the local proxy in source mode. Following shows an example command to start the local proxy. In the following command, the local proxy is configured to listen for new connections on port 5555. In this command:

- `-r` specifies the AWS Region, which must be the same Region where your tunnel was created.
- `-s` specifies the port to which the proxy should connect.
- `-t` specifies the client token text.

```
./localproxy -r us-east-1 -s 5555 -t source-client-access-token
```

Running this command will start the local proxy in source mode. If you receive the following error after running the command, set up the CA path. For information, see Secure tunneling local proxy on GitHub.

```
Could not perform SSL handshake with proxy server: certificate verify failed
```

The following shows a sample output of running the local proxy in source mode.

```
Starting proxy in source mode
Attempting to establish web socket connection with endpoint wss://data.tunneling.iot.us-east-1.amazonaws.com:443
Resolved proxy server IP: 10.10.0.11
Successfully connected to proxy server
Performing SSL handshake with proxy server
Successfully completed SSL handshake with proxy server
HTTP/1.1 101 Switching Protocols
  Connection: upgrade
  channel-id: 01234567890abc23-00001234-0005678a-b1234c5de677a001-2bc3d456
  upgrade: websocket

Web socket session ID: 01234567890abc23-00001234-0005678a-b1234c5de677a001-2bc3d456
Web socket subprotocol selected: aws.iot.securetunneling-2.0
Successfully established websocket connection with proxy server: wss://data.tunneling.iot.us-east-1.amazonaws.com:443
Setting up web socket pings for every 5000 milliseconds
```
Scheduled next read:

...  
Starting web socket read loop continue reading...
Resolved bind IP: 127.0.0.1
Listening for new connection on port 5555

Start an SSH session

Open another terminal and use the following command to start a new SSH session by connecting to the local proxy on port 5555.

```
ssh username@localhost -p 5555
```

You might be prompted for a password for the SSH session. When you are done with the SSH session, type `exit` to close the session.

Cleaning up

- **Close tunnel**

  We recommend that you close the tunnel after you've finished using it. A tunnel can also become closed if it stayed open for longer than the specified tunnel duration. A tunnel cannot be reopened once closed. You can still duplicate a tunnel by opening the closed tunnel and then choosing `Duplicate tunnel`. Specify the tunnel duration that you want to use and then create the new tunnel.

- To close an individual tunnel or multiple tunnels from the AWS IoT console, go to the Tunnels hub, choose the tunnels that you want to close, and then choose `Close tunnel`.

- To close an individual tunnel or multiple tunnels using the AWS IoT API Reference API, use the `CloseTunnel` API operation.

```
aws iotsecuretunneling close-tunnel
--tunnel-id "01234567-89ab-0123-4c56-789a01234bcd"
```

- **Delete tunnel**

  You can delete a tunnel permanently from your AWS account.

  **Warning**
  Deletion actions are permanent and can't be undone.

  - To delete an individual tunnel or multiple tunnels from the AWS IoT console, go to the Tunnels hub, choose the tunnels that you want to delete, and then choose `Delete tunnel`.

  - To delete an individual tunnel or multiple tunnels using the AWS IoT API Reference API, use the `CloseTunnel` API operation. When using the API, set the `delete` flag to `true`.

```
aws iotsecuretunneling close-tunnel
--tunnel-id "01234567-89ab-0123-4c56-789a01234bcd"
--delete true
```

Open a tunnel for remote device and use browser-based SSH

From the AWS IoT console, you can create a tunnel either from the Tunnels hub or from the details page of an IoT thing that you created. When you create a tunnel from the Tunnels hub, you can specify
whether to create a tunnel using the quick setup or the manual setup. For an example tutorial, see [Open a tunnel and start SSH session to remote device](p. 811).

When you create a tunnel from the thing details page of the AWS IoT console, you can also specify whether to create a new tunnel or open an existing tunnel for that thing as illustrated in this tutorial. If you choose an existing tunnel, you can access the most recent, open tunnel that you created for this device. You can then use the command line interface within the terminal to SSH into the device.

**Prerequisites**

- The firewalls that the remote device is behind must allow outbound traffic on port 443. The tunnel that you create will use this port to connect to the remote device.

- You have created an IoT thing (for example, RemoteDevice1) in the AWS IoT registry. This thing corresponds to the representation of your remote device in the cloud. For more information, see [Register a device in the AWS IoT registry](p. 811).

- You have an IoT device agent (see [IoT agent snippet](p. 841)) running on the remote device that connects to the AWS IoT device gateway and is configured with an MQTT topic subscription. For more information, see [connect a device to the AWS IoT device gateway](p. 811).

- You must have an SSH daemon running on the remote device.

**Open a new tunnel for the remote device**

Say you want to open a tunnel into your remote device, RemoteDevice1. First, create an IoT thing with the name RemoteDevice1 in the AWS IoT registry. You can then create a tunnel using the AWS Management Console, the AWS IoT API Reference API, or the AWS CLI.

By configuring a destination when creating a tunnel, the secure tunneling service delivers the destination client access token to the remote device over MQTT and the reserved MQTT topic ($aws/things/RemoteDevice1/tunnels/notify). For more information, see [Tunnel creation methods in AWS IoT console](p. 812).

**To create a tunnel for remote device from console**

1. Choose the thing, RemoteDevice1, to view its details, and then choose *Create secure tunnel*.

2. Choose whether to create a new tunnel or open an existing tunnel. To create a new tunnel, choose *Create new tunnel*. You can then choose whether to use the manual setup or the quick setup method to create the tunnel. For more information, see [Open a tunnel using manual setup and connect to remote device](p. 818) and [Open a tunnel and use browser-based SSH to access remote device](p. 813).

**To create a tunnel for remote device using API**
To open a new tunnel, you can use the [OpenTunnel](https://aws.amazon.com) API operation. The following code shows an example of running this command.

```bash
aws iotsecuretunneling open-tunnel \
  --region us-east-1 \
  --endpoint https://api.us-east-1.tunneling.iot.amazonaws.com \
  --cli-input-json file://input.json
```

Following shows the contents for the `input.json` file. You can use the `destinationConfig` parameter to specify the name of the destination device (for example, `RemoteDevice1`) and the service that you want to use to access the destination device, such as `SSH`. Optionally, you can also specify additional parameters such as tunnel description and tags.

**Contents of input.json**

```json
{
  "description": "Tunnel to remote device1",
  "destinationConfig": {
    "services": [ "SSH" ],
    "thingName": "RemoteDevice1"
  }
}
```

Running this command creates a new tunnel and provides you the source and destination access tokens.

```json
{
  "tunnelId": "01234567-89ab-0123-4c56-789a01234bcd",
  "tunnelArn": "arn:aws:iot:us-east-1:123456789012:tunnel/01234567-89ab-0123-4c56-789a01234bcd",
  "sourceAccessToken": "<SOURCE_ACCESS_TOKEN>",
  "destinationAccessToken": "<DESTINATION_ACCESS_TOKEN>"
}
```

### Open an existing tunnel and use browser-based SSH

Say you created the tunnel for your remote device, `RemoteDevice1`, using the manual setup method or using the AWS IoT API Reference API. You can then open the existing tunnel for the device and choose [Quick setup](https://aws.amazon.com) to use the browser-based SSH feature. The configurations of an existing tunnel can't be edited so you can't use the manual setup method.

To use the browser-based SSH feature, you won't have to download the source access token or configure the local proxy. A web-based local proxy will be automatically configured for you so you can start interacting with your remote device.

**To use the quick setup method and browser-based SSH**

1. Go to the details page of the thing that you created, `RemoteDevice1`, and Create secure tunnel.
2. Choose [Use existing tunnel](https://aws.amazon.com) to open the most recent, open tunnel that you created for the remote device. The tunnel configurations can't be edited so you can't use the manual setup method for the tunnel. To use the quick setup method, choose [Quick setup](https://aws.amazon.com).
3. Proceed to review and confirm the tunnel configuration details and create the tunnel. The tunnel configurations can't be edited.

When you create the tunnel, secure tunneling will use the [RotateTunnelAccessToken](https://aws.amazon.com) API operation to revoke the original access tokens and generate new access tokens. If your remote device uses MQTT, these tokens will be automatically delivered to the remote device on the MQTT topic that it's subscribed to. You can also choose to download these tokens manually to your source device.

---

825
After you've created the tunnel, you can use the browser-based SSH to interact with the remote device directly from the console using the in-context command-line interface. To use this command-line interface, choose the tunnel for the thing that you created, and in the details page, expand the Command-line interface section. As the local proxy has already been configured for you, you can start entering commands to quickly get started with accessing and interacting with your remote device, RemoteDevice1.

For more information about the quick setup method and using the browser-based SSH, see Open a tunnel and use browser-based SSH to access remote device (p. 813).

Cleaning up

• Close tunnel

We recommend that you close the tunnel after you've finished using it. A tunnel can also become closed if it stayed open for longer than the specified tunnel duration. A tunnel cannot be reopened once closed. You can still duplicate a tunnel by opening the closed tunnel and then choosing Duplicate tunnel. Specify the tunnel duration that you want to use and then create the new tunnel.

• To close an individual tunnel or multiple tunnels from the AWS IoT console, go to the Tunnels hub, choose the tunnels that you want to close, and then choose Close tunnel.

• To close an individual tunnel or multiple tunnels using the AWS IoT API Reference API, use the CloseTunnel API operation.

```
aws iotsecuretunneling close-tunnel \
  --tunnel-id "01234567-89ab-0123-4c56-789a01234bcd"
```

• Delete tunnel

You can delete a tunnel permanently from your AWS account.

**Warning**
Deletion actions are permanent and can't be undone.

• To delete an individual tunnel or multiple tunnels from the AWS IoT console, go to the Tunnels hub, choose the tunnels that you want to delete, and then choose Delete tunnel.

• To delete an individual tunnel or multiple tunnels using the AWS IoT API Reference API, use the CloseTunnel API operation. When using the API, set the delete flag to true.

```
aws iotsecuretunneling close-tunnel \
  --tunnel-id "01234567-89ab-0123-4c56-789a01234bcd" \
  --delete true
```

Local proxy

The local proxy transmits data sent by the application running on the source device by using secure tunneling over a WebSocket secure connection. You can download the local proxy source from GitHub.

The local proxy can run in two modes: source or destination. In source mode, the local proxy runs on the same device or network as the client application that initiates the TCP connection. In destination mode, the local proxy runs on the remote device, along with the destination application. A single tunnel can support up to three data streams at a time by using tunnel multiplexing. For each data stream, secure tunneling uses multiple TCP connections, which reduces the potential for a time out. For more information, see Multiplex data streams and using simultaneous TCP connections in a secure tunnel (p. 836).
How to use the local proxy

You can run the local proxy on the source and destination devices to transmit data to the secure tunneling endpoints. If your devices are in a network that use a web proxy, the web proxy can intercept the connections before forwarding them to the internet. In this case, you'll need to configure your local proxy to use the web proxy. For more information, see Configure local proxy for devices that use web proxy (p. 830).

Local proxy workflow

The following steps show how the local proxy is run on the source and destination devices.

1. **Connect local proxy to secure tunneling**

   First, local proxy must establish a connection to secure tunneling. When you start the local proxy, use the following arguments:

   - The `-r` argument to specify the AWS Region in which the tunnel is opened.
   - The `-t` argument to pass either the source or destination client access token returned from the OpenTunnel.

   **Note**
   Two local proxies using the same client access token value cannot be connected at the same time.

2. **Perform source or destination actions**

   After the WebSocket connection is established, the local proxy performs either source mode or destination mode actions, depending on its configuration.

   By default, the local proxy attempts to reconnect to secure tunneling if any input/output (I/O) errors occur or if the WebSocket connection is closed unexpectedly. This causes the TCP connection to close. If any TCP socket errors occur, the local proxy sends a message through the tunnel to notify the other side to close its TCP connection. By default, the local proxy always uses SSL communication.

3. **Stop the local proxy**

   After you use the tunnel, it is safe to stop the local proxy process. We recommend that you explicitly close the tunnel by calling CloseTunnel. Active tunnel clients might not be closed immediately after calling CloseTunnel.

For more information about how to use the AWS Management Console to open a tunnel and start an SSH session, see Open a tunnel and start SSH session to remote device (p. 811).

Local proxy best practices

When running the local proxy, follow these best practices:

- Avoid the use of the `-t` local proxy argument to pass in an access token. We recommend that you use the AWSIOT_TUNNEL_ACCESS_TOKEN environment variable to set the access token for the local proxy.
- Run the local proxy executable with least privileges in the operating system or environment.
- Avoid running the local proxy as an administrator on Windows.
- Avoid running the local proxy as root on Linux and macOS.
- Consider running the local proxy on separate hosts, containers, sandboxes, chroot jail, or a virtualized environment.
- Build the local proxy with relevant security flags, depending on your toolchain.
• On devices with multiple network interfaces, use the `-b` argument to bind the TCP socket to the network interface used to communicate with the destination application.

**Example command and output**

The following shows an example of a command that you run and the corresponding output. The example shows how the local proxy can be configured in both source and destination modes. The local proxy upgrades the HTTPS protocol to WebSockets to establish a long-lived connection and then starts transmitting data through the connection to the secure tunneling device endpoints.

**Before you run these commands:**

You must have opened a tunnel and obtained the client access tokens for the source and destination. You must have also built the local proxy as described previously. To build the local proxy, open the [local proxy source code](https://github.com/aws-iot/local-proxy) in the GitHub repository and follow the instructions for building and installing the local proxy.

**Note**

The following commands used in the examples use the verbosity flag to illustrate an overview of the different steps described previously after you run the local proxy. We recommend that you use this flag only for testing purposes.

**Running local proxy in source mode**

The following commands show how to run the local proxy in source mode.

**Linux/macOS**

In Linux or macOS, run the following commands in the terminal to configure and start the local proxy on your source.

```
export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
./localproxy -s 5555 -v 5 -r us-west-2
```

Where:

• `-s` is the source listen port, which starts the local proxy in source mode.
• `-v` is the verbosity of the output, which can be a value between zero and six.
• `-r` is the endpoint region where the tunnel is opened.

For more information about the parameters, see [Options set using command line arguments](https).

**Windows**

In Windows, you configure the local proxy similar to how you do for Linux or macOS, but how you define the environment variables is different from the other platforms. Run the following commands in the cmd window to configure and start the local proxy on your source.

```
set AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
\localproxy -s 5555 -v 5 -r us-west-2
```

Where:

• `-s` is the source listen port, which starts the local proxy in source mode.
• `-v` is the verbosity of the output, which can be a value between zero and six.
• -r is the endpoint region where the tunnel is opened.

For more information about the parameters, see [Options set using command line arguments](#).

The following shows a sample output of running the local proxy in source mode:

```plaintext
Starting proxy in source mode
Attempting to establish web socket connection with endpoint wss://data.tunneling.iot.us-west-2.amazonaws.com:443
Resolved proxy server IP: 10.10.0.11
Connected successfully with proxy server
Performing SSL handshake with proxy server
Successfully completed SSL handshake with proxy server
HTTP/1.1 101 Switching Protocols

Connection: upgrade
channel-id: 01234567890abc23-00001234-0005678a-b1234c5de677a001-2bc3d456
upgrade: websocket

Web socket session ID: 01234567890abc23-00001234-0005678a-b1234c5de677a001-2bc3d456
Web socket subprotocol selected: aws.iot.securetunneling-2.0
Successfully established web socket connection with proxy server: wss://data.tunneling.iot.us-west-2.amazonaws.com:443
Setting up web socket pings for every 5000 milliseconds
Scheduled next read:

Starting web socket read loop continue reading...
Resolved bind IP: 127.0.0.1
Listening for new connection on port 5555
```

### Running local proxy in destination mode

The following commands show how to run the local proxy in destination mode.

**Linux/macOS**

In Linux or macOS, run the following commands in the terminal to configure and start the local proxy on your destination.

```bash
export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
./localproxy -d 22 -v 5 -r us-west-2
```

Where:

• -d is the destination application which starts the local proxy in destination mode.
• -v is the verbosity of the output, which can be a value between zero and six.
• -r is the endpoint region where the tunnel is opened.

For more information about the parameters, see [Options set using command line arguments](#).
Windows

In Windows, you configure the local proxy similar to how you do for Linux or macOS, but how you define the environment variables is different from the other platforms. Run the following commands in the cmd window to configure and start the local proxy on your destination.

```bash
set AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
localproxy -d 22 -v 5 -r us-west-2
```

Where:

- `-d` is the destination application which starts the local proxy in destination mode.
- `-v` is the verbosity of the output, which can be a value between zero and six.
- `-r` is the endpoint region where the tunnel is opened.

For more information about the parameters, see [Options set using command line arguments](#).

The following shows a sample output of running the local proxy in destination mode.

```
Starting proxy in destination mode
Attempting to establish web socket connection with endpoint wss://data.tunneling.iot.us-west-2.amazonaws.com:443
Resolved proxy server IP: 10.10.0.11
Connected successfully with proxy server
Performing SSL handshake with proxy server
Successfully completed SSL handshake with proxy server
HTTP/1.1 101 Switching Protocols
Connection: upgrade
channel-id: 01234567890abc23-00001234-0005678a-b1234c5de677a001-2bc3d456
upgrade: websocket

Web socket session ID: 01234567890abc23-00001234-0005678a-b1234c5de677a001-2bc3d456
Web socket subprotocol selected: aws.iot.securetunneling-2.0
Successfully established web socket connection with proxy server: wss://data.tunneling.iot.us-west-2.amazonaws.com:443
Setting up web socket pings for every 5000 milliseconds
Scheduled next read:

Starting web socket read loop continue reading...
```

Configure local proxy for devices that use web proxy

You can use local proxy on AWS IoT devices to communicate with AWS IoT secure tunneling APIs. The local proxy transmits data sent by the device application using secure tunneling over a WebSocket secure connection. The local proxy can work in source or destination mode. In source mode, it runs on the same device or network that initiates the TCP connection. In destination mode, the local proxy runs on the remote device, along with the destination application. For more information, see [Local proxy](p. 826).
The local proxy needs to connect directly to the internet to use AWS IoT secure tunneling. For a long-lived TCP connection with secure tunneling, the local proxy upgrades the HTTPS request to establish a WebSockets connection to one of the secure tunneling device connection endpoints.

If your devices are in a network that uses a web proxy, the web proxy can intercept the connections before forwarding them to the internet. To establish a long-lived connection to the secure tunneling device connection endpoints, configure your local proxy to use the web proxy as described in the websocktet specification.

Note
The AWS IoT Device Client (p. 1431) doesn't support devices that use a web proxy. To work with the web proxy, you'll need to use a local proxy and configure it to work with a web proxy as described below.

The following steps show how the local proxy works with a web proxy.

1. The local proxy sends an HTTP CONNECT request to the web proxy that contains the remote address of the secure tunneling service, along with the web proxy authentication information.
2. The web proxy will then create a long-lived connection to the remote secure tunneling endpoints.
3. The TCP connection is established and the local proxy will now work in both source and destination modes for data transmission.

To complete this procedure, perform the following steps.

- Build the local proxy (p. 831)
- Configure your web proxy (p. 831)
- Configure and start the local proxy (p. 832)

Build the local proxy

Open the local proxy source code in the GitHub repository and follow the instructions for building and installing the local proxy.

Configure your web proxy

The local proxy relies on the HTTP tunneling mechanism described by the HTTP/1.1 specification. To comply with the specifications, your web proxy must allow devices to use the CONNECT method.

How you configure your web proxy depends on the web proxy you're using and the web proxy version. To make sure you configure the web proxy correctly, check your web proxy's documentation.

To configure your web proxy, first identify your web proxy URL and confirm whether your web proxy supports HTTP tunneling. The web proxy URL will be used later when you configure and start the local proxy.

1. Identify your web proxy URL

Your web proxy URL will be in the following format.

```
protocol://web_proxy_host_domain:web_proxy_port
```

AWS IoT secure tunneling supports only basic authentication for web proxy. To use basic authentication, you must specify the username and password as part of the web proxy URL. The web proxy URL will be in the following format.

```
protocol://username:password@web_proxy_host_domain:web_proxy_port
```
Configure local proxy for devices that use web proxy

- **protocol** can be http or https. We recommend that you use https.
- **web_proxy_host_domain** is the IP address of your web proxy or a DNS name that resolves to the IP address of your web proxy.
- **web_proxy_port** is the port on which the web proxy is listening.
- The web proxy uses this **username** and **password** to authenticate the request.

2. **Test your web proxy URL**

To confirm whether your web proxy supports TCP tunneling, use a **curl** command and make sure that you get a 2xx or a 3xx response.

For example, if your web proxy URL is https://server.com:1235, use a **proxy-insecure** flag with the curl command because the web proxy might rely on a self-signed certificate.

```
export HTTPS_PROXY=https://server.com:1235
curl -I https://aws.amazon.com --proxy-insecure
```

If your web proxy URL has a http port (for example, http://server.com:1234), you don't have to use the **proxy-insecure** flag.

```
export HTTPS_PROXY=http://server.com:1234
curl -I https://aws.amazon.com
```

**Configure and start the local proxy**

To configure the local proxy to use a web proxy, you must configure the HTTPS_PROXY environment variable with either the DNS domain names or the IP addresses and port numbers that your web proxy uses.

After you've configured the local proxy, you can use the local proxy as explained in this README document.

**Note**

Your environment variable declaration is case sensitive. We recommend that you define each variable once using either all uppercase or all lowercase letters. The following examples show the environment variable declared in uppercase letters. If the same variable is specified using both uppercase and lowercase letters, the variable specified using lowercase letters takes precedence.

The following commands show how to configure the local proxy that is running on your destination to use the web proxy and start the local proxy.

- **AWSIOT_TUNNEL_ACCESS_TOKEN**: This variable holds the client access token (CAT) for the destination.
- **HTTPS_PROXY**: This variable holds the web proxy URL or the IP address for configuring the local proxy.

The commands shown in the following examples depend on the operating system that you use and whether the web proxy is listening on an HTTP or an HTTPS port.

**Web proxy listening on an HTTP port**

If your web proxy is listening on an HTTP port, you can provide the web proxy URL or IP address for the HTTPS_PROXY variable.
Linux/macOS

In Linux or macOS, run the following commands in the terminal to configure and start the local proxy on your destination to use a web proxy listening to an HTTP port.

```
export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
export HTTPS_PROXY=http://proxy.example.com:1234
./localproxy -r us-east-1 -d 22
```

If you have to authenticate with the proxy, you must specify a `username` and `password` as part of the HTTPS_PROXY variable.

```
export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
export HTTPS_PROXY=http://username:password@proxy.example.com:1234
./localproxy -r us-east-1 -d 22
```

Windows

In Windows, you configure the local proxy similar to how you do for Linux or macOS, but how you define the environment variables is different from the other platforms. Run the following commands in the cmd window to configure and start the local proxy on your destination to use a web proxy listening to an HTTP port.

```
set AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
set HTTPS_PROXY=http://proxy.example.com:1234
\localproxy -r us-east-1 -d 22
```

If you have to authenticate with the proxy, you must specify a `username` and `password` as part of the HTTPS_PROXY variable.

```
set AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
set HTTPS_PROXY=http://username:password@10.15.20.25:1234
\localproxy -r us-east-1 -d 22
```

Web proxy listening on an HTTPS port

Run the following commands if your web proxy is listening on an HTTPS port.

**Note**

If you're using a self-signed certificate for the web proxy or if you're running the local proxy on an OS that doesn't have native OpenSSL support and default configurations, you'll have to set up your web proxy certificates as described in the Certificate setup section in the GitHub repository.

The following commands will look similar to how you configured your web proxy for an HTTP proxy, with the exception that you'll also specify the path to the certificate files that you installed as described previously.

Linux/macOS

In Linux or macOS, run the following commands in the terminal to configure the local proxy running on your destination to use a web proxy listening to an HTTPS port.

```
export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
export HTTPS_PROXY=http://proxy.example.com:1234
```
Configure local proxy for devices that use web proxy

If you have to authenticate with the proxy, you must specify a **username** and **password** as part of the HTTPS_PROXY variable.

```bash
export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
export HTTPS_PROXY=http://username:password@proxy.example.com:1234
./localproxy -r us-east-1 -d 22 -c /path/to/certs
```

### Windows

In Windows, run the following commands in the cmd window to configure and start the local proxy running on your destination to use a web proxy listening to an HTTP port.

```bash
set AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
set HTTPS_PROXY=http://proxy.example.com:1234
./localproxy -r us-east-1 -d 22 -c /path/to/certs
```

If you have to authenticate with the proxy, you must specify a **username** and **password** as part of the HTTPS_PROXY variable.

```bash
set AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
set HTTPS_PROXY=http://username:password@10.15.20.25:1234
./localproxy -r us-east-1 -d 22 -c /path/to/certs
```

### Example command and output

The following shows an example of a command that you run on a Linux OS and the corresponding output. The example shows a web proxy that’s listening on an HTTP port and how the local proxy can be configured to use the web proxy in both source and destination modes. Before you can run these commands, you must have already opened a tunnel and obtained the client access tokens for the source and destination. You must have also built the local proxy and configured your web proxy as described previously.

Here’s an overview of the steps after you start the local proxy. The local proxy:

- Identifies the web proxy URL so that it can use the URL to connect to the proxy server.
- Establishes a TCP connection with the web proxy.
- Sends an HTTP CONNECT request to the web proxy and waits for the HTTP/1.1 200 response, which indicates that connection has been established.
- Upgrades the HTTPS protocol to WebSockets to establish a long-lived connection.
- Starts transmitting data through the connection to the secure tunneling device endpoints.

**Note**

The following commands used in the examples use the verbosity flag to illustrate an overview of the different steps described previously after you run the local proxy. We recommend that you use this flag only for testing purposes.

### Running local proxy in source mode

The following commands show how to run the local proxy in source mode.

```bash
export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
```

834
The following shows a sample output of running the local proxy in source mode.

...  
Parsed basic auth credentials for the URL  
Found Web proxy information in the environment variables, will use it to connect via the proxy.

...  
Starting proxy in source mode  
Attempting to establish web socket connection with endpoint wss://data.tunneling.iot.us-west-2.amazonaws.com:443  
Resolved Web proxy IP: 10.10.0.11

Connected successfully with Web Proxy  
Successfully sent HTTP CONNECT to the Web proxy  
Full response from the Web proxy:  
HTTP/1.1 200 Connection established  
TCP tunnel established successfully  
Successfully completed SSL handshake with proxy server  
Web socket session ID: a010aaffae745f5-00001341-000b8138-cc6c878d00e8a0b-f10b06d4b  
Web socket subprotocol selected: aws.iot.securetunneling-2.0

Successfully established websocket connection with proxy server: wss://data.tunneling.iot.us-west-2.amazonaws.com:443

Seting up web socket pings for every 5000 milliseconds

Scheduled next read:

...  
Starting web socket read loop continue reading...

Resolv bind IP: 127.0.0.1

Listening for new connection on port 5555

Running local proxy in destination mode

The following commands show how to run the local proxy in destination mode.

export AWSIOT_TUNNEL_ACCESS_TOKEN=${access_token}
export HTTPS_PROXY=http:username:password@10.15.10.25:1234
./localproxy -d 22 -v 5 -r us-west-2

The following shows a sample output of running the local proxy in destination mode.

...  
Parsed basic auth credentials for the URL  
Found Web proxy information in the environment variables, will use it to connect via the proxy.

...  
Starting proxy in destination mode  
Attempting to establish web socket connection with endpoint wss://data.tunneling.iot.us-west-2.amazonaws.com:443  
Resolved Web proxy IP: 10.10.0.1

Connected successfully with Web Proxy  
Successfully sent HTTP CONNECT to the Web proxy
Multiplexing and simultaneous TCP connections

You can use multiple data streams per tunnel by using the secure tunneling multiplexing feature. With multiplexing, you can troubleshoot devices using multiple data streams. You can also reduce your operational load by eliminating the need to build, deploy, and start multiple local proxies or open multiple tunnels to the same device. For example, multiplexing can be used in case of a web browser that requires sending multiple HTTP and SSH data streams.

For each data stream, AWS IoT secure tunneling supports simultaneous TCP connections. Using simultaneous connections reduces the potential for a time-out in case of multiple requests from the client. For example, it can reduce the loading time when remotely accessing a web server that is local to the destination device.

The following sections explain more about multiplexing and using simultaneous TCP connections, and their different use cases.

Topics

- Multiplexing multiple data streams in a secure tunnel (p. 836)
- Using simultaneous TCP connections in a secure tunnel (p. 839)

Multiplexing multiple data streams in a secure tunnel

You can use the multiplexing feature for devices that use multiple connections or ports. Multiplexing can also be used when you require multiple connections to a remote device to troubleshoot any issues. For example, it can be used in case of a web browser that requires sending multiple HTTP and SSH data streams. The application data from both streams are sent to the device concurrently over the multiplexed tunnel.

Example use case

Say you need to connect to an on-device web application to change some networking parameters, while simultaneously issuing shell commands through the terminal to verify that the device is working properly with the new networking parameters. In this scenario, you may need to connect to the device through both HTTP and SSH and transfer two parallel data streams in order to concurrently access the web application and terminal. With the multiplexing feature, these two independent streams can be transferred over the same tunnel at the same time.
How to set up a multiplexed tunnel

The following procedure walks you through how to set up a multiplexed tunnel for troubleshooting devices using applications that require connections to multiple ports. You will set up one tunnel with two multiplexed streams: one HTTP stream and one SSH stream.

1. **(Optional) Create configuration files**

   You can optionally configure the source and destination device with configuration files. Use configuration files if your port mappings are likely to change frequently. You can skip this step if you prefer to specify the port mapping explicitly using the CLI, or if you don't need to start the local proxy on designated listening ports. For more information about how to use configuration files, see Options set via --config in GitHub.

   1. On your source device, in the folder where your local proxy will run, create a configuration folder called `Config`. Inside this folder, create a file called `SSHSource.ini` with the following content:

      ```ini
      HTTP1 = 5555
      SSH1 = 3333
      ```

   2. On your destination device, in the folder where your local proxy will run, create a configuration folder called `Config`. Inside this folder, create a file called `SSHDestination.ini` with the following content:

      ```ini
      HTTP1 = 80
      SSH1 = 22
      ```

2. **Open a tunnel**

   Open a tunnel using the OpenTunnel API operation or the open-tunnel CLI command. Configure the destination by specifying SSH1 and HTTP1 as the services and the name of the AWS IoT thing that corresponds to your remote device. Your SSH and HTTP applications are running on this remote device. You must have already created the IoT thing in the AWS IoT registry. For more information, see How to manage things with the registry (p. 269).

   ```bash
   aws iotsecuretunneling open-tunnel \
   --destination-config thingName=RemoteDevice1,services=HTTP1,SSH1
   ```

   Running this command generates the source and destination access tokens which you'll use to run the local proxy.
3. Configure and start the local proxy

Before you can run the local proxy, either set up the AWS IoT Device Client, or download the local proxy source code from GitHub and build it for the platform of your choice. You can then start the destination and the source local proxy to connect to the secure tunnel. For more information about configuring and using the local proxy, see How to use the local proxy (p. 827).

**Note**

On your source device, if you don't use any configuration files or specify the port mapping using the CLI, you can still use the same command to run the local proxy. The local proxy in source mode will automatically pick up available ports to use and the mappings for you.

**Start local proxy using configuration files**

Run the following commands to run the local proxy in the source and destination modes using configuration files.

```
// ----------------- Start the destination local proxy -----------------------
./localproxy -r us-east-1 -m dst -t destination_client_access_token

// ----------------- Start the source local proxy ----------------------------
// You also run the same command below if you want the local proxy to
// choose the mappings for you instead of using configuration files.
./localproxy -r us-east-1 -m src -t source_client_access_token
```

**Start local proxy using CLI port mapping**

Run the following commands to run the local proxy in the source and destination modes by specifying the port mappings explicitly using the CLI.

```
// ----------------- Start the destination local proxy -----------------------
./localproxy -r us-east-1 -d HTTP1=80,SSH1=22 -t destination_client_access_token

// ----------------- Start the source local proxy ----------------------------
./localproxy -r us-east-1 -s HTTP1=5555,SSH1=33 -t source_client_access_token
```

The application data from SSH and HTTP connection can now be transferred concurrently over the multiplexed tunnel. As seen in the map below, the service identifier acts as a readable format to translate the port mapping between the source and destination device. With this configuration, secure tunneling forwards any incoming HTTP traffic from port 5555 on the source device to port 80 on the destination device, and any incoming SSH traffic from port 3333 to port 22 on the destination device.
Using simultaneous TCP connections in a secure tunnel

AWS IoT secure tunneling supports more than one TCP connection simultaneously for each data stream. You can use this capability when you require simultaneous connections to a remote device. Using simultaneous TCP connections reduces the potential for a time-out in case of multiple requests from the client. For example, when accessing a web server that has multiple components running on it, simultaneous TCP connections can reduce the time it takes to load the site.

**Note**

Simultaneous TCP connections have a bandwidth limit of 800 Kilobytes per second for each AWS account. AWS IoT secure tunneling can configure this limit for you depending on the number of incoming requests.

**Example use case**

Say you need to remotely access a web server that’s local to the destination device and has multiple components running on it. With a single TCP connection, while trying to access the web server, sequential loading can increase the amount of time it takes to load the resources on the site. The simultaneous TCP connections can reduce the loading time by meeting the resource requirements of the site, thereby reducing the access time. The following diagram shows how simultaneous TCP connections are supported for the data stream to the web server application running on the remote device.

**Note**

If you want to access multiple applications running on the remote device using the tunnel, you can use tunnel multiplexing. For more information, see Multiplexing multiple data streams in a secure tunnel (p. 836).
How to use simultaneous TCP connections

The following procedure walks you through how to use simultaneous TCP connections for accessing the web browser on the remote device. When there are multiple requests from the client, AWS IoT secure tunneling automatically sets up simultaneous TCP connections to handle the requests, thereby reducing the loading time.

1. **Open a tunnel**

   Open a tunnel using the OpenTunnel API operation or the `open-tunnel` CLI command. Configure the destination by specifying HTTP as the service and the name of the AWS IoT thing that corresponds to your remote device. Your web server application is running on this remote device. You must have already created the IoT thing in the AWS IoT registry. For more information, see [How to manage things with the registry](p. 269).

   ```bash
   aws iotsecuretunneling open-tunnel --destination-config thingName=RemoteDevice1,services=HTTP
   ```

   Running this command generates the source and destination access tokens which you'll use to run the local proxy.

   ```json
   
   {  
   "tunnelId": "b2de92a3-b0ff-46c0-b0f2-afa28b00cecd",  
   "tunnelArn": "arn:aws:iot:us-west-2:451600097591:tunnel/b2de92a3-b0ff-46c0-b0f2-afa28b00cecd",  
   "sourceAccessToken": source_client_access_token,  
   "destinationAccessToken": destination_client_access_token  
   }
   ```

2. **Configure and start the local proxy**

   Before you can run the local proxy, download the local proxy source code from [GitHub](https://github.com) and build it for the platform of your choice. You can then start the destination and the source local proxy to connect to the secure tunnel and start using the remote web server application.

   **Note**

   For AWS IoT secure tunneling to use simultaneous TCP connections, you must upgrade to the latest version of the local proxy. This feature is not available if you configure the local proxy using the AWS IoT Device Client.

   ```bash
   // Start the destination local proxy
   ./localproxy -r us-east-1 -d HTTP=80 -t destination_client_access_token
   ```
// Start the source local proxy
./localproxy -r us-east-1 -s HTTP=5555 -t source_client_access_token

For more information about configuring and using the local proxy, see How to use the local proxy (p. 827).

You can now use the tunnel to access the web server application. AWS IoT secure tunneling will automatically set up and handle the simultaneous TCP connections when there are multiple requests from the client.

Configuring a remote device and using IoT agent

The IoT agent is used to receive the MQTT message that includes the client access token and start a local proxy on the remote device. You must install and run the IoT agent on the remote device if you want secure tunneling to deliver the client access token using MQTT. The IoT agent must subscribe to the following reserved IoT MQTT topic:

Note
If you want to deliver the destination client access token to the remote device through methods other than subscribing to the reserved MQTT topic, you might need a destination client access token (CAT) listener and a local proxy. The CAT listener must work with your chosen client access token delivery mechanism and be able to start a local proxy in destination mode.

IoT agent snippet

The IoT agent must subscribe to the following reserved IoT MQTT topic so that it can receive the MQTT message and start the local proxy:

$aws/things/thing-name/tunnels/notify

Where thing-name is the name of AWS IoT thing associated with the remote device.

The following is an example MQTT message payload:

```
{
    "clientAccessToken": "destination-client-access-token",
    "clientMode": "destination",
    "region": "aws-region",
    "services": ["destination-service"]
}
```

After it receives an MQTT message, the IoT agent must start a local proxy on the remote device with the appropriate parameters.

The following Java code demonstrates how to use the AWS IoT Device SDK and ProcessBuilder from the Java library to build a simple IoT agent to work with secure tunneling.

```
// Find the IoT device endpoint for your AWS account
final String endpoint = iotClient.describeEndpoint(new DescribeEndpointRequest().withEndpointType("iot:Data-ATS")).getEndpointAddress();

// Instantiate the IoT Agent with your AWS credentials
final String thingName = "RemoteDeviceA";
final String tunnelNotificationTopic = String.format("$aws/things/%s/tunnels/notify", thingName);
```
final AWSIoTClient mqttClient = new AWSIoTClient(endpoint, thingName, "your_aws_access_key", "your_aws_secret_key");

try {
    mqttClient.connect();
    final TunnelNotificationListener listener = new TunnelNotificationListener(tunnelNotificationTopic);
    mqttClient.subscribe(listener, true);
} finally {
    mqttClient.disconnect();
}

private static class TunnelNotificationListener extends AWSIoTTopic {
    public TunnelNotificationListener(String topic) {
        super(topic);
    }

    @Override
    public void onMessage(AWSIoTMessage message) {
        try {
            // Deserialize the MQTT message
            final JSONObject json = new JSONObject(message.getStringPayload());

            final String accessToken = json.getString("clientAccessToken");
            final String region = json.getString("region");

            final String clientMode = json.getString("clientMode");
            if (!clientMode.equals("destination")) {
                throw new RuntimeException("Client mode " + clientMode + " in the MQTT message is not expected");
            }

            final JSONArray servicesArray = json.getJSONArray("services");
            if (servicesArray.length() > 1) {
                throw new RuntimeException("Services in the MQTT message has more than 1 service");
            }

            final String service = servicesArray.get(0).toString();
            if (!service.equals("SSH")) {
                throw new RuntimeException("Service " + service + " is not supported");
            }

            // Start the destination local proxy in a separate process to connect to the SSH Daemon listening port 22
            final ProcessBuilder pb = new ProcessBuilder("localproxy", "-t", accessToken, 
                    
                    "-r", region,  
                    "-d", "localhost:22");
            pb.start();
        } catch (Exception e) {
            log.error("Failed to start the local proxy", e);
        }
    }
}
Tunnel access prerequisites

- Learn how to secure AWS resources by using IAM policies.
- Learn how to create and evaluate IAM conditions.
- Learn how to secure AWS resources using resource tags.

Tunnel access policies

You must use the following policies for authorizing permissions to use the secure tunneling API. For more information about AWS IoT security see Identity and access management for AWS IoT (p. 390).

**iot:OpenTunnel**

The `iot:OpenTunnel` policy action grants a principal permission to call OpenTunnel.

In the **Resource** element of the IAM policy statement:

- Specify the wildcard tunnel ARN:
  
  `arn:aws:iot:aws-region:aws-account-id:tunnel/*`

- Specify a thing ARN to manage the OpenTunnel permission for specific IoT things:
  
  `arn:aws:iot:aws-region:aws-account-id:thing/thing-name`

For example, the following policy statement allows you to open a tunnel to the IoT thing named TestDevice.

```
{
    "Effect": "Allow",
    "Action": "iot:OpenTunnel",
    "Resource": [
        "arn:aws:iot:aws-region:aws-account-id:tunnel/*",
    ]
}
```

The `iot:OpenTunnel` policy action supports the following condition keys:

- `iot:ThingGroupArn`
- `iot:TunnelDestinationService`
- `aws:RequestTag/tag-key`
- `aws:SecureTransport`
- `aws:TagKeys`

The following policy statement allows you to open a tunnel to the thing if the thing belongs to a thing group with a name that starts with TestGroup and the configured destination service on the tunnel is SSH.

```
[
    "Effect": "Allow",
    "Action": "iot:OpenTunnel",
    "Resource": [
        "arn:aws:iot:aws-region:aws-account-id:tunnel/*"
    ]
]
```
You can also use resource tags to control permission to open tunnels. For example, the following policy statement allows a tunnel to be opened if the tag key Owner is present with a value of Admin and no other tags are specified. For general information about using tags, see [Tagging your AWS IoT resources](p. 291).

```json
{
    "Effect": "Allow",
    "Action": "iot:OpenTunnel",
    "Resource": [
        "arn:aws:iot:aws-region:aws-account-id:tunnel/*"
    ],
    "Condition": {
        "StringEquals": {
            "aws:RequestTag/Owner": "Admin"
        },
        "ForAllValues:TagKeys": "Owner"
    }
}
```

**iot:RotateTunnelAccessToken**

The *iot:RotateTunnelAccessToken* policy action grants a principal permission to call *RotateTunnelAccessToken*.

In the Resource element of the IAM policy statement:

- Specify a fully qualified tunnel ARN:
  
  ```text
  arn:aws:iot:aws-region:aws-account-id:tunnel/tunnel-id
  ```

  You can also use the wildcard tunnel ARN:

  ```text
  arn:aws:iot:aws-region:aws-account-id:tunnel/*
  ```

- Specify a thing ARN to manage the RotateTunnelAccessToken permission for specific IoT things:

  ```text
  arn:aws:iot:aws-region:aws-account-id:thing/thing-name
  ```

For example, the following policy statement allows you to rotate either a tunnel's source access token or a client's destination access token for the IoT thing named TestDevice.

```json
{
    "Effect": "Allow",
    "Action": "iot:RotateTunnelAccessToken",
```
The `iot:RotateTunnelAccessToken` policy action supports the following condition keys:

- `iot:ThingGroupArn`
- `iot:TunnelDestinationService`
- `iot:ClientMode`
- `aws:SecureTransport`

The following policy statement allows you to rotate the destination access token to the thing if the thing belongs to a thing group with a name that starts with `TestGroup`, the configured destination service on the tunnel is SSH, and the client is in `DESTINATION` mode.

```json
{
   "Effect": "Allow",
   "Action": "iot:RotateTunnelAccessToken",
   "Resource": [
      "arn:aws:iot:aws-region:aws-account-id:tunnel/*"
   ],
   "Condition": {
      "ForAnyValue:StringLike": {
         "iot:ThingGroupArn": [
         ]
      },
      "ForAllValues:StringEquals": {
         "iot:TunnelDestinationService": [
            "SSH"
         ],
         "iot:ClientMode": "DESTINATION"
      }
   }
}
```

**`iot:DescribeTunnel`**

The `iot:DescribeTunnel` policy action grants a principal permission to call `DescribeTunnel`.

In the Resource element of the IAM policy statement, specify a fully qualified tunnel ARN:

`arn:aws:iot:aws-region:aws-account-id:tunnel/tunnel-id`

You can also use the wildcard ARN:

`arn:aws:iot:aws-region:aws-account-id:tunnel/*`

The `iot:DescribeTunnel` policy action supports the following condition keys:

- `aws:ResourceTag/tag-key`
- `aws:SecureTransport`

The following policy statement allows you to call `DescribeTunnel` if the requested tunnel is tagged with the key `Owner` with a value of `Admin`.

```json
{ }
```
Tunnel access policies

```json
{
  "Effect": "Allow",
  "Action": "iot:DescribeTunnel",
  "Resource": [
    "arn:aws:iot:aws-region:aws-account-id:tunnel/*"
  ],
  "Condition": {
    "StringEquals": {
      "aws:ResourceTag/Owner": "Admin"
    }
  }
}

**iot:ListTunnels**


In the `Resource` element of the IAM policy statement:

- Specify the wildcard tunnel ARN:
  ```text
  arn:aws:iot:aws-region:aws-account-id:tunnel/*
  ```
- Specify a thing ARN to manage the `ListTunnels` permission on selected IoT things:
  ```text
  arn:aws:iot:aws-region:aws-account-id:thing(thing-name)
  ```

The `iot:ListTunnels` policy action supports the condition key `aws:SecureTransport`.

The following policy statement allows you to list tunnels for the thing named `TestDevice`.

```json
{
  "Effect": "Allow",
  "Action": "iot:ListTunnels",
  "Resource": [
    "arn:aws:iot:aws-region:aws-account-id:tunnel/*",
  ]
}

**iot:ListTagsForResource**


In the `Resource` element of the IAM policy statement, specify a fully qualified tunnel ARN:

```text
arn:aws:iot:aws-region:aws-account-id:tunnel/tunnel-id
```

You can also use the wildcard tunnel ARN:

```text
arn:aws:iot:aws-region:aws-account-id:tunnel/*
```

The `iot:ListTagsForResource` policy action supports the condition key `aws:SecureTransport`.

**iot:CloseTunnel**

The `iot:CloseTunnel` policy action grants a principal permission to call [CloseTunnel](https://docs.aws.amazon.com/IoT/latest/DeveloperGuide/iotevents-close.html).

In the `Resource` element of the IAM policy statement, specify a fully qualified tunnel ARN:

```text
arn:aws:iot:aws-region:aws-account-id:tunnel/*
```
arn:aws:iot:aws-region: aws-account-id:tunnel/tunnel-id

You can also use the wildcard tunnel ARN:

arn:aws:iot:aws-region:aws-account-id:tunnel/*

The iot:CloseTunnel policy action supports the following condition keys:

• iot:Delete
• aws:ResourceTag/tag-key
• aws:SecureTransport

The following policy statement allows you to call CloseTunnel if the request's Delete parameter is false and the requested is tagged with the key Owner with a value of QATeam.

```
{
  "Effect": "Allow",
  "Action": "iot:CloseTunnel",
  "Condition": {
    "Bool": {
      "iot:Delete": "false",
      "StringEquals": {
        "aws:ResourceTag/Owner": "QATeam"
      }
    }
  }
}
```

**iot:TagResource**

The iot:TagResource policy action grants a principal permission to call TagResource.

In the Resource element of the IAM policy statement, specify a fully qualified tunnel ARN:

```
arn:aws:iot:aws-region: aws-account-id:tunnel/tunnel-id
```

You can also use the wildcard tunnel ARN:

```
arn:aws:iot:aws-region:aws-account-id:tunnel/*
```

The iot:TagResource policy action supports the condition key aws:SecureTransport.

**iot:UntagResource**

The iot:UntagResource policy action grants a principal permission to call UntagResource.

In the Resource element of the IAM policy statement, specify a fully qualified tunnel ARN:

```
arn:aws:iot:aws-region: aws-account-id:tunnel/tunnel-id
```

You can also use the wildcard tunnel ARN:

```
arn:aws:iot:aws-region:aws-account-id:tunnel/*
```

The iot:UntagResource policy action supports the condition key aws:SecureTransport.
Resolving AWS IoT secure tunneling connectivity issues by rotating client access tokens

When you use AWS IoT secure tunneling, you might run into connectivity issues even if the tunnel is open. The following sections show some possible issues and how you can resolve them by rotating the client access tokens. To rotate the client access token (CAT), use the RotateTunnelAccessToken API or the rotate-tunnel-access-token AWS CLI. Depending on whether you run into an error with using the client in the source or destination mode, you can rotate the CAT either in source or destination mode, or both.

**Note**

- If you're not sure whether the CAT needs to be rotated on the source or destination, you can rotate the CAT on both the source and destination by setting ClientMode to ALL when using the RotateTunnelAccessToken API.
- Rotating the CAT doesn't extend the tunnel duration. For example, say the tunnel duration is 12 hours and the tunnel has already been open for 4 hours. When you rotate the access tokens, the new tokens that are generated can only be used for the remaining 8 hours.

**Topics**

- Invalid client access token error (p. 848)
- Client token mismatch error (p. 848)
- Remote device connectivity issues (p. 849)

**Invalid client access token error**

When using AWS IoT secure tunneling, you can run into a connection error when using the same client access token (CAT) to reconnect to the same tunnel. In this case, the local proxy can't connect to the secure tunneling proxy server. If you're using a client in the source mode, you might see the following error message:

```
Invalid access token: The access token was previously used and cannot be used again
```

The error occurs because the client access token (CAT) can only be used once by the local proxy, and it then becomes invalid. To resolve this error, rotate the client access token in the SOURCE mode to generate a new CAT for the source. For an example that shows how to rotate the source CAT, see Rotate source CAT example (p. 849).

**Client token mismatch error**

**Note**

Using client tokens to reuse the CAT is not recommended. We recommend that you use the RotateTunnelAccessToken API instead to rotate the client access tokens to reconnect to the tunnel.

If you're using client tokens, you can reuse the CAT for reconnecting to the tunnel. To reuse the CAT, you must provide the client token with the CAT the first time you connect to secure tunneling. Secure tunneling stores the client token so for subsequent connection attempts using the same token, the client token must also be provided. For more information about using client tokens, see the local proxy reference implementation in GitHub.

When using client tokens, if you're using a client in the source mode, you might see the following error:
Invalid client token: The provided client token does not match the client token that was previously set.

The error occurs because the client token provided doesn't match the client token that was provided with the CAT when accessing the tunnel. To resolve this error, rotate the CAT in the SOURCE mode to generate a new CAT for the source. The following shows an example:

**Rotate source CAT example**

The following shows an example of how to run the `rotate-tunnel-access-token` API in the SOURCE mode to generate a new CAT for the source:

```bash
aws iotsecuretunneling rotate-tunnel-access-token \
  --region <region> \
  --tunnel-id <tunnel-id> \
  --client-mode SOURCE
```

Running this command generates a new source access token and returns the ARN of your tunnel.

```
{
    "sourceAccessToken": "<source-access-token>",
    "tunnelArn": "arn:aws:iot:<region>:<account-id>:tunnel/<tunnel-id>"
}
```

You can now use the new source token to connect the local proxy in source mode.

```bash
export AWSIOT_TUNNEL_ACCESS_TOKEN=<source-access-token>
./localproxy -r <region> -s <port>
```

The following shows a sample output of running the local proxy:

```
...
[info] Starting proxy in source mode
[info] Successfully established websocket connection with proxy server ...
[info] Listening for new connection on port <port>
...
```

**Remote device connectivity issues**

When using AWS IoT secure tunneling, the device might get disconnected unexpectedly even if the tunnel is open. To identify whether a device is still connected to the tunnel, you can use the `describe-tunnel` API or the `describe-tunnel` AWS CLI.

A device can get disconnected for multiple reasons. To resolve the connectivity issue, you can rotate the CAT on the destination if the device was disconnected due to the following possible reasons:

- The CAT on the destination became invalid.
- The token wasn't delivered to the device over the secure tunneling reserved MQTT topic:

  ```
  $aws/things/<thing-name>/tunnels/notify
  ```

The following example shows how to resolve this issue:
Rotate destination CAT example

Consider a remote device, `<RemoteThing1>`. To open a tunnel for that thing, you can use the following command:

```bash
aws iotsecuretunneling open-tunnel \
--region <region> \
--destination-config thingName=<RemoteThing1>,services=SSH
```

Running this command generates the tunnel details and the CAT for your source and destination.

```json
{
    "sourceAccessToken": "<source-access-token>",
    "destinationAccessToken": "<destination-access-token>",
    "tunnelId": "<tunnel-id>",
    "tunnelArn": "arn:aws:iot:<region>:<account-id>:tunnel/<tunnel-id>"
}
```

However, when you use the DescribeTunnel API, the output indicates that the device has been disconnected, as illustrated below:

```bash
aws iotsecuretunneling describe-tunnel \
--tunnel-id <tunnel-id> \
--region <region>
```

Running this command displays that the device is still not connected.

```json
{
    "tunnel": {
        "destinationConnectionState": {
            "status": "DISCONNECTED"
        },
        ...
    }
}
```

To resolve this error, run the RotateTunnelAccessToken API with the client in DESTINATION mode and the configurations for the destination. Running this command revokes the old access token, generates a new token, and resends this token to the MQTT topic:

```bash
$aws/things/<thing-name>/tunnels/notify
```

```bash
aws iotsecuretunneling rotate-tunnel-access-token \
--tunnel-id <tunnel-id> \
--client-mode DESTINATION \
--destination-config thingName=<RemoteThing1>,services=SSH \
--region <region>
```

Running this command generates the new access token as shown below. The token is then delivered to the device to connect to the tunnel, if the device agent is set up correctly.

```json
{
    "destinationAccessToken": "destination-access-token",
    "tunnelArn": "arn:aws:iot:<region>:account-id:tunnel/<tunnel-id>"
}
```
Device provisioning

AWS provides several different ways to provision a device and install unique client certificates on it. This section describes each way and how to select the best one for your IoT solution. These options are described in detail in the whitepaper titled Device Manufacturing and Provisioning with X.509 Certificates in AWS IoT Core.

Select the option that fits your situation best

- **You can install certificates on IoT devices before they are delivered**

  If you can securely install unique client certificates on your IoT devices before they are delivered for use by the end user, you want to use just-in-time provisioning (JITP) (p. 860) or just-in-time registration (JITR) (p. 314).

  Using JITP and JITR, the certificate authority (CA) used to sign the device certificate is registered with AWS IoT and is recognized by AWS IoT when the device first connects. The device is provisioned in AWS IoT on its first connection using the details of its provisioning template.

  For more information on single thing, JITP, JITR, and bulk provisioning of devices that have unique certificates, see the section called “Provisioning devices that have device certificates” (p. 859).

- **End users or installers can use an app to install certificates on their IoT devices**

  If you cannot securely install unique client certificates on your IoT device before they are delivered to the end user, but the end user or an installer can use an app to register the devices and install the unique device certificates, you want to use the provisioning by trusted user (p. 856) process.

  Using a trusted user, such as an end user or an installer with a known account, can simplify the device manufacturing process. Instead of a unique client certificate, devices have a temporary certificate that enables the device to connect to AWS IoT for only 5 minutes. During that 5-minute window, the trusted user obtains a unique client certificate with a longer life and installs it on the device. The limited life of the claim certificate minimizes the risk of a compromised certificate.

  For more information, see the section called “Provisioning by trusted user” (p. 856).

- **End users CANNOT use an app to install certificates on their IoT devices**

  If neither of the previous options will work in your IoT solution, the provisioning by claim (p. 854) process is an option. With this process, your IoT devices have a claim certificate that is shared by other devices in the fleet. The first time a device connects with a claim certificate, AWS IoT registers the device using its provisioning template and issues the device its unique client certificate for subsequent access to AWS IoT.

  This option enables automatic provisioning of a device when it connects to AWS IoT, but could present a larger risk in the event of a compromised claim certificate. If a claim certificate becomes compromised, you can deactivate the certificate. Deactivating the claim certificate prevents all devices with that claim certificate from being registered in the future. However, deactivating the claim certificate does not block devices that have already been provisioned.

  For more information, see the section called “Provisioning by claim” (p. 854).

Provisioning devices in AWS IoT

When you provision a device with AWS IoT, you must create resources so your devices and AWS IoT can communicate securely. Other resources can be created to help you manage your device fleet. The following resources can be created during the provisioning process:
• An IoT thing.

IoT things are entries in the AWS IoT device registry. Each thing has a unique name and set of attributes, and is associated with a physical device. Things can be defined using a thing type or grouped into thing groups. For more information, see Managing devices with AWS IoT (p. 269).

Although not required, creating a thing makes it possible to manage your device fleet more effectively by searching for devices by thing type, thing group, and thing attributes. For more information, see Fleet indexing (p. 885).

Note
For Fleet Hub to index your Thing's connectivity status data, provision your Thing and configure it so the Thing name matches the client ID used on the Connect request.

• An X.509 certificate.

Devices use X.509 certificates to perform mutual authentication with AWS IoT. You can register an existing certificate or have AWS IoT generate and register a new certificate for you. You associate a certificate with a device by attaching it to the thing that represents the device. You must also copy the certificate and associated private key onto the device. Devices present the certificate when connecting to AWS IoT. For more information, see Authentication (p. 297).

• An IoT policy.

IoT policies define the operations that a device can perform in AWS IoT. IoT policies are attached to device certificates. When a device presents the certificate to AWS IoT, it is granted the permissions specified in the policy. For more information, see Authorization (p. 334). Each device needs a certificate to communicate with AWS IoT.

AWS IoT supports automated fleet provisioning using provisioning templates. Provisioning templates describe the resources AWS IoT requires to provision your device. Templates contain variables that enable you to use one template to provision multiple devices. When you provision a device, you specify values for the variables specific to the device using a dictionary or map. To provision another device, specify new values in the dictionary.

You can use automated provisioning whether or not your devices have unique certificates (and their associated private key).

Fleet provisioning APIs

There are several categories of APIs used in fleet provisioning:

• These control plane functions create and manage the fleet provisioning templates and configure trusted user policies.
  - CreateProvisioningTemplate
  - CreateProvisioningTemplateVersion
  - DeleteProvisioningTemplate
  - DeleteProvisioningTemplateVersion
  - DescribeProvisioningTemplate
  - DescribeProvisioningTemplateVersion
  - ListProvisioningTemplates
  - ListProvisioningTemplateVersions
  - UpdateProvisioningTemplate

• Trusted users can use this control plane function to generate a temporary onboarding claim. This temporary claim is passed to the device during Wi-Fi configuration or a similar method.
Provisioning devices that don't have device certificates using fleet provisioning

By using AWS IoT fleet provisioning, AWS IoT can generate and securely deliver device certificates and private keys to your devices when they connect to AWS IoT for the first time. AWS IoT provides client certificates that are signed by the Amazon Root certificate authority (CA).

There are two ways to use fleet provisioning:

- **Provisioning by claim** (p. 854)
- **Provisioning by trusted user** (p. 856)

Provisioning by claim

Devices can be manufactured with a provisioning claim certificate and private key (which are special purpose credentials) embedded in them. If these certificates are registered with AWS IoT, the service can exchange them for unique device certificates that the device can use for regular operations. This process includes the following steps:

**Before you deliver the device**

1. Call **CreateProvisioningClaim** to create a provisioning claim certificate. This API returns a template ARN. For more information, see **Device provisioning MQTT API** (p. 879).
   - You can also create a fleet provisioning template in the AWS IoT console.
     a. From the navigation pane, choose **Connect**, then choose **Fleet provisioning templates**.
     b. Choose **Create template** and follow the prompts.
2. Create certificates and associated private keys to be used as provisioning claim certificates.
3. Register these certificates with AWS IoT and associate an IoT policy that restricts the use of the certificates. The following example IoT policy restricts the use of the certificate associated with this policy to provisioning devices.

   ```json
   {
   "Version": "2012-10-17",
   "Statement": [
   {
   "Effect": "Allow",
   "Action": ["iot:Connect"],
   "Resource": "*"]
   ,
   {
   "Effect": "Allow",
   "Action": ["iot:Publish","iot:Receive"],
   "Resource": [
   ```

   ![Image with JSON code]

   854
4. Give the AWS IoT service permission to create or update IoT resources such as things and certificates in your account when provisioning devices. Do this by attaching the AWSIoTThingsRegistration managed policy to an IAM role (called the provisioning role) that trusts the AWS IoT service principal.

5. Manufacture the device with the provisioning claim certificate securely embedded in it.

The device is now ready to be delivered to where it will be installed for use.

Important
Provisioning claim private keys should be secured at all times, including on the device. We recommend that you use AWS IoT CloudWatch metrics and logs to monitor for indications of misuse. If you detect misuse, turn off the provisioning claim certificate so it cannot be used for device provisioning.

To initialize the device for use

1. The device uses the AWS IoT Device SDKs, Mobile SDKs, and AWS IoT Device Client (p. 1428) to connect to and authenticate with AWS IoT using the provisioning claim certificate that is installed on the device.

   Note
   For security, the certificateOwnershipToken returned by CreateCertificateFromCsr (p. 880) and CreateKeysAndCertificate (p. 881) expires after one hour. RegisterThing (p. 883) must be called before the certificateOwnershipToken expires. If the certificate created by CreateCertificateFromCsr (p. 880) or CreateKeysAndCertificate (p. 881) has not been activated and has not been attached to a policy or a thing by the time the token expires, the certificate is deleted. If the token expires, the device can call CreateCertificateFromCsr (p. 880) or CreateKeysAndCertificate (p. 881) again to generate a new certificate.

2. The device obtains a permanent certificate and private key by using one of these options. The device will use the certificate and key for all future authentication with AWS IoT.

   a. Call CreateKeysAndCertificate (p. 881) to create a new certificate and private key using the AWS certificate authority.

   Or

   b. Call CreateCertificateFromCsr (p. 880) to generate a certificate from a certificate signing request that keeps its private key secure.

3. From the device, call RegisterThing (p. 883) to register the device with AWS IoT and create cloud resources.
The Fleet Provisioning service uses a provisioning template to define and create cloud resources such as IoT things. The template can specify attributes and groups that the thing belongs to. The thing groups must exist before the new thing can be added to them.

4. After saving the permanent certificate on the device, the device must disconnect from the session that it initiated with the provisioning claim certificate and reconnect using the permanent certificate.

The device is now ready to communicate normally with AWS IoT.

Provisioning by trusted user

In many cases, a device connects to AWS IoT for the first time when a trusted user, such as an end user or installation technician, uses a mobile app to configure the device in its deployed location.

Important
You must manage the trusted user's access and permission to perform this procedure. One way to do this is to provide and maintain an account for the trusted user that authenticates them and grants them access to the AWS IoT features and API operations required to perform this procedure.

Before you deliver the device

1. Call `CreateProvisioningTemplate` to create a provisioning template and return its `templateArn` and `templateName`.
2. Create an IAM role that is used by a trusted user to initiate the provisioning process. The provisioning template allows only that user to provision a device. For example:

   ```json
   {
     "Effect": "Allow",
     "Action": [
       "iot:CreateProvisioningClaim"
     ],
     "Resource": [
       "arn:aws:iot:aws-region:aws-account-id:provisioningtemplate/templateName"
     ]
   }
   ```

3. Give the AWS IoT service permission to create or update IoT resources, such as things and certificates in your account when provisioning devices. You do this by attaching the `AWSIoTThingsRegistration` managed policy to an IAM role (called the provisioning role) that trusts the AWS IoT service principal.
4. Provide the means to identify your trusted users, such as by providing them with an account that can authenticate them and authorize their interactions with the AWS API operations necessary to register their devices.

To initialize the device for use

1. A trusted user signs in to your provisioning mobile app or web service.
2. The mobile app or web application uses the IAM role and calls `CreateProvisioningClaim` to obtain a temporary provisioning claim certificate from AWS IoT.

   **Note**
   For security, the temporary provisioning claim certificate that `CreateProvisioningClaim` returns expires after five minutes. The following steps must successfully return a valid certificate before the temporary provisioning claim certificate expires. Temporary provisioning claim certificates do not appear in your account's list of certificates.
3. The mobile app or web application supplies the temporary provisioning claim certificate to the device along with any required configuration information, such as Wi-Fi credentials.

4. The device uses the temporary provisioning claim certificate to connect to AWS IoT using the AWS IoT Device SDKs, Mobile SDKs, and AWS IoT Device Client (p. 1428).

5. The device obtains a permanent certificate and private key by using one of these options within five minutes of connecting to AWS IoT with the temporary provisioning claim certificate. The device will use the certificate and key these options return for all future authentication with AWS IoT.
   a. Call `CreateKeysAndCertificate` (p. 881) to create a new certificate and private key using the AWS certificate authority.
   
   Or
   
   b. Call `CreateCertificateFromCsr` (p. 880) to generate a certificate from a certificate signing request that keeps its private key secure.

   Note
   Remember `CreateKeysAndCertificate` (p. 881) or `CreateCertificateFromCsr` (p. 880) must return a valid certificate within five minutes of connecting to AWS IoT with the temporary provisioning claim certificate.

6. The device calls `RegisterThing` (p. 883) to register the device with AWS IoT and create cloud resources.

   The Fleet Provisioning service uses a provisioning template to define and create cloud resources such as IoT things. The template can specify attributes and groups that the thing belongs to. The thing groups must exist before the new thing can be added to them.

7. After saving the permanent certificate on the device, the device must disconnect from the session that it initiated with the temporary provisioning claim certificate and reconnect using the permanent certificate.

The device is now ready to communicate normally with AWS IoT.

**Using pre-provisioning hooks with the AWS CLI**

The following procedure creates a provisioning template with pre-provisioning hooks. The Lambda function used here is an example that can be modified.

**To create and apply a pre-provisioning hook to a provisioning template**

1. Create a Lambda function that has a defined input and output. Lambda functions are highly customizable. `allowProvisioning` and `parameterOverrides` are required for creating pre-provisioning hooks. For more information about creating Lambda functions, see [Using AWS Lambda with the AWS Command Line Interface](#).

   The following is an example of a Lambda function output:

   ```json
   {
   "allowProvisioning": True,
   "parameterOverrides": {
       "incomingKey0": "incomingValue0",
       "incomingKey1": "incomingValue1"
   }
   }
   ```

2. AWS IoT uses resource-based policies to call Lambda, so you must give AWS IoT permission to call your Lambda function.
**Important**

Be sure to include the **source-arn** or **source-account** in the global condition context keys of the policies attached to your Lambda action to prevent permission manipulation. For more information about this, see Cross-service confused deputy prevention (p. 346).

The following is an example using **add-permission** give IoT permission to your Lambda.

```
aws lambda add-permission \
  --function-name myLambdaFunction \
  --statement-id iot-permission \
  --action lambda:InvokeFunction \
  --principal iot.amazonaws.com
```

3. **Add a pre-provisioning hook to a template using either the** [create-provisioning-template](https://docs.aws.amazon.com/iot/latest/developerguide/create-provisioning-template.html) or [update-provisioning-template](https://docs.aws.amazon.com/iot/latest/developerguide/update-provisioning-template.html) **command.**

The following CLI example uses the **create-provisioning-template** to create a provisioning template that has pre-provisioning hooks:

```
aws iot create-provisioning-template \
  --template-name myTemplate \
  --provisioning-role-arn arn:aws:iam:us-east-1:1234564789012:role/myRole \
  --template-body file://template.json \
  --pre-provisioning-hook file://hooks.json
```

The output of this command looks like the following:

```
{
    "templateArn": "arn:aws:iot:us-east-1:1234564789012:provisioningtemplate/myTemplate",
    "defaultVersionId": 1,
    "templateName": "myTemplate"
}
```

You can also load a parameter from a file instead of typing it all as a command line parameter value to save time. For more information, see [Loading AWS CLI Parameters from a File](https://docs.aws.amazon.com/cli/latest/userguide/cli-aws-parameters.html). The following shows the template parameter in expanded JSON format:

```
{
    "Parameters": {
        "DeviceLocation": {
            "Type": "String"
        }
    },
    "Mappings": {
        "LocationTable": {
            "Seattle": {
                "LocationUrl": "https://example.aws"
            }
        }
    },
    "Resources": {
        "thing": {
            "Type": "AWS::IoT::Thing",
            "Properties": {
                "AttributePayload": {
                    "version": "v1",
                    "serialNumber": "serialNumber"
                }
            }
        }
    }
}
```
Provisioning devices that have device certificates

AWS IoT provides three ways to provision devices when they already have a device certificate (and associated private key) on them:

- Single-thing provisioning with a provisioning template. This is a good option if you only need to provision devices one at a time.
• Just-in-time provisioning (JITP) with a template that provisions a device when it first connects to AWS IoT. This is a good option if you need to register large numbers of devices, but you don’t have information about them that you can assemble into a bulk provisioning list.

• Bulk registration. This option allows you to specify a list of single-thing provisioning template values that are stored in a file in an S3 bucket. This approach works well if you have a large number of known devices whose desired characteristics you can assemble into a list.

Topics
• Single thing provisioning (p. 860)
• Just-in-time provisioning (p. 860)
• Bulk registration (p. 865)

Single thing provisioning

To provision a thing, use the RegisterThing API or the register-thing CLI command. The register-thing CLI command takes the following arguments:

--template-body
The provisioning template.

--parameters
A list of name-value pairs for the parameters used in the provisioning template, in JSON format (for example, {"ThingName" : "MyProvisionedThing", "CSR" : "csr-text"}).

See Provisioning templates (p. 865).

RegisterThing or register-thing returns the ARNs for the resources and the text of the certificate it created:

```json
{
  "certificatePem": "certificate-text",
  "resourceArns": {
    "certificate": "arn:aws:iot:us-west-2:123456789012:cert/cd82bb924d8c6c6cbb14986dcb4f40f30d892cc6b3ce7ad5008ed6542ee2b049",
    "thing": "arn:aws:iot:us-west-2:123456789012:thing/MyProvisionedThing"
  }
}
```

If a parameter is omitted from the dictionary, the default value is used. If no default value is specified, the parameter is not replaced with a value.

Just-in-time provisioning

You can use just-in-time provisioning (JITP) to provision your devices when they first attempt to connect to AWS IoT. To provision the device, you must enable automatic registration and associate a provisioning template with the CA certificate used to sign the device certificate. Provisioning successes and errors are logged as Device provisioning metrics (p. 459) in Amazon CloudWatch.

Topics
• JITP overview (p. 861)
• Register CA using provisioning template (p. 863)
• Register CA using provisioning template name (p. 864)

JITP overview

When a device attempts to connect to AWS IoT by using a certificate signed by a registered CA certificate, AWS IoT loads the template from the CA certificate and uses it to call RegisterThing (p. 883). The JITP workflow first registers a certificate with a status value of PENDING_ACTIVATION. When the device provisioning flow is complete, the status of the certificate is changed to ACTIVE.

AWS IoT defines the following parameters that you can declare and reference in provisioning templates:

- AWS::IoT::Certificate::Country
- AWS::IoT::Certificate::Organization
- AWS::IoT::Certificate::OrganizationalUnit
- AWS::IoT::Certificate::DistinguishedNameQualifier
- AWS::IoT::Certificate::StateName
- AWS::IoT::Certificate::CommonName
- AWS::IoT::Certificate::SerialNumber
- AWS::IoT::Certificate::Id

The values for these provisioning template parameters are limited to what JITP can extract from the subject field of the certificate of the device being provisioned. The certificate must contain values for all of the parameters in the template body. The AWS::IoT::Certificate::Id parameter refers to an internally generated ID, not an ID that is contained in the certificate. You can get the value of this ID using the principal() function inside an AWS IoT rule.

Note
You can provision devices using AWS IoT Core just-in-time provisioning (JITP) feature without having to send the entire trust chain on a device's first connection to AWS IoT Core. Presenting the CA certificate is optional, but the device is required to send the Server Name Indication (SNI) extension when it connects to AWS IoT Core.

Example template body

The following JSON file is an example template body of a complete JITP template.

```json
{
  "Parameters":
  {
    "AWS::IoT::Certificate::CommonName":{
      "Type":"String"
    },
    "AWS::IoT::Certificate::SerialNumber":{
      "Type":"String"
    },
    "AWS::IoT::Certificate::Country":{
      "Type":"String"
    },
    "AWS::IoT::Certificate::StateName":{
      "Type":"String"
    },
    "AWS::IoT::Certificate::Id":{
      "Type":"String"
    }
  },
  "Resources":
  {
    "thing":{
      "Type":"AWS::IoT::Thing",
      "Properties":{
        "CertificateArn":null,
        "DeviceProperties":null,
        "ThingName":null,
        "ThingType":null,
        "ThingArn":null,
        "RoleArn":null,
        "CertificateActivation":null,
        "CertificateSerialNumber":null,
        "CertificateCountry":null,
        "CertificateOrganization":null,
        "CertificateOrganizationalUnit":null,
        "CertificateDistinguishedNameQualifier":null,
        "CertificateStateName":null,
        "CertificateCommonName":null,
        "CertificateSerialNumber":null,
        "CertificateId":null
      }
    }
  }
}
```
"ThingName":{
  "Ref":"AWS::IoT::Certificate::CommonName"
},
"AttributePayload":{
  "version":"v1",
  "serialNumber":{
    "Ref":"AWS::IoT::Certificate::SerialNumber"
  }
},
"ThingTypeName":"lightBulb-versionA",
"ThingGroups":[
  "v1-lightbulbs",
  {
    "Ref":"AWS::IoT::Certificate::Country"
  }
],
"OverrideSettings":{
  "AttributePayload":"MERGE",
  "ThingTypeName":"REPLACE",
  "ThingGroups":"DO_NOTHING"
},
"certificate":{
  "Type":"AWS::IoT::Certificate",
  "Properties":{
    "CertificateId":{
      "Ref":"AWS::IoT::Certificate::Id"
    },
    "Status":"ACTIVE"
  }
},
"policy":{
  "Type":"AWS::IoT::Policy",
  "Properties":{
  }
}

This sample template declares values for the AWS::IoT::Certificate::CommonName, AWS::IoT::Certificate::SerialNumber, AWS::IoT::Certificate::Country, and AWS::IoT::Certificate::Id provisioning parameters that are extracted from the certificate and used in the Resources section. The JITP workflow then uses this template to perform the following actions:

- Register a certificate and set its status to PENDING_ACTIVE.
- Create one thing resource.
- Create one policy resource.
- Attach the policy to the certificate.
- Attach the certificate to the thing.
- Update the certificate status to ACTIVE.

Note that the device provisioning fails if the certificate doesn’t have all of the properties mentioned in the Parameters section of the templateBody. For example, if AWS::IoT::Certificate::Country is included in the template, but the certificate doesn’t have a Country property, the device provisioning fails.
You can also use CloudTrail to troubleshoot issues with your JITP template. For information about the metrics that are logged in Amazon CloudWatch, see Device provisioning metrics (p. 459). For more information about provisioning templates, see Provisioning templates (p. 865).

**Note**

During the provisioning process, just-in-time provisioning (JITP) calls other AWS IoT control plane API operations. These calls might exceed the AWS IoT Throttling Quotas set for your account and result in throttled calls. Contact AWS Customer Support to raise your throttling quotas if necessary.

### Register CA using provisioning template

To register a CA by using a complete provisioning template, follow these steps:

1. Save your provisioning template and the role ARN information like the following example as a JSON file:

   ```json
   {
     "templateBody": "{
       \"Parameters\": {
          \"AWS::IoT::Certificate::CommonName\": {\n            \"Type\": \"String\",\n            \"AWS::IoT::Certificate::SerialNumber\": {\n              \"Type\": \"String\",\n            },\n            \"AWS::IoT::Certificate::Country\": {\n              \"Type\": \"String\",\n            },\n            \"AWS::IoT::Certificate::Id\": {\n              \"Type\": \"String\",\n            }
        },\n        \"Resources\": {
          \"thing\": {\n            \"Type\": \"AWS::IoT::Thing\",\n            \"Properties\": {\n              \"version\": \"v1\",\n              \"ThingName\": {\n                \"Ref\": \"AWS::IoT::Certificate::CommonName\"\n              },\n              \"AttributePayload\": {\n                \"version\": \"v1-cutlightbulbs\",\n                \"serialNumber\": {\n                  \"Ref\": \"AWS::IoT::Certificate::SerialNumber\"\n                },\n                \"ThingGroupName\": {\n                  \"Ref\": \"lightBulbs\"\n                },\n                \"ThingGroups\": {\n                  \"Ref\": \"AWS::IoT::Certificate::Country\"\n                },\n                \"OverrideSettings\": {\n                  \"AttributePayload\": \"MERGE\",
                  \"ThingTypeName\": \"replace\",
                  \"ThingGroups\": {\n                    \"Ref\": \"AWS::IoT::Certificate::Id\"\n                  },\n                  \"OverrideSettings\": {\n                    \"Status\": \"ACTIVE\"
                  }
                },\n                \"CertificateId\": {\n                  \"Ref\": \"AWS::IoT::Certificate::Id\"\n                },\n                \"Status\": \"DO_NOTHING\"
            },\n            \"policy\": {\n              \"Type\": \"AWS::IoT::Policy\",\n              \"Properties\": {\n                \"PolicyDocument\": {\n                  \"Version\": \"2012-10-17\",\n                  \"Statement\": [[ \n                    \"Effect\": \"Allow\", \n                    \"Action\": [\n                      \"iot:Publish\"], \n                    \"Resource\": [\n                      \"arn:aws:iot:us-east-1:123456789012:topic/\"foo/\"bar/\"\"] ]]
              }
            }
          }
        }
    }
   }
   
   "roleArn": "arn:aws:iam:123456789012:role/JITPRole"
   }
```

In this example, the value of the templateBody field must be a JSON object specified as an escaped string and can use only the values in the preceding list (p. 861). You can use a variety of tools to create the required JSON output, such as json.dumps (Python) or JSON.stringify (Node). The value of the roleARN field must be the ARN of a role that has the AWSIoTThingsRegistration attached to it. Also, your template can use an existing PolicyName instead of the inline PolicyDocument in the example.

2. Register a CA certificate with the RegisterCACertificate API operation or the register-ca-certificate CLI command. You will specify the directory of the provisioning template and role ARN information that you saved in the previous step:
The following shows an example of how to register a CA certificate in DEFAULT mode using the AWS CLI:

```bash
aws iot register-ca-certificate --ca-certificate file://your-ca-cert --verification-cert file://your-verification-cert --set-as-active --allow-auto-registration --registration-config file://your-template
```

The following shows an example of how to register a CA certificate in SNI_ONLY mode using the AWS CLI:

```bash
aws iot register-ca-certificate --ca-certificate file://your-ca-cert --certificate-mode SNI_ONLY --set-as-active --allow-auto-registration --registration-config file://your-template
```

For more information, see Register your CA Certificates.

3. (Optional) Update the settings for a CA certificate by using the UpdateCACertificate API operation or the update-ca-certificate CLI command.

The following shows an example of how to update a CA certificate using the AWS CLI:

```bash
aws iot update-ca-certificate --certificate-id caCertificateId --new-auto-registration-status ENABLE --registration-config file://your-template
```

Register CA using provisioning template name

To register a CA by using a provisioning template name, follow these steps:

1. Save your provisioning template body as a JSON file. You can find an example template body in example template body (p. 861).

2. To create a provisioning template, use the CreateProvisioningTemplate API or the create-provisioning-template CLI command:

```bash
aws iot create-provisioning-template --template-name your-template-name \ --template-body file://your-template-body.json --type JITP \ --provisioning-role-arn arn:aws:iam::123456789012:role/test
```

**Note**
For just-in-time provisioning (JITP), you must specify template type to be JITP when creating the provisioning template. For more information about the template type, see CreateProvisioningTemplate in the AWS API Reference.

3. To register CA with template name, use the RegisterCACertificate API or the register-ca-certificate CLI command:

```bash
aws iot register-ca-certificate --ca-certificate file://your-ca-cert --verification-cert file://your-verification-cert \ --set-as-active --allow-auto-registration --registration-config templateName=your-template-name
```
Bulk registration

You can use the `start-thing-registration-task` command to register things in bulk. This command takes a provisioning template, an S3 bucket name, a key name, and a role ARN that allows access to the file in the S3 bucket. The file in the S3 bucket contains the values used to replace the parameters in the template. The file must be a newline-delimited JSON file. Each line contains all of the parameter values for registering a single device. For example:

```json
{"ThingName": "foo", "SerialNumber": "123", "CSR": "csr1"}
{"ThingName": "bar", "SerialNumber": "456", "CSR": "csr2"}
```

The following bulk registration-related API operations might be useful:

- `ListThingRegistrationTasks`: Lists the current bulk thing provisioning tasks.
- `DescribeThingRegistrationTask`: Provides information about a specific bulk thing registration task.
- `StopThingRegistrationTask`: Stops a bulk thing registration task.
- `ListThingRegistrationTaskReports`: Used to check the results and failures for a bulk thing registration task.

**Note**

- Only one bulk registration operation task can run at a time (per account).
- Bulk registration operations call other AWS IoT control plane API operations. These calls might exceed the AWS IoT Throttling Quotas in your account and cause throttle errors. Contact AWS Customer Support to raise your AWS IoT throttling quotas, if necessary.

Provisioning templates

A provisioning template is a JSON document that uses parameters to describe the resources your device must use to interact with AWS IoT. A provisioning template contains two sections: Parameters and Resources. There are two types of provisioning templates in AWS IoT. One is used for just-in-time provisioning (JITP) and bulk registration, and the second is used for fleet provisioning.

**Topics**

- Parameters section (p. 865)
- Resources section (p. 866)
- Template example for bulk registration (p. 869)
- Template example for just-in-time provisioning (JITP) (p. 870)
- Fleet provisioning (p. 871)

Parameters section

The Parameters section declares the parameters used in the Resources section. Each parameter declares a name, a type, and an optional default value. The default value is used when the dictionary passed in with the template does not contain a value for the parameter. The Parameters section of a template document looks like the following:

```json
{
    "Parameters" : {
        "ThingName" : {
```
"Type" : "String",
"SerialNumber" : {
  "Type" : "String"
},
"Location" : {
  "Type" : "String",
  "Default" : "WA"
},
"CSR" : {
  "Type" : "String"
}
}

This template body snippet declares four parameters: ThingName, SerialNumber, Location, and CSR. All of these parameters are of type String. The Location parameter declares a default value of "WA".

**Resources section**

The Resources section of the template body declares the resources required for your device to communicate with AWS IoT: a thing, a certificate, and one or more IoT policies. Each resource specifies a logical name, a type, and a set of properties.

A logical name allows you to refer to a resource elsewhere in the template.

The type specifies the kind of resource that you are declaring. Valid types are:

- AWS::IoT::Thing
- AWS::IoT::Certificate
- AWS::IoT::Policy

The properties you specify depend on the type of resource you are declaring.

**Thing resources**

Thing resources are declared using the following properties:

- ThingName: String.
- AttributePayload: Optional. A list of name-value pairs.
- ThingTypeName: Optional. String for an associated thing type for the thing.
- ThingGroups: Optional. A list of groups to which the thing belongs.
- BillingGroup: Optional. String for an associated billing group name.
- PackageVersions: Optional. String for an associated package and version names.

**Certificate resources**

You can specify certificates in one of the following ways:

- A certificate signing request (CSR).
- A certificate ID of an existing device certificate. (Only certificate IDs can be used with a fleet provisioning template.)
- A device certificate created with a CA certificate registered with AWS IoT. If you have more than one CA certificate registered with the same subject field, you must also pass in the CA certificate used to sign the device certificate.
Note
When you declare a certificate in a template, use only one of these methods. For example, if you use a CSR, you cannot also specify a certificate ID or a device certificate. For more information, see X.509 client certificates (p. 300).

For more information, see X.509 Certificate overview (p. 297).

Certificate resources are declared using the following properties:

- CertificateId: String.
- Status: Optional. String that can be ACTIVE or INACTIVE. Defaults to ACTIVE.

Examples:

- Certificate specified with a CSR:

  ```json
  {  
    "certificate" : {  
      "Type" : "AWS::IoT::Certificate",
      "Properties" : {  
        "CertificateSigningRequest": {"Ref" : "CSR"},
        "Status" : "ACTIVE"
      }
    }
  }
  ```

- Certificate specified with an existing certificate ID:

  ```json
  {  
    "certificate" : {  
      "Type" : "AWS::IoT::Certificate",
      "Properties" : {  
        "CertificateId": {"Ref" : "CertificateId"}
      }
    }
  }
  ```

- Certificate specified with an existing certificate .pem and CA certificate .pem:

  ```json
  {  
    "certificate" : {  
      "Type" : "AWS::IoT::Certificate",
      "Properties" : {  
        "CACertificatePem": {"Ref" : "CACertificatePem"},
      }
    }
  }
  ```

Policy resources

Policy resources are declared using one of the following properties:
AWS IoT Core Developer Guide
Resources section

- **PolicyName**: Optional. String. Defaults to a hash of the policy document. The PolicyName can only reference AWS IoT policies but not IAM policies. If you are using an existing AWS IoT policy, for the PolicyName property, enter the name of the policy. Do not include the PolicyDocument property.
- **PolicyDocument**: Optional. A JSON object specified as an escaped string. If PolicyDocument is not provided, the policy must already be created.

**Note**
If a Policy section is present, PolicyName or PolicyDocument, but not both, must be specified.

**Override settings**

If a template specifies a resource that already exists, the OverrideSettings section allows you to specify the action to take:

**DO NOTHING**
- Leave the resource as is.

**REPLACE**
- Replace the resource with the resource specified in the template.

**FAIL**
- Cause the request to fail with a ResourceConflictsException.

**MERGE**
- Valid only for the ThingGroups and AttributePayload properties of a thing. Merge the existing attributes or group memberships of the thing with those specified in the template.

When you declare a thing resource, you can specify OverrideSettings for the following properties:

- **ATTRIBUTE_PAYLOAD**
- **THING_TYPE_NAME**
- **THING_GROUPS**

When you declare a certificate resource, you can specify OverrideSettings for the Status property.

OverrideSettings are not available for policy resources.

**Resource example**

The following template snippet declares a thing, a certificate, and a policy:

```json
{
    "Resources" : {
        "thing" : {
            "Type" : "AWS::IoT::Thing",
            "Properties" : {
                "ThingName" : {"Ref" : "ThingName"},
                "AttributePayload" : { "version" : "v1", "serialNumber" : {"Ref" : "SerialNumber"} },
                "ThingTypeName" : "lightBulb-versionA",
                "ThingGroups" : ["v1-lightbulbs", {"Ref" : "Location"}]
            }
        },
        "OverrideSettings" : {
```
The thing is declared with:

- The logical name "thing".
- The type AWS::IoT::Thing.
- A set of thing properties.

The thing properties include the thing name, a set of attributes, an optional thing type name, and an optional list of thing groups to which the thing belongs.

Parameters are referenced by {"Ref": "parameter-name"}. When the template is evaluated, the parameters are replaced with the parameter's value from the dictionary passed in with the template.

The certificate is declared with:

- The logical name "certificate".
- The type AWS::IoT::Certificate.
- A set of properties.

The properties include the CSR for the certificate, and setting the status to ACTIVE. The CSR text is passed as a parameter in the dictionary passed with the template.

The policy is declared with:

- The logical name "policy".
- The type AWS::IoT::Policy.
- Either the name of an existing policy or a policy document.

**Template example for bulk registration**

The following JSON file is an example of a complete provisioning template that specifies the certificate with a CSR:

(The PolicyDocument field value must be a JSON object specified as an escaped string.)
The following JSON file is an example of a complete provisioning template that specifies an existing certificate with a certificate ID:
Fleet provisioning templates are used by AWS IoT to set up cloud and device configuration. These templates use the same parameters and resources as the JITP and bulk registration templates. For more information, see Provisioning templates (p. 865). Fleet provisioning templates can
contain a Mapping section and a DeviceConfiguration section. You can use intrinsic functions inside a fleet provisioning template to generate a device-specific configuration. Fleet provisioning templates are named resources and are identified by ARNs (for example, arn:aws:iot:us-west-2:1234568788:provisioningtemplate/templateName).

Mappings

The optional Mappings section matches a key to a corresponding set of named values. For example, if you want to set values based on an AWS Region, you can create a mapping that uses the AWS Region name as a key and contains the values you want to specify for each specific Region. You use the Fn::FindInMap intrinsic function to retrieve values in a map.

You cannot include parameters, pseudo parameters, or call intrinsic functions in the Mappings section.

Device configuration

The device configuration section contains arbitrary data that you want to send to your devices when provisioning. For example:

```json
{
   "DeviceConfiguration": {
      "Foo":"Bar"
   }
}
```

If you're sending messages to your devices by using the JavaScript Object Notation (JSON) payload format, AWS IoT Core formats this data as JSON. If you're using the Concise Binary Object Representation (CBOR) payload format, AWS IoT Core formats this data as CBOR. The DeviceConfiguration section doesn't support nested JSON objects.

Intrinsic functions

Intrinsic functions are used in any section of the provisioning template except the Mappings section.

Fn::Join

Appends a set of values into a single value, separated by the specified delimiter. If a delimiter is an empty string, the values are concatenated with no delimiter.

Important

Fn::Join is not supported for the section called “Policy resources” (p. 867).

Fn::Select

Returns a single object from a list of objects by index.

Important

Fn::Select does not check for null values or if the index is out of bounds of the array. Both conditions result in a provisioning error, so you should ensure you chose a valid index value, and that the list contains non-null values.

Fn::FindInMap

Returns the value corresponding to keys in a two-level map that is declared in the Mappings section.

Fn::Split

Splits a string into a list of string values so you can select an element from the list of strings. You specify a delimiter that determines where the string is split (for example, a comma). After you split a string, use Fn::Select to select an element.
For example, if a comma-delimited string of subnet IDs is imported to your stack template, you can split the string at each comma. From the list of subnet IDs, use `Fn::Select` to specify a subnet ID for a resource.

**Fn::Sub**

Substitutes variables in an input string with values that you specify. You can use this function to construct commands or outputs that include values that aren't available until you create or update a stack.

**Template example for fleet provisioning**

```json
{
  "Parameters" : {
    "ThingName" : {
      "Type" : "String"
    },
    "SerialNumber" : {
      "Type" : "String"
    },
    "DeviceLocation" : {
      "Type" : "String"
    }
  },
  "Mappings" : {
    "LocationTable" : {
      "Seattle" : {
        "LocationUrl" : "https://example.aws"
      }
    }
  },
  "Resources" : {
    "thing" : {
      "Type" : "AWS::IoT::Thing",
      "Properties" : {
        "AttributePayload" : {
          "version" : "v1",
          "serialNumber" : "serialNumber"
        },
        "ThingName" : {
          "Ref" : "ThingName"
        },
        "ThingTypeName" : {
          "Fn::Join" : [
            ",",
            ["ThingPrefix_",
              {"Ref" : "SerialNumber"}]
          ]
        },
        "ThingGroups" : ["v1-lightbulbs", "WA"],
        "BillingGroup" : "LightBulbBillingGroup"
      },
      "OverrideSettings" : {
        "AttributePayload" : "MERGE",
        "ThingTypeName" : "REPLACE",
        "ThingGroups" : "DO NOTHING"
      }
    },
    "certificate" : {
      "Type" : "AWS::IoT::Certificate",
      "Properties" : {
        "CertificateId" : {
          "Ref" : "AWS::IoT::Certificate::Id"
        },
        "Status" : "Active"
      }
    },
    "policy" : {
      "Type" : "AWS::IoT::Policy",
      "Properties" : {
        "PolicyDocument" : {
          "Version" : "2012-10-17"
        }
      }
    }
  }
}
```
Pre-provisioning hooks

AWS recommends using pre-provisioning hook functions when creating provisioning templates to allow more control of which and how many devices your account onboards. Pre-provisioning hooks are Lambda functions that validate parameters passed from the device before allowing the device to be provisioned. This Lambda function must exist in your account before you provision a device because it's called every time a device sends a request through the section called “RegisterThing” (p. 883).

**Important**
Be sure to include the source-arn or source-account in the global condition context keys of the policies attached to your Lambda action to prevent permission manipulation. For more information about this, see Cross-service confused deputy prevention (p. 346).

For devices to be provisioned, your Lambda function must accept the input object and return the output object described in this section. The provisioning proceeds only if the Lambda function returns an object with "allowProvisioning": True.

Pre-provision hook input

AWS IoT sends this object to the Lambda function when a device registers with AWS IoT.

```json
{
    "claimCertificateId" : "string",
    "certificateId" : "string",
    "certificatePem" : "string",
    "clientId" : "221a6d10-9c7f-42f1-9153-e52e6fc869c1",
    "parameters" : {
        "string" : "string",
        ...
    }
}
```

The parameters object passed to the Lambda function contains the properties in the parameters argument passed in the the section called “RegisterThing” (p. 883) request payload.

Pre-provision hook return value

The Lambda function must return a response that indicates whether it has authorized the provisioning request and the values of any properties to override.
The following is an example of a successful response from the pre-provisioning function.

```json
{
   "allowProvisioning": true,
   "parameter Overrides": {
      "Key": "newCustomValue",
      ...
   }
}
```

"parameter Overrides" values will be added to "parameters" parameter of the section called "RegisterThing" (p. 883) request payload.

**Note**

- If the Lambda function fails, the provisioning request fails with ACCESS_DENIED and an error is logged to CloudWatch Logs.
- If the Lambda function doesn't return "allowProvisioning": "true" in the response, the provisioning request fails with ACCESS_DENIED.
- The Lambda function must finish running and return within 5 seconds, otherwise the provisioning request fails.

**Pre-provisioning hook Lambda example**

**Python**

An example of a pre-provisioning hook Lambda in Python.

```python
import json

def pre_provisioning_hook(event, context):
    print(event)
    return {
        'allowProvisioning': True,
        'parameterOverrides': {
            'DeviceLocation': 'Seattle'
        }
    }
```

**Java**

An example of a pre-provisioning hook Lambda in Java.

**Handler class:**

```java
package example;

import java.util.Map;
import java.util.HashMap;
import com.amazonaws.services.lambda.runtime.Context;
import com.amazonaws.services.lambda.runtime.RequestHandler;

public class PreProvisioningHook implements RequestHandler<PreProvisioningHookRequest, PreProvisioningHookResponse> {
    public PreProvisioningHookResponse handleRequest(PreProvisioningHookRequest object, Context context) {
```
Map<String, String> parameterOverrides = new HashMap<String, String>();
parameterOverrides.put("DeviceLocation", "Seattle");

PreProvisioningHookResponse response = PreProvisioningHookResponse.builder()
  .allowProvisioning(true)
  .parameterOverrides(parameterOverrides)
  .build();

  return response;
}
}

Request class:

package example;
import java.util.Map;
import lombok.Builder;
import lombok.Data;
import lombok.AllArgsConstructor;
import lombok.NoArgsConstructor;
@Data
@Builder
@AllArgsConstructor
@NoArgsConstructor
public class PreProvisioningHookRequest {
  private String claimCertificateId;
  private String certificateId;
  private String certificatePem;
  private String templateArn;
  private String clientId;
  private Map<String, String> parameters;
}

Response class:

package example;
import java.util.Map;
import lombok.Builder;
import lombok.Data;
import lombokAllArgsConstructor;
import lombokNoArgsConstructor;
@Data
@Builder
@AllArgsConstructor
@NoArgsConstructor
public class PreProvisioningHookResponse {
  private boolean allowProvisioning;
  private Map<String, String> parameterOverrides;
}

JavaScript

An example of a pre-provisioning hook Lambda in JavaScript.

exports.handler = function(event, context, callback) {
  console.log(JSON.stringify(event, null, 2));
}
Creating IAM policies and roles for a user installing a device

Note
These procedures are for use only when directed by the AWS IoT console. To go to this page from the console, open create a new provisioning template.

Why can't this be done in the AWS IoT console?
For the most secure experience, IAM actions are performed in the IAM console. The procedures in this section walk you through the steps to create the IAM roles and policies that are needed to use the provisioning template.

Creating an IAM policy for the user who will install a device
This procedure describes how to create an IAM policy that authorizes a user to install a device using a provisioning template.

While performing this procedure, you'll be switching between the IAM console and the AWS IoT console. We recommend having both consoles open at the same time while you complete this procedure.

To create an IAM policy for the user who will install a device
1. Open the Policies hub in the IAM console.
2. Choose Create Policy.
3. On the Create policy page, choose the JSON tab.
4. Switch to the page in the AWS IoT console where you chose Configure user policy and role.
5. In the Sample provisioning policy, choose Copy.
6. Switch back to the IAM console.
7. In the JSON editor, paste the policy you copied from the AWS IoT console. This policy is specific to the template you’re creating in the AWS IoT console.
8. To continue, choose Next: Tags.
9. On the Add tags (Optional) page, choose Add tag for each tag you want to add to this policy. You can skip this step if you don’t have any tags to add.
10. To continue, choose Next: Review.
11. On the Review policy page, do the following:
   a. For Name*, enter a name for the policy that will help you remember the policy's purpose.
      Note the name you give this policy because you’ll use it in the next procedure.
b. You can choose to enter an optional description for the policy you're creating.
c. Review the rest of this policy and its tags.
12. To finish creating the new policy, choose Create policy.

After you create your new policy, continue to the section called “Creating an IAM role for the user who will install a device” (p. 878) to create the user’s role entry that you'll attach this policy.

Creating an IAM role for the user who will install a device

These steps describe how to create an IAM role that authenticates the user who will install a device using a provisioning template.

To create an IAM policy for the user who will install a device

1. Open the Role hub in the IAM console.
2. Choose Create role.
3. In Select trusted entity, choose the type of trusted entity that you want to give access to the template you're creating.
4. Choose or enter the identification of the trusted entity that you want to grant access to, and then choose Next.
5. On the Add permissions page, in Permission policies, in the search box, enter the name of the policy you created in the previous procedure (p. 877).
6. For the policy list, choose the policy that you created in the previous procedure, and then choose Next.
7. In the Name, review, and create section, do the following:
   a. For Role name, enter a role name that will help you remember the role's purpose.
   b. For Description, you can choose to enter an optional description of the Role. This isn't required to continue.
   c. Review the values in Step 1 and Step 2.
   d. For Add tags (Optional), you can choose to add tags to this role. This isn't required to continue.
   e. Verify the information on this page is complete and correct, and then choose Create role.

After you create the new role, return to the AWS IoT console to continue creating the template.

Updating an existing policy to authorize a new template

The following steps describe how to add a new template to an IAM policy that authorizes a user to install a device using a provisioning template.

To add a new template to an existing IAM policy

1. Open the Policies hub in the IAM console.
2. In the search box, enter the name of the policy to update.
3. For the list below the search box, find the policy you want to update and choose the policy name.
4. For Policy summary, choose the JSON tab, if that panel isn't already visible.
5. To modify the policy document, choose Edit policy.
6. In the editor, choose the JSON tab, if that panel isn't already visible.
7. In the policy document, find the policy statement that contains the iot:CreateProvisioningClaim action.

    If the policy document doesn't contain a policy statement with the iot:CreateProvisioningClaim action, copy the following statement snippet and paste it as an additional entry in the Statement array in the policy document.

    **Note**
    This snippet must be placed before the closing ] character in the Statement array. You might need to add a comma before or after this snippet to correct any syntax errors.

    ```json
    {
        "Effect": "Allow",
        "Action": ["iot:CreateProvisioningClaim"],
        "Resource": ["--PUT YOUR NEW TEMPLATE ARN HERE--"]
    }
    ```

8. Switch to the page in the AWS IoT console where you chose Modify user role permissions.
10. Switch back to the IAM console.
11. Paste the copied Amazon Resource Name (ARN) at the top of the list of template ARNs in the Statement array so that it's the first entry.

    If this is the only ARN in the array, remove the comma at end of the value you just pasted.
12. Review the updated policy statement and correct any errors indicated by the editor.
14. Review the policy and then choose Save changes.
15. Return to the AWS IoT console.

---

**Device provisioning MQTT API**

The Fleet Provisioning service supports these MQTT API operations:

- the section called “CreateCertificateFromCsr” (p. 880)
- the section called “CreateKeysAndCertificate” (p. 881)
- the section called “RegisterThing” (p. 883)

This API supports response buffers in Concise Binary Object Representation (CBOR) format and JavaScript Object Notation (JSON), depending on the `payload-format` of the topic. For the sake of clarity, however, the response and request examples in this section are shown in JSON format.

<table>
<thead>
<tr>
<th>payload-format</th>
<th>Response format data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>cbor</td>
<td>Concise Binary Object Representation (CBOR)</td>
</tr>
<tr>
<td>json</td>
<td>JavaScript Object Notation (JSON)</td>
</tr>
</tbody>
</table>
Important
Before publishing a request message topic, subscribe to the response topics to receive the response. The messages used by this API use MQTT's publish/subscribe protocol to provide a request and response interaction.
If you do not subscribe to the response topics before you publish a request, you might not receive the results of that request.

CreateCertificateFromCsr

Creates a certificate from a certificate signing request (CSR). AWS IoT provides client certificates that are signed by the Amazon Root certificate authority (CA). The new certificate has a PENDING_ACTIVATION status. When you call RegisterThing to provision a thing with this certificate, the certificate status changes to ACTIVE or INACTIVE as described in the template.

For more information on creating a client certificate using your Certificate Authority certificate and a certificate signing request, refer to Create a client certificate using your CA certificate (p. 310).

Note
For security, the certificateOwnershipToken returned by CreateCertificateFromCsr (p. 880) expires after one hour. RegisterThing (p. 883) must be called before the certificateOwnershipToken expires. If the certificate created by CreateCertificateFromCsr (p. 880) has not been activated and has not been attached to a policy or a thing by the time the token expires, the certificate is deleted. If the token expires, the device can call CreateCertificateFromCsr (p. 880) to generate a new certificate.

CreateCertificateFromCsr request

Publish a message with the $aws/certificates/create-from-csr/payload-format topic.

payload-format
The message payload format as cbor or json.

CreateCertificateFromCsr request payload

```json
{
    "certificateSigningRequest": "string"
}
```

certificateSigningRequest
The CSR, in PEM format.

CreateCertificateFromCsr response

Subscribe to $aws/certificates/create-from-csr/payload-format/accepted.

payload-format
The message payload format as cbor or json.

CreateCertificateFromCsr response payload

```json
{
}
```
CreateKeysAndCertificate

Creates new keys and a certificate. AWS IoT provides client certificates that are signed by the Amazon Root certificate authority (CA). The new certificate has a PENDING_ACTIVATION status. When you call RegisterThing to provision a thing with this certificate, the certificate status changes to ACTIVE or INACTIVE as described in the template.

Note

For security, the certificateOwnershipToken returned by CreateKeysAndCertificate (p. 881) expires after one hour. RegisterThing (p. 883) must be called before the certificateOwnershipToken expires. If the certificate created by CreateKeysAndCertificate (p. 881)
has not been activated and has not been attached to a policy or a thing by the time
the token expires, the certificate is deleted. If the token expires, the device can call
CreateKeysAndCertificate (p. 881) to generate a new certificate.

CreateKeysAndCertificate request

Publish a message on $aws/certificates/create/payload-format with an empty message
payload.

payload-format

The message payload format as cbor or json.

CreateKeysAndCertificate response

Subscribe to $aws/certificates/create/payload-format/accepted.

payload-format

The message payload format as cbor or json.

CreateKeysAndCertificate response

```json
{
  "certificateId": "string",
  "certificatePem": "string",
  "privateKey": "string",
  "certificateOwnershipToken": "string"
}
```

certificateId

The certificate ID.
certificatePem

The certificate data, in PEM format.
privateKey

The private key.
certificateOwnershipToken

The token to prove ownership of the certificate during provisioning.

CreateKeysAndCertificate error

To receive error responses, subscribe to $aws/certificates/create/payload-format/rejected.

payload-format

The message payload format as cbor or json.

CreateKeysAndCertificate error payload

```json
{
}
```
RegisterThing

Provisions a thing using a pre-defined template.

RegisterThing request

Publish a message on $aws/provisioning-templates/templateName/provision/payload-format.

payload-format

The message payload format as cbor or json.

TemplateName

The provisioning template name.

RegisterThing request payload

{  "certificateOwnershipToken": "string",  "parameters": {    "string": "string",    ...  } }

certificateOwnershipToken

The token to prove ownership of the certificate. The token is generated by AWS IoT when you create a certificate over MQTT.

parameters

Optional. Key-value pairs from the device that are used by the pre-provisioning hooks (p. 874) to evaluate the registration request.

RegisterThing response

Subscribe to $aws/provisioning-templates/templateName/provision/payload-format/accepted.
payload-format

   The message payload format as cbor or json.

templateName

   The provisioning template name.

RegisterThing response payload

```
{
   "deviceConfiguration": {
      "string": "string",
      ...
   },
   "thingName": "string"
}
```

deviceConfiguration

   The device configuration defined in the template.

thingName

   The name of the IoT thing created during provisioning.

RegisterThing error response

To receive error responses, subscribe to $aws/provisioning-templates/templateName/provision/payload-format/rejected.

payload-format

   The message payload format as cbor or json.

templateName

   The provisioning template name.

RegisterThing error response payload

```
{
   "statusCode": int,
   "errorCode": "string",
   "errorMessage": "string"
}
```

statusCode

   The status code.

errorCode

   The error code.

errorMessage

   The error message.
Fleet indexing

You can use fleet indexing to index, search, and aggregate your devices’ data from the following sources: AWS IoT registry (p. 269), AWS IoT Device Shadow (p. 657), AWS IoT connectivity (p. 1219), AWS IoT Device Management Software Package Catalog (p. 1168), and AWS IoT Device Defender (p. 929) violations. You can query a group of devices, and aggregate statistics on device records that are based on different combinations of device attributes, including state, connectivity, and device violations. With fleet indexing, you can organize, investigate, and troubleshoot your fleet of devices.

Fleet indexing provides the following capabilities.

Managing index updates

You can set up a fleet index to index updates for your thing groups, thing registries, device shadows, device connectivity, and device violations. When you activate fleet indexing, AWS IoT creates an index for your things or thing groups. AWS_Things is the index created for all of your things. AWS_ThingGroups is the index that contains all of your thing groups. After fleet indexing is active, you can run queries on your index. For example, you can find all devices that are handheld and have more than 70 percent battery life. AWS IoT updates the index continually with your latest data. For more information, see Managing fleet indexing (p. 886).

Searching across data sources

You can create a query string based on a query language (p. 905) and use it to search across data sources. You can configure data sources in the fleet indexing setting. The query string describes the things that you want to find. You can create queries by using AWS managed fields, custom fields, and any attributes from your indexed data sources. For more information about data sources that support fleet indexing, see Managing thing indexing (p. 889).

Querying for aggregate data

You can search your devices for aggregate data and return statistics, percentile, cardinality, or a list of things with search queries about particular fields. You can run aggregations on AWS managed fields or any attributes you configure as custom fields within fleet indexing settings. For more information about aggregation query, see Querying for aggregate data (p. 899).

Monitoring aggregate data and creating alarms by using fleet metrics

You can use fleet metrics to send aggregate data to CloudWatch automatically, analyze trends, and create alarms to monitor the aggregate state of your fleet based on pre-defined thresholds. For more information about fleet metrics, see Fleet metrics (p. 909).
Managing fleet indexing

Fleet indexing manages two types of indexes for you: thing indexing and thing group indexing.

**Thing indexing**

The index created for all of your things is called **AWS_Things**. Thing indexing supports the following data sources: **AWS IoT registry (p. 269)** data, **AWS IoT Device Shadow (p. 657)** data, **AWS IoT connectivity (p. 1219)** data, and **AWS IoT Device Defender (p. 929)** violations data. By adding these data sources to your fleet indexing configuration, you can search for things, query for aggregate data, and create dynamic thing groups and fleet metrics based on your search queries.

**Registry**—AWS IoT provides a registry that helps you manage things. You can add the registry data to your fleet indexing configuration to search for devices based on the thing names, descriptions, and other registry attributes. For more information about the registry, see [How to manage things with the registry (p. 269)].

**Shadow**—The **AWS IoT Device Shadow service (p. 657)** provides shadows that help you store your device state data. Thing indexing supports both classic unnamed shadows and named shadows. To index named shadows, activate your named shadow settings and specify your shadow names in thing indexing configuration. By default, you can add up to 10 shadow names per AWS account. To see how to increase the number of shadow names limit, see [AWS IoT Device Management Quotas] in the AWS General Reference.

To add named shadows for indexing:

- If you use the **AWS IoT console**, turn on **Thing indexing**, choose **Add named shadows**, and add your shadow names through **Named shadow selection**.
- If you use the **AWS Command Line Interface (AWS CLI)**, set `namedShadowIndexingMode` to be **ON**, and specify shadow names in **IndexingFilter**. To see example CLI commands, see [Manage thing indexing (p. 889)].

**Important**

July 20, 2022 is the General Availability (GA) release of the AWS IoT Device Management fleet indexing integration with AWS IoT Core named shadows and AWS IoT Device Defender detect violations. With this GA release, you can index specific named shadows by specifying shadow names. If you added your named shadows for indexing during this feature's public preview period from November 30, 2021 to July 19, 2022, we encourage you to reconfigure your fleet indexing settings and choose specific shadow names to reduce indexing cost and optimize performance.

For more information about shadows, see [AWS IoT Device Shadow service (p. 657)].

**Connectivity**—Device connectivity data helps you identify the connection status of your devices. This connectivity data is driven by **lifecycle events (p. 1219)**. When a client connects or disconnects, AWS IoT publishes lifecycle events with messages to MQTT topics. A connect or disconnect message can be a list of JSON elements that provide details of the connection status. For more information about device connectivity, see [Lifecycle events (p. 1219)].

**Device Defender violations**—AWS IoT Device Defender violations data helps identify anomalous device behaviors against the normal behaviors that you define in a Security Profile. A Security Profile contains a set of expected device behaviors. Each behavior uses a metric that specifies the normal behavior of your devices. For more information about Device Defender violations, see [AWS IoT Device Defender Detect (p. 1031)].

For more information, see [Managing thing indexing (p. 889)].
Thing group indexing

AWS_ThingGroups is the index that contains all of your thing groups. You can use this index to search for groups based on group name, description, attributes, and all parent group names.

For more information, see Managing thing group indexing (p. 898).

Managed fields

Managed fields contain data associated with things, thing groups, device shadows, device connectivity, and Device Defender violations. AWS IoT defines the data type in managed fields. You specify the values of each managed field when you create an AWS IoT thing. For example, thing names, thing groups, and thing descriptions are all managed fields. Fleet indexing indexes managed fields based on the indexing mode that you specify. Managed fields can't be changed or appear in customFields. For more information, see Custom fields (p. 888).

The following lists managed fields for thing indexing:

- Managed fields for the registry

```
"managedFields" : [
  {name:thingId, type:String},
  {name:thingName, type:String},
  {name:registry.version, type:Number},
  {name:registry.thingTypeName, type:String},
  {name:registry.thingGroupNames, type:String},
]
```

- Managed fields for classic unnamed shadows

```
"managedFields" : [
  {name:shadow.version, type:Number},
  {name:shadow.hasDelta, type:Boolean}
]
```

- Managed fields for named shadows

```
"managedFields" : [
  {name:shadow.name.shadowName.version, type:Number},
  {name:shadow.name.shadowName.hasDelta, type:Boolean}
]
```

- Managed fields for thing connectivity

```
"managedFields" : [
  {name:connectivity.timestamp, type:Number},
  {name:connectivity.version, type:Number},
  {name:connectivity.connected, type:Boolean},
  {name:connectivity.disconnectReason, type:String}
]
```

- Managed fields for Device Defender

```
"managedFields" : [
  {name:deviceDefender.violationCount, type:Number},
  {name:deviceDefender.securityprofile.behaviorname.metricName, type:String},
  {name:deviceDefender.securityprofile.behaviorname.lastViolationTime, type:Number},
  {name:deviceDefender.securityprofile.behaviorname.lastViolationValue, type:String},
  {name:deviceDefender.securityprofile.behaviorname.inViolation, type:Boolean}
]`
Custom fields

You can aggregate thing attributes, Device Shadow data, and Device Defender violations data by creating custom fields to index them. The customFields attribute is a list of field name and data type pairs. You can perform aggregation queries based on data type. The indexing mode that you choose affects fields can be specified in customFields. For example, if you specify the REGISTRY indexing mode, you can't specify a custom field from a thing shadow. You can use the update-indexing-configuration CLI command to create or update the custom fields (see an example command in Updating indexing configuration examples (p. 891)).

- Custom field names

Custom field names for thing and thing group attributes begin with attributes., followed by the attribute name. If unnamed shadow indexing is on, things can have custom field names that begin with shadow.desired or shadow.reported, followed by the unnamed shadow data value name. If named shadow indexing is on, things can have custom field names that begin with shadow.name.*.desired. or shadow.name.*.reported., followed by the named shadow data value. If Device Defender violations indexing is on, things can have custom field names that begin with deviceDefender., followed by the Device Defender violations data value.

The attribute or data value name that follows the prefix can have only alphanumerics, - (hyphen), and _ (underscore) characters. It can't have any spaces.

If there’s a type inconsistency between a custom field in your configuration and the value being indexed, fleet indexing ignores the inconsistent value for aggregation queries. CloudWatch Logs are helpful when troubleshooting aggregation query problems. For more information, see Troubleshooting aggregation queries for the fleet indexing service (p. 1447).

- Custom field types
Custom field types have the following supported values: Number, String, and Boolean.

## Manage thing indexing

The index created for all of your things is AWS_Things. You can control what to index from the following data sources: AWS IoT registry (p. 269) data, AWS IoT Device Shadow (p. 657) data, AWS IoT connectivity (p. 1219) data, and AWS IoT Device Defender (p. 929) violations data.

### Enabling thing indexing

You use the `update-indexing-configuration` CLI command or the `UpdateIndexingConfiguration` API operation to create the AWS_Things index and control its configuration. By using the `--thing-indexing-configuration` (thingIndexingConfiguration) parameter, you control what kind of data (for example, registry, shadow, device connectivity data, and Device Defender violations data) is indexed.

The `--thing-indexing-configuration` parameter takes a string with the following structure:

```json
{
    "thingIndexingMode": "OFF"|"REGISTRY"|"REGISTRY_AND_SHADOW",
    "thingConnectivityIndexingMode": "OFF"|"STATUS",
    "deviceDefenderIndexingMode": "OFF"|"VIOLATIONS",
    "namedShadowIndexingMode": "OFF"|"ON",
    "managedFields": [
        {
            "name": "string",
            "type": "Number"|"String"|"Boolean"
        },
        ...
    ],
    "customFields": [
        {
            "name": "string",
            "type": "Number"|"String"|"Boolean"
        },
        ...
    ],
    "filter": {
        "namedShadowNames": [ "string" ]
    }
}
```

### Thing indexing mode

The `thingIndexingMode` attribute controls what kind of data is indexed.

**Important**

To activate thing indexing, the `thingIndexingMode` attribute can't be set to be OFF.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Valid values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>thingIndexingMode</td>
<td>OFF, REGISTRY, REGISTRY_AND_SHADOW</td>
<td>No indexing. Index registry and thing shadow data.</td>
</tr>
<tr>
<td></td>
<td>REGISTRY</td>
<td>Index registry data.</td>
</tr>
</tbody>
</table>

The `thingConnectivityIndexingMode` attribute specifies if thing connectivity data is indexed.
<table>
<thead>
<tr>
<th>Attribute</th>
<th>Valid values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>thingConnectivityIndexingMode</td>
<td>Not specified.</td>
<td>The thing connectivity data isn't indexed.</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>The thing connectivity data isn't indexed.</td>
</tr>
<tr>
<td></td>
<td>STATUS</td>
<td>The thing connectivity data is indexed.</td>
</tr>
</tbody>
</table>

The `deviceDefenderIndexingMode` attribute specifies if Device Defender violations data is indexed.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Valid values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>deviceDefenderIndexingMode</td>
<td>Not specified.</td>
<td>Device Defender violations data isn't indexed.</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>Device Defender violations data isn't indexed.</td>
</tr>
<tr>
<td></td>
<td>VIOLATIONS</td>
<td>Device Defender violations data is indexed.</td>
</tr>
</tbody>
</table>

The `namedShadowIndexingMode` attribute specifies if named shadow data is indexed.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Valid values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>namedShadowIndexingMode</td>
<td>Not specified.</td>
<td>Named shadow data isn't indexed.</td>
</tr>
<tr>
<td></td>
<td>OFF</td>
<td>Named shadow data isn't indexed.</td>
</tr>
<tr>
<td></td>
<td>ON</td>
<td>Named shadow data is indexed.</td>
</tr>
</tbody>
</table>

**Note**
To select named shadows to add to your fleet indexing configuration, set `namedShadowIndexingMode` to be `ON` and specify your named shadow names in `filter`.

**Managed fields and custom fields**

**Managed fields**

Managed fields contain data associated with things, thing groups, device shadows, device connectivity, and Device Defender violations. AWS IoT defines the data type in managed fields. You specify the values of each managed field when you create an AWS IoT thing. For example, thing names, thing groups, and thing descriptions are all managed fields. Fleet indexing indexes managed fields based on the indexing mode that you specify. Managed fields can't be changed or appear in `customFields`.

**Custom fields**

You can aggregate attributes, Device Shadow data, and Device Defender violations data by creating custom fields to index them. The `customFields` attribute is a list of field name and data type pairs.
You can perform aggregation queries based on data type. The indexing mode that you choose affects fields can be specified in customFields. For example, if you specify the REGISTRY indexing mode, you can't specify a custom field from a thing shadow. You can use the update-indexing-configuration CLI command to create or update the custom fields (see an example command in Updating indexing configuration examples (p. 891)). For more information, see Custom fields (p. 888).

### Updating indexing configuration examples

You can use the AWS IoT update-indexing-configuration CLI command to update your indexing configuration. The following examples show how to use update-indexing-configuration.

**Short syntax:**

```bash
aws iot update-indexing-configuration --thing-indexing-configuration \\
'thingIndexingMode=REGISTRY_AND_SHADOW,deviceDefenderIndexingMode=VIOLATIONS,namedShadowIndexingMode=ON,filter={namedShadowNames=[thing1shadow]},thingConnectivityIndexingMode=STATUS,customFields=[\{name=attributes.version,type=Number\},\{name=shadow.name.thing1shadow.desired.DefaultDesired,type=String\},\{name=shadow.desired.power, type=Boolean\},\{name=deviceDefender.securityProfile1.NUMBER_VALUE_BEHAVIOR.lastViolationValue.number, type=Number\}]'
```

**JSON syntax:**

```json
aws iot update-indexing-configuration --cli-input-json ' {
   "thingIndexingConfiguration": {"thingIndexingMode": "REGISTRY_AND_SHADOW", "thingConnectivityIndexingMode": "STATUS", "deviceDefenderIndexingMode": "VIOLATIONS", "namedShadowIndexingMode": "ON", "filter": {"namedShadowNames": ["thing1shadow"]}, "customFields": [ {"name": "shadow.name.thing1shadow.desired.DefaultDesired", "type": "String"}, {"name": "shadow.desired.power", "type": "Boolean"}, {"name": "attributes.version", "type": "Number"}, {"name": "deviceDefender.securityProfile1.NUMBER_VALUE_BEHAVIOR.lastViolationValue.number", "type": "Number"} ] }'
```

This command doesn't produce any output.

To check the thing index status, run the describe-index CLI command:

```bash
aws iot describe-index --index-name "AWS_Things"
```

The output of the describe-index command looks like the following:

```json
{
   "indexName": "AWS_Things",
   "indexStatus": "ACTIVE",
   "schema": "MULTI_INDEXING_MODE"
}
```

**Note**

It can take a moment for fleet indexing to update the fleet index. We recommend waiting until the indexStatus shows ACTIVE before using it. You can have different values in the schema field depending on what data sources you've configured. For more information, see Describing a thing index (p. 893).

To get your thing indexing configuration details, run the get-indexing-configuration CLI command:
aws iot get-indexing-configuration

The output of the `get-indexing-configuration` command looks like the following:

```json
{
    "thingIndexingConfiguration": {
        "thingIndexingMode": "REGISTRY_AND_SHADOW",
        "thingConnectivityIndexingMode": "STATUS",
        "deviceDefenderIndexingMode": "VIOLATIONS",
        "namedShadowIndexingMode": "ON",
        "managedFields": [
            {
                "name": "connectivity.disconnectReason",
                "type": "String"
            },
            {
                "name": "registry.version",
                "type": "Number"
            },
            {
                "name": "thingName",
                "type": "String"
            },
            {
                "name": "deviceDefender.violationCount",
                "type": "Number"
            },
            {
                "name": "shadow.hasDelta",
                "type": "Boolean"
            },
            {
                "name": "shadow.name.*.version",
                "type": "Number"
            },
            {
                "name": "shadow.version",
                "type": "Number"
            },
            {
                "name": "connectivity.version",
                "type": "Number"
            },
            {
                "name": "connectivity.timestamp",
                "type": "Number"
            },
            {
                "name": "shadow.name.*.hasDelta",
                "type": "Boolean"
            },
            {
                "name": "registry.thingTypeName",
                "type": "String"
            },
            {
                "name": "thingId",
                "type": "String"
            },
            {
                "name": "connectivity.connected",
                "type": "Boolean"
            }
        ]
    }
}
```
To update the custom fields, you can run the `update-indexing-configuration` command. An example is as follows:

```bash
code
aws iot update-indexing-configuration --thing-indexing-configuration
'thingIndexingMode=REGISTRY_AND_SHADOW,customFields=[[name=attributes.version,type=Number],
{name=attributes.color,type=String},
{name=shadow.desired.power,type=Boolean},
{name=shadow.desired.intensity,type=Number]]'
```

This command added `shadow.desired.intensity` to the indexing configuration.

**Note**
Updating the custom field indexing configuration overwrites all existing custom fields. Make sure to specify all custom fields when calling `update-indexing-configuration`.

After the index is rebuilt, you can use an aggregation query on the newly added fields, search registry data, shadow data, and thing connectivity status data.

When changing the indexing mode, make sure all of your custom fields are valid by using the new indexing mode. For example, if you start off using `REGISTRY_AND_SHADOW` mode with a custom field called `shadow.desired.temperature`, you must delete the `shadow.desired.temperature` custom field before changing the indexing mode to `REGISTRY`. If your indexing configuration contains custom fields that aren't indexed by the indexing mode, the update fails.

**Describing a thing index**

The following command shows you how to use the `describe-index` CLI command to retrieve the current status of the thing index.
The first time that you fleet indexing, AWS IoT builds your index. When `indexStatus` is in the `BUILDING` state, you can't query the index. The schema for the things index indicates which type of data (REGISTRY_AND_SHADOW_AND_CONNECTIVITY_STATUS) is indexed.

Changing the configuration of your index causes the index to be rebuilt. During this process, the `indexStatus` is `REBUILDING`. You can run queries on data in the things index while it's being rebuilt. For example, if you change the index configuration from REGISTRY to REGISTRY_AND_SHADOW while the index is being rebuilt, you can query registry data, including the latest updates. However, you can't query the shadow data until the rebuild is complete. The amount of time it takes to build or rebuild the index depends on the amount of data.

You can see different values in the schema field depending on the data sources that you've configured. The following table shows the different schema values and the corresponding descriptions:

<table>
<thead>
<tr>
<th>Schema</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>No data sources are configured or indexed.</td>
</tr>
<tr>
<td>REGISTRY</td>
<td>Registry data is indexed.</td>
</tr>
<tr>
<td>REGISTRY_AND_SHADOW</td>
<td>Registry data and unnamed (classic) shadow data are indexed.</td>
</tr>
<tr>
<td>REGISTRY_AND_CONNECTIVITY</td>
<td>Registry data and connectivity data are indexed.</td>
</tr>
<tr>
<td>REGISTRY_AND_SHADOW_AND_CONNECTIVITY_STATUS</td>
<td>Registry data, unnamed (classic) shadow data, and connectivity data are indexed.</td>
</tr>
<tr>
<td>MULTI_INDEXING_MODE</td>
<td>Named shadow or Device Defender violations data is indexed, in addition to registry, unnamed (classic) shadow or connectivity data.</td>
</tr>
</tbody>
</table>

### Querying a thing index

Use the `search-index` CLI command to query data in the index.

```
aws iot search-index --index-name "AWS_Things" --query-string "thingName:mything*"
```

```
{
  "things": [
    {
      "thingName": "mything1",
      "thingGroupName": [
        "mygroup1"
      ]
    }
  ]
}
```
"thingId":"a4b9f759-b0f2-4857-8a4b-967745ed9f4e",
"attributes":{
    "attribute1":"abc"
},
"connectivity": {
    "connected":false,
    "timestamp":1556649874716,
    "disconnectReason": "CONNECTION_LOST"
}
},
{
"thingName":"mything2",
"thingTypeName":"MyThingType",
"thingGroupNames": ["mygroup1", "mygroup2"],
"thingId":"01014ef9-e97e-44c6-985a-d0b06924f2af",
"attributes":{
    "model":"1.2",
    "country":"usa"
},
"shadow":{
    "desired":{
        "location":"new york",
        "myvalues":[3, 4, 5]
    },
    "reported":{
        "location":"new york",
        "myvalues":[1, 2, 3],
        "stats":{
            "battery":78
        }
    }
},
"metadata":{
    "desired":{
        "location":{
            "timestamp":123456789
        },
        "myvalues":{
            "timestamp":123456789
        }
    },
    "reported":{
        "location":{
            "timestamp":34535454
        },
        "myvalues":{
            "timestamp":34535454
        },
        "stats":{
            "battery":{
                "timestamp":34535454
            }
        }
    }
},
"version":10,
"timestamp":34535454
},
"connectivity": {
    "connected":true,
    "timestamp":1556649855046
}
]
,"nextToken":"AQFCuvk7zZ3D9pOYMbFCeHbdZ+h=G"
In the JSON response, "connectivity" (as enabled by the thingConnectivityIndexingMode=STATUS setting) provides a Boolean value, a timestamp, and a disconnectReason that indicates whether the device is connected to AWS IoT Core. The device "mything1" disconnected (false) at POSIX time 1556649874716 due to CONNECTION_LOST. For more information about disconnect reasons, see Lifecycle events (p. 1219).

```json
"connectivity": {
  "connected":false,
  "timestamp":1556649874716,
  "disconnectReason": "CONNECTION_LOST"
}
```

The device "mything2" connected (true) at POSIX time 1556649855046:

```json
"connectivity": {
  "connected":true,
  "timestamp":1556649855046
}
```

Timestamps are given in milliseconds since epoch, so 1556649855046 represents 6:44:15.046 PM on Tuesday, April 30, 2019 (UTC).

**Important**

If a device has been disconnected for approximately an hour, the "timestamp" value and the "disconnectReason" value of the connectivity status might be missing.

## Restrictions and limitations

These are the restrictions and limitations for AWS_Things.

### Shadow fields with complex types

A shadow field is indexed only if the value of the field is a simple type, such as a JSON object that doesn't contain an array, or an array that consists entirely of simple types. Simple type means a string, number, or one of the literals true or false. For example, given the following shadow state, the value of field "palette" isn't indexed because it's an array that contains items of complex types. The value of field "colors" is indexed because each value in the array is a string.

```json
{
  "state": {
    "reported": {
      "switched": "ON",
      "colors": [ "RED", "GREEN", "BLUE" ],
      "palette": [
        {
          "name": "RED",
          "intensity": 124
        },
        {
          "name": "GREEN",
          "intensity": 68
        },
        {
          "name": "BLUE",
          "intensity": 201
        }
      ]
    }
  }
}
```
Nested shadow field names

The names of nested shadow fields are stored as a period (.) delimited string. For example, given a shadow document:

```json
{
    "state": {
        "desired": {
            "one": {
                "two": {
                    "three": "v2"
                }
            }
        }
    }
}
```

The name of field `three` is stored as `desired.one.two.three`. If you also have a shadow document, it's stored like this:

```json
{
    "state": {
        "desired": {
            "one.two.three": "v2"
        }
    }
}
```

Both match a query for `shadow.desired.one.two.three:v2`. As a best practice, don't use periods in shadow field names.

Shadow metadata

A field in a shadow's metadata section is indexed, but only if the corresponding field in the shadow's "state" section is indexed. (In the previous example, the "palette" field in the shadow's metadata section isn't indexed either.)

Unregistered devices

Fleet indexing indexes the connectivity status for a device whose connection `clientId` is the same as the `thingName` of a registered thing in `Registry`.

Unregistered shadows

If you use `UpdateThingShadow` to create a shadow using a thing name that hasn't been registered in your AWS IoT account, fields in this shadow aren't indexed. This applies to both classic unnamed shadow and named shadow.

Numeric values

If any registry or shadow data is recognized by the service as a numeric value, it's indexed as such. You can form queries involving ranges and comparison operators on numeric values (for example, "attribute.foo<5" or "shadow.reported.foo:[75 TO 80]"). To be recognized as numeric, the value of the data must be a valid, literal type JSON number. The value can be an integer in the range $-2^{53}...2^{53}-1$, a double-precision floating point with optional exponential notation, or part of an array that contains only these values.

Null values

Null values aren't indexed.
Maximum values

- The maximum number of custom fields for aggregation queries is 5.
- The maximum number of requested percentiles for aggregation queries is 100.

Authorization

You can specify the things index as an Amazon Resource Name (ARN) in an AWS IoT policy action, as follows.

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>iot:DescribeIndex</code></td>
<td>An index ARN (for example, <code>arn:aws:iot:your-aws-region:index/AWS_Things</code>).</td>
</tr>
</tbody>
</table>

Note

- If you have permissions to query the fleet index, you can access the data of things across the entire fleet.

Manage thing group indexing

AWS_ThingGroups is the index that contains all of your thing groups. You can use this index to search for groups based on group name, description, attributes, and all parent group names.

Enabling thing group indexing

You can use the `thing-group-indexing-configuration` setting in the `UpdateIndexingConfiguration` API to create the AWS_ThingGroups index and control its configuration. You can use the `GetIndexingConfiguration` API to retrieve the current indexing configuration.

To update the thing group indexing configurations, run the `update-indexing-configuration` CLI command:

```
aws iot update-indexing-configuration --thing-group-indexing-configuration thingGroupIndexingMode=ON
```

You can also update configurations for both thing and thing group indexing in a single command, as follows:

```
aws iot update-indexing-configuration --thing-indexing-configuration thingIndexingMode=REGISTRY --thing-group-indexing-configuration thingGroupIndexingMode=ON
```

The following are valid values for `thingGroupIndexingMode`.

- OFF: No indexing/delete index.
- ON: Create or configure the AWS_ThingGroups index.
To retrieve the current thing and thing group indexing configurations, run the `get-indexing-configuration` CLI command:

```
aws iot get-indexing-configuration
```

The response of the command looks like the following:

```json
{
   "thingGroupIndexingConfiguration": {
      "thingGroupIndexingMode": "ON"
   }
}
```

### Describing group indexes

To retrieve the current status of the AWS_ThingGroups index, use the `describe-index` CLI command:

```
aws iot describe-index --index-name "AWS_ThingGroups"
```

The response of the command looks like the following:

```json
[
   "indexStatus": "ACTIVE",
   "indexName": "AWS_ThingGroups",
   "schema": "THING_GROUPS"
]
```

AWS IoT builds your index the first time that you indexing. You can't query the index if the `indexStatus` is BUILDING.

### Querying a thing group index

To query data in the index, use the `search-index` CLI command:

```
aws iot search-index --index-name "AWS_ThingGroups" --query-string "thingGroupName:mythinggroup*"
```

### Authorization

You can specify the thing groups index as a resource ARN in an AWS IoT policy action, as follows.

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource</th>
</tr>
</thead>
<tbody>
<tr>
<td>iot:SearchIndex</td>
<td>An index ARN (for example, arn:aws:iot:<code>your-aws-region:index/AWS_ThingGroups</code>).</td>
</tr>
<tr>
<td>iot:DescribeIndex</td>
<td>An index ARN (for example, arn:aws:iot:<code>your-aws-region:index/AWS_ThingGroups</code>).</td>
</tr>
</tbody>
</table>

### Querying for aggregate data

AWS IoT provides four APIs (GetStatistics, GetCardinality, GetPercentiles, and GetBucketsAggregation) that allow you to search your device fleet for aggregate data.
GetStatistics

The GetStatistics API and the get-statistics CLI command return the count, average, sum, minimum, maximum, sum of squares, variance, and standard deviation for the specified aggregated field.

The get-statistics CLI command takes the following parameters:

index-name

The name of the index to search. The default value is AWS_Things.

query-string

The query used to search the index. You can specify "*" to get the count of all indexed things in your AWS account.

aggregationField

(Optional) The field to aggregate. This field must be a managed or custom field defined when you call update-indexing-configuration. If you don't specify an aggregation field, registry.version is used as the aggregation field.

query-version

The version of the query to use. The default value is 2017-09-30.

The type of aggregation field can affect the statistics returned.

GetStatistics with string values

If you aggregate on a string field, calling GetStatistics returns a count of devices that have attributes that match the query. For example:

```
aws iot get-statistics --aggregation-field 'attributes.stringAttribute'
--query-string '***'
```

This command returns the number of devices that contain an attribute named stringAttribute:

```
{
  "statistics": {
    "count": 3
  }
}
```

GetStatistics with Boolean values

When you call GetStatistics with a Boolean aggregation field:

- AVERAGE is the percentage of devices that match the query.
- MINIMUM is 0 or 1 according to the following rules:
  - If all the values for the aggregation field are false, MINIMUM is 0.
  - If all the values for the aggregation field are true, MINIMUM is 1.
  - If the values for the aggregation field are a mixture of false and true, MINIMUM is 0.
- MAXIMUM is 0 or 1 according to the following rules:
• If all the values for the aggregation field are false, MAXIMUM is 0.
• If all the values for the aggregation field are true, MAXIMUM is 1.
• If the values for the aggregation field are a mixture of false and true, MAXIMUM is 1.
• SUM is the sum of the integer equivalent of the Boolean values.
• COUNT is the count of things that match the query string criteria and contain a valid aggregation field value.

**GetStatistics with numerical values**

When you call GetStatistics and specify an aggregation field of type Number, GetStatistics returns the following values:

- **count**
  - The count of things that match the query string criteria and contain a valid aggregation field value.
- **average**
  - The average of the numerical values that match the query.
- **sum**
  - The sum of the numerical values that match the query.
- **minimum**
  - The smallest of the numerical values that match the query.
- **maximum**
  - The largest of the numerical values that match the query.
- **sumOfSquares**
  - The sum of the squares of the numerical values that match the query.
- **variance**
  - The variance of the numerical values that match the query. The variance of a set of values is the average of the squares of the differences of each value from the average value of the set.
- **stdDeviation**
  - The standard deviation of the numerical values that match the query. The standard deviation of a set of values is a measure of how spread out the values are.

The following example shows how to call **get-statistics** with a numerical custom field.

```bash
aws iot get-statistics --aggregation-field 'attributes.numericAttribute2' --query-string '*'
```

```json
{
  "statistics": {
    "count": 3,
    "average": 33.333333333333336,
    "sum": 100.0,
    "minimum": -125.0,
    "maximum": 150.0,
    "sumOfSquares": 43750.0,
    "variance": 13472.22222222222,
    "stdDeviation": 116.06990230986766
  }
}
```
For numerical aggregation fields, if the field values exceed the maximum double value, the statistics values are empty.

**GetCardinality**

The `GetCardinality` API and the `get-cardinality` CLI command return the approximate count of unique values that match the query. For example, you might want to find the number of devices with battery levels at less than 50 percent:

```
aws iot get-cardinality --index-name AWS_Things --query-string "batterylevel > 50" --aggregation-field "shadow.reported.batterylevel"
```

This command returns the number of things with battery levels at more than 50 percent:

```
{
   "cardinality": 100
}
```

cardinality is always returned by `get-cardinality` even if there are no matching fields. For example:

```
aws iot get-cardinality --query-string "thingName:Non-existent*" --aggregation-field "attributes.customField_STR"
```

```
{
   "cardinality": 0
}
```

The `get-cardinality` CLI command takes the following parameters:

- **index-name**: The name of the index to search. The default value is `AWS_Things`.
- **query-string**: The query used to search the index. You can specify "*" to get the count of all indexed things in your AWS account.
- **aggregationField**: The field to aggregate.
- **query-version**: The version of the query to use. The default value is `2017-09-30`.

**GetPercentiles**

The `GetPercentiles` API and the `get-percentiles` CLI command groups the aggregated values that match the query into percentile groupings. The default percentile groupings are: 1, 5, 25, 50, 75, 95, 99, although you can specify your own when you call `GetPercentiles`. This function returns a value for each percentile group specified (or the default percentile groupings). The percentile group "1" contains the aggregated field value that occurs in approximately one percent of the values that match the query. The percentile group "5" contains the aggregated field value that occurs in approximately five percent of the values that match the query, and so on. The result is an approximation, the more values that match the query, the more accurate the percentile values.
The following example shows how to call the `get-percentiles` CLI command.

```bash
aws iot get-percentiles --query-string "thingName:*" --aggregation-field "attributes.customField_NUM" --percents 10 20 30 40 50 60 70 80 90 99
```

```json
{
  "percentiles": [
    {
      "value": 3.0,
      "percent": 80.0
    },
    {
      "value": 2.5999999999999996,
      "percent": 70.0
    },
    {
      "value": 3.0,
      "percent": 90.0
    },
    {
      "value": 2.0,
      "percent": 50.0
    },
    {
      "value": 2.0,
      "percent": 60.0
    },
    {
      "value": 1.0,
      "percent": 10.0
    },
    {
      "value": 2.0,
      "percent": 40.0
    },
    {
      "value": 1.0,
      "percent": 20.0
    },
    {
      "value": 1.4,
      "percent": 30.0
    },
    {
      "value": 3.0,
      "percent": 99.0
    }
  ]
}
```

The following command shows the output returned from `get-percentiles` when there are no matching documents.

```bash
aws iot get-percentiles --query-string "thingName:Non-existent*"
 --aggregation-field "attributes.customField_NUM"
```

```json
{
  "percentiles": []
}
```

The `get-percentile` CLI command takes the following parameters:
index-name

The name of the index to search. The default value is AWS_Things.

query-string

The query used to search the index. You can specify "*" to get the count of all indexed things in your AWS account.

aggregationField

The field to aggregate, which must be of Number type.

query-version

The version of the query to use. The default value is 2017-09-30.

percents

(Optional) You can use this parameter to specify custom percentile groupings.

GetBucketsAggregation

The GetBucketsAggregation API and the get-buckets-aggregation CLI command return a list of buckets and the total number of things that fit the query string criteria.

The following example shows how to call the get-buckets-aggregation CLI command.

```
aws iot get-buckets-aggregation --query-string '*' --index-name AWS_Things --aggregation-field 'shadow.reported.batterylevelpercent' --buckets-aggregation-type 'termsAggregation={maxBuckets=5}'
```

This command returns the following:

```
{
  "totalCount": 20,
  "buckets": [
    {
      "keyValue": "100",
      "count": 12
    },
    {
      "keyValue": "90",
      "count": 5
    },
    {
      "keyValue": "75",
      "count": 3
    }
  ]
}
```

The get-buckets-aggregation CLI command takes the following parameters:

index-name

The name of the index to search. The default value is AWS_Things.

query-string

The query used to search the index. You can specify "*" to get the count of all indexed things in your AWS account.
aggregation-field

The field to aggregate.

buckets-aggregation-type

The basic control of the response shape and the bucket aggregation type to perform.

Authorization

You can specify the thing groups index as a resource ARN in an AWS IoT policy action, as follows.

<table>
<thead>
<tr>
<th>Action</th>
<th>Resource</th>
</tr>
</thead>
</table>

Query syntax

In fleet indexing, you use a query syntax to specify queries.

Supported features

The query syntax supports the following features:

- Terms and phrases
- Searching fields
- Prefix search
- Range search
- Boolean operators AND, OR, NOT, and -. The hyphen is used to exclude something from search results (for example, thingName:(tv* AND -plasma)).
- Grouping
- Field grouping
- Escaping special characters (such as with \)

Unsupported features

The query syntax doesn't support the following features:

- Leading wildcard search (such as "*xyz"), but searching for "*" matches all things
- Regular expressions
- Boosting
- Ranking
- Fuzzy searches
- Proximity search
- Sorting
- Aggregation
- Special characters: ``, @, #, \, /, ', ;, and ,.
Notes

A few things to note about the query language:

- The default operator is AND. A query for "thingName:abc thingType:xyz" is equivalent to "thingName:abc AND thingType:xyz".
- If a field isn't specified, AWS IoT searches for the term in all the registry, Device Shadow, and Device Defender fields.
- All field names are case sensitive.
- Search is case insensitive. Words are separated by white-space characters as defined by Java's Character.isWhitespace(int).
- Indexing of Device Shadow data (unnamed shadows and named shadows) includes reported, desired, delta, and metadata sections.
- Device shadow and registry versions aren't searchable, but are present in the response.
- The maximum number of terms in a query is twelve.

Example thing queries

Specify queries in a query string using a query syntax. The queries are passed to the SearchIndex API. The following table lists some example query strings.

<table>
<thead>
<tr>
<th>Query string</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>abc</td>
<td>Queries for &quot;abc&quot; in any registry, shadow (classic unnamed shadow and named shadow), or Device Defender violations field.</td>
</tr>
<tr>
<td>thingName:myThingName</td>
<td>Queries for a thing with name &quot;myThingName&quot;.</td>
</tr>
<tr>
<td>thingName:my*</td>
<td>Queries for things with names that begin with &quot;my&quot;.</td>
</tr>
<tr>
<td>thingName:ab?</td>
<td>Queries for things with names that have &quot;ab&quot; plus one additional character (for example, &quot;aba&quot;, &quot;abb&quot;, &quot;abc&quot;, and so on.</td>
</tr>
<tr>
<td>thingTypeName:aa</td>
<td>Queries for things that are associated with type &quot;aa&quot;.</td>
</tr>
<tr>
<td>thingGroupNames:a</td>
<td>Queries for things with a parent thing group name &quot;a&quot;.</td>
</tr>
<tr>
<td>thingGroupNames:a*</td>
<td>Queries for things with a parent thing group name matching the pattern &quot;a*&quot;.</td>
</tr>
<tr>
<td>attributes.myAttribute:75</td>
<td>Queries for things with an attribute named &quot;myAttribute&quot; that has the value 75.</td>
</tr>
<tr>
<td>attributes.myAttribute:[75 TO 80]</td>
<td>Queries for things with an attribute named &quot;myAttribute&quot; that has a value that falls within a numeric range (75–80, inclusive).</td>
</tr>
<tr>
<td>attributes.myAttribute:[75 TO 80]</td>
<td>Queries for things with an attribute named &quot;myAttribute&quot; that has a value that falls within the numeric range (&gt;75 and &lt;=80).</td>
</tr>
<tr>
<td>Query string</td>
<td>Result</td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
</tr>
<tr>
<td>attributes.serialNumber: [&quot;abcd&quot; TO &quot;abcf&quot;]</td>
<td>Queries for things with an attribute named &quot;serialNumber&quot; that has a value within an alphanumeric string range. This query returns things with a &quot;serialNumber&quot; attribute with values &quot;abcd&quot;, &quot;abce&quot;, or &quot;abcf&quot;.</td>
</tr>
<tr>
<td>attributes.myAttribute:i*t</td>
<td>Queries for things with an attribute named &quot;myAttribute&quot; where the value is 'i', followed by any number of characters, followed by 't'.</td>
</tr>
<tr>
<td>attributes.attr1:abc AND attributes.attr2&lt;5 NOT attributes.attr3&gt;10</td>
<td>Queries for things that combine terms using Boolean expressions. This query returns things that have an attribute named &quot;attr1&quot; with a value &quot;abc&quot;, an attribute named &quot;attr2&quot; that's less than 5, and an attribute named &quot;attr3&quot; that's not greater than 10.</td>
</tr>
<tr>
<td>shadow.hasDelta:true</td>
<td>Queries for things with an unnamed shadow that has a delta element.</td>
</tr>
<tr>
<td>NOT attributes.model:legacy</td>
<td>Queries for things where the attribute named &quot;model&quot; is not &quot;legacy&quot;.</td>
</tr>
</tbody>
</table>
| shadow.reported.stats.battery:{70 TO 100} (v2 OR v3) NOT attributes.model:legacy | Queries for things with the following:  
  - The thing's shadow stats.battery attribute has a value between 70 and 100.  
  - The text "v2" or "v3" occurs in a thing's name, type name, or attribute values.  
  - The thing's model attribute is not set to "legacy". |
| shadow.reported.myvalues:2 | Queries for things where the myvalues array in the shadow's reported section contains a value of 2. |
| shadow.reported.location:* NOT shadow.desired.stats.battery:* | Queries for things with the following:  
  - The location attribute exists in the shadow's reported section.  
  - The stats.battery attribute doesn't exist in the shadow's desired section. |
| shadow.name.<shadowName>.hasDelta:true | Queries for things that have a shadow with the given name and also a delta element. |
| shadow.name.<shadowName>.desired.filament:* | Queries for things that have a shadow with the given name and also a desired filament property. |
| shadow.name.<shadowName>.reported.location:* | Queries for things that have a shadow with the given name and where the location attribute exists in the named shadow's reported section. |
| connectivity.connected:true | Queries for all connected devices. |
| connectivity.connected:false | Queries for all disconnected devices. |
Example thing group queries

Queries are specified in a query string using a query syntax and passed to the SearchIndex API. The following table lists some example query strings.

<table>
<thead>
<tr>
<th>Query string</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>abc</td>
<td>Queries for &quot;abc&quot; in any field.</td>
</tr>
<tr>
<td>thingGroupName:myGroupThingName</td>
<td>Queries for a thing group with name &quot;myGroupThingName&quot;.</td>
</tr>
</tbody>
</table>
### Fleet metrics

Fleet metrics is a feature of [fleet indexing](p. 885), a managed service that allows you to index, search, and aggregate your devices’ data in AWS IoT. You can use fleet metrics, to monitor your fleet devices’ aggregate state in [CloudWatch](https://aws.amazon.com/cloudwatch/) over time, including reviewing your fleet devices’ disconnection rate or average battery level changes of a specified period.

<table>
<thead>
<tr>
<th>Query string</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>thingGroupName:my*</td>
<td>Queries for thing groups with names that begin with &quot;my&quot;.</td>
</tr>
<tr>
<td>thingGroupName:ab?</td>
<td>Queries for thing groups with names that have &quot;ab&quot; plus one additional character (for example: &quot;aba&quot;, &quot;abb&quot;, &quot;abc&quot;, and so on).</td>
</tr>
<tr>
<td>attributes.myAttribute:75</td>
<td>Queries for thing groups with an attribute named &quot;myAttribute&quot; that has the value 75.</td>
</tr>
<tr>
<td>attributes.myAttribute:[75 TO 80]</td>
<td>Queries for thing groups with an attribute named &quot;myAttribute&quot; whose value falls within a numeric range (75–80, inclusive).</td>
</tr>
<tr>
<td>attributes.myAttribute:[75 TO 80]</td>
<td>Queries for thing groups with an attribute named &quot;myAttribute&quot; whose value falls within the numeric range (&gt;75 and &lt;=80).</td>
</tr>
<tr>
<td>attributes.myAttribute:[:abcd&quot; TO &quot;abcf&quot;]</td>
<td>Queries for thing groups with an attribute named &quot;myAttribute&quot; whose value is within an alphanumeric string range. This query returns thing groups with a &quot;serialNumber&quot; attribute with values &quot;abcd&quot;, &quot;abce&quot;, or &quot;abcf&quot;.</td>
</tr>
<tr>
<td>attributes.myAttribute:i*t</td>
<td>Queries for thing groups with an attribute named &quot;myAttribute&quot; whose value is 'i', followed by any number of characters, followed by 't'.</td>
</tr>
<tr>
<td>attributes.attr1:abc AND attributes.attr2&lt;5 NOT attributes.attr3&gt;10</td>
<td>Queries for thing groups that combine terms using Boolean expressions. This query returns thing groups that have an attribute named &quot;attr1&quot; with a value &quot;abc&quot;, an attribute named &quot;attr2&quot; that's less than 5, and an attribute named &quot;attr3&quot; that's not greater than 10.</td>
</tr>
<tr>
<td>NOT attributes.myAttribute:cde</td>
<td>Queries for thing groups where the attribute named &quot;myAttribute&quot; is not &quot;cde&quot;.</td>
</tr>
<tr>
<td>parentGroupNames:(myParentThingGroupName)</td>
<td>Queries for thing groups whose parent group name matches &quot;myParentThingGroupName&quot;.</td>
</tr>
<tr>
<td>parentGroupNames:(myParentThingGroupName OR myRootThingGroupName)</td>
<td>Queries for thing groups whose parent group name matches &quot;myParentThingGroupName&quot; or &quot;myRootThingGroupName&quot;.</td>
</tr>
<tr>
<td>parentGroupNames:(myParentThingGroupNameNa*)</td>
<td>Queries for thing groups whose parent group name begins with &quot;myParentThingGroupName&quot;.</td>
</tr>
</tbody>
</table>
Getting started tutorial

In this tutorial, you create a fleet metric (p. 909) to monitor your sensors’ temperatures to detect potential anomalies. When creating the fleet metric, you define an aggregation query (p. 899) that detects the number of sensors with temperatures exceeding 80 degrees Fahrenheit. You specify the query to run every 60 seconds and the query results are emitted to CloudWatch, where you can view the number of sensors that have potential high-temperature risks, and set alarms. To complete this tutorial, you’ll use AWS CLI.

In this tutorial, you’ll learn how to:

- Set up (p. 910)
- Create fleet metrics (p. 912)
- View metrics in CloudWatch (p. 913)
- Clean up resources (p. 914)

This tutorial takes about 15 minutes to complete.

Prerequisites

- Install the latest version of AWS CLI
- Familiarize yourself with Querying for aggregate data
- Familiarize yourself with Using Amazon CloudWatch metrics

Set up

To use fleet metrics, enable fleet indexing. To enable fleet indexing for your things or thing groups with specified data sources and associated configurations, follow the instructions in Managing thing indexing (p. 889) and Managing thing group indexing (p. 898).

To set up

1. Run the following command to enable fleet indexing and specify the data sources to search from.

```bash
aws iot update-indexing-configuration \
--thing-indexing-configuration \
"thingIndexingMode=REGISTRY_AND_SHADOW,customFields=[{name=attributes.temperature,type=Number},\ {name=attributes.rackId,type=String},\ {name=attributes.stateNormal,type=Boolean}],thingConnectivityIndexingMode=STATUS"
```

The preceding example CLI command enables fleet indexing to support searching registry data, shadow data, and thing connectivity status using the AWS_Things index.

The configuration change can take a few minutes to complete. Verify that your fleet indexing is enabled before you create fleet metrics.

To check if your fleet indexing has been enabled, run the following CLI command:

```bash
aws --region us-east-1 iot describe-index --index-name "AWS_Things"
```
2. Run the following bash script to create ten things and describe them.

```bash
# Bash script. Type `bash` before running in other shells.

Temperatures=(70 71 72 73 74 75 47 97 98 99)
Racks=(Rack1 Rack2 Rack3 Rack4 Rack5 Rack6 Rack6 Rack6 Rack6 Rack6)
IsNormal=(true true true true true true false false false false)

for ((i=0; i < 10; i++))
do
  thing=$(aws iot create-thing --thing-name "TempSensor$i" --attribute-payload
          attributes="{temperature=${Temperatures[@]:$i:1},rackId=${Racks[@]:$i:1},stateNormal=${IsNormal[@]:$i:1}}")
  aws iot describe-thing --thing-name "TempSensor$i"
done
```

This script creates ten things to represent ten sensors. Each thing has attributes of `temperature`, `rackId`, and `stateNormal` as described in the following table:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Data type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>temperature</td>
<td>Number</td>
<td>Temperature value in Fahrenheit</td>
</tr>
<tr>
<td>rackId</td>
<td>String</td>
<td>ID of the server rack that contains sensors</td>
</tr>
<tr>
<td>stateNormal</td>
<td>Boolean</td>
<td>Whether the sensor's temperature value is normal or not</td>
</tr>
</tbody>
</table>

The output of this script contains ten JSON files. One of the JSON file looks like the following:

```json
{
  "version": 1,
  "thingName": "TempSensor0",
  "defaultClientId": "TempSensor0",
  "attributes": {
    "rackId": "Rack1",
    "stateNormal": "true",
    "temperature": "70"
  },
  "thingArn": "arn:aws:iot:region:account:thing/TempSensor0",
  "thingId": "example-thing-id"
}
```

For more information, see the [AWS IoT Core Developer Guide](https://docs.aws.amazon.com/iot/core/latest/developerguide/).
Create fleet metrics

To create a fleet metric

1. Run the following command to create a fleet metric named `high_temp_FM`. You create the fleet metric to monitor the number of sensors with temperatures exceeding 80 degrees Fahrenheit in CloudWatch.

   ```bash
   aws iot create-fleet-metric --metric-name "high_temp_FM" --query-string "thingName:TempSensor* AND attributes.temperature >80" --period 60 --aggregation-field "attributes.temperature" --aggregation-type name=Statistics,values=count
   ```

   --metric-name
   Data type: string. The --metric-name parameter specifies a fleet metric name. In this example, you're creating a fleet metric named `high_temp_FM`.

   --query-string
   Data type: string. The --query-string parameter specifies the query string. In this example, the query string means to query all the things with names starting with `TempSensor` and with temperatures higher than 80 degrees Fahrenheit. For more information, see Query syntax (p. 905).

   --period
   Data type: integer. The --period parameter specifies the time to retrieve the aggregated data in seconds. In this example, you specify that the fleet metric you're creating retrieves the aggregated data every 60 seconds.

   --aggregation-field
   Data type: string. The --aggregation-field parameter specifies the attribute to evaluate. In this example, the temperature attribute is to be evaluated.

   --aggregation-type
   The --aggregation-type parameter specifies the statistical summary to display in the fleet metric. For your monitoring tasks, you can customize the aggregation query properties for the different aggregation types (Statistics, Cardinality, and Percentile). In this example, you specify count for the aggregation type and Statistics to return the count of devices that have attributes that match the query, in other words, to return the count of the devices with names starting with `TempSensor` and with temperatures higher than 80 degrees Fahrenheit. For more information, see Querying for aggregate data (p. 899).

   The output of this command looks like the following:

   ```json
   {
     "metricArn": "arn:aws:iot:region:111122223333:fleetmetric/high_temp_FM",
     "metricName": "high_temp_FM"
   }
   ```

   Note
   It can take a moment for the data points to display in CloudWatch.

   To learn more about how to create a fleet metric, read Managing fleet metrics (p. 915).

   If you can't create a fleet metric, read Troubleshooting fleet metrics (p. 1448).

2. (Optional) Run the following command to describe your fleet metric named `high_temp_FM`:
aws iot describe-fleet-metric --metric-name "high_temp_FM"

The output of this command looks like the following:

```
{
  "queryVersion": "2017-09-30",
  "lastModifiedDate": 1625249775.834,
  "queryString": "*",
  "period": 60,
  "metricArn": "arn:aws:iot:region:111122223333:fleetmetric/high_temp_FM",
  "aggregationField": "registry.version",
  "version": 1,
  "aggregationType": {
    "values": [
      "count"
    ],
    "name": "Statistics"
  },
  "indexName": "AWS_Things",
  "creationDate": 1625249775.834,
  "metricName": "high_temp_FM"
}
```

**View fleet metrics in CloudWatch**

After creating the fleet metric, you can view the metric data in CloudWatch. In this tutorial, you will see the metric that shows the number of sensors with names starting with `TempSensor` and with temperatures higher than 80 degrees Fahrenheit.

**To view data points in CloudWatch**

2. On the CloudWatch menu on the left panel, choose **Metrics** to expand the submenu and then choose **All metrics**. This opens the page with the upper half to display the graph and the lower half containing four tabbed sections.
3. The first tabbed section **All metrics** lists all the metrics that you can view in groups, choose **IoT Fleet Metrics**. This contains all of your fleet metrics.
4. On the **Aggregation type** section of the **All metrics** tab, choose **Aggregation type** to view all the fleet metrics you created.
5. Choose the fleet metric to display graph on the left of the **Aggregation type** section. You will see the value `count` to the left of your **Metric name**, and this is the value of the aggregation type that you specified in the [Create fleet metrics (p. 912)](#) section of this tutorial.
6. Choose the second tab named **Graphed metrics** to the right of the **All metrics** tab to view the fleet metric you chose from the previous step.

You should be able to see a graph that displays the number of sensors with temperatures higher than 80 degrees Fahrenheit like the following:
7. (Optional) You can set a metric alarm.

   1. On the CloudWatch menu on the left panel, choose Alarms to expand the submenu and then choose All alarms.
   2. On the Alarms page, choose Create alarm on the upper right corner. Follow the Create alarm instructions in console to create an alarm as needed. For more information, see Using Amazon CloudWatch alarms.

To learn more, read Using Amazon CloudWatch metrics.

If you can't see data points in CloudWatch, read Troubleshooting fleet metrics (p. 1448).

**Clean up**

**To delete fleet metrics**

You use the delete-fleet-metric CLI command to delete fleet metrics.

To delete the fleet metric named high_temp_FM, run the following command.

```bash
aws iot delete-fleet-metric --metric-name "high_temp_FM"
```

**To clean up things**

You use the delete-thing CLI command to delete things.

To delete the ten things that you created, run the following script:
Managing fleet metrics

This topic shows how to use the AWS IoT console and AWS CLI to manage your fleet metrics.

Managing fleet metrics (Console)

you've enabled fleet indexing with associated data sources and configurations before creating fleet metrics.

Enable fleet indexing

If you've already enabled fleet indexing, skip this section.

If you haven't enabled fleet indexing, follow these instructions.

2. On the AWS IoT menu, choose Settings.
3. To view the detailed settings, on the Settings page, scroll down to the Fleet indexing section.
4. To update your fleet indexing settings, to the right of the Fleet indexing section, select Manage indexing.
5. On the Manage fleet indexing page, update your fleet indexing settings based on your needs.
   • Configuration
      To turn on thing indexing, toggle Thing indexing on, and then select the data sources you want to index from.
      To turn on thing group indexing, toggle Thing group indexing on.
   • Custom fields for aggregation - optional
      Custom fields are a list of field name and field type pairs.
      To add a custom field pair, choose Add new field. Enter a custom field name such as attributes.temperature, then select a field type from the Field type menu. Note that a custom field name begins with attributes. and will be saved as an attribute to run thing aggregations queries.
      To update and save the setting, choose Update.

Create a fleet metric

2. On the AWS IoT menu, choose Manage, and then choose Fleet metrics.

To clean up metrics in CloudWatch

CloudWatch doesn't support metrics deletion. Metrics expire based on their retention schedules. To learn more, Using Amazon CloudWatch metrics.

# Bash script. Type 'bash' before running in other shells.
for ((i=0; i < 10; i++))
do
  thing=$(aws iot delete-thing --thing-name "TempSensor$i")
done
3. On the Fleet metrics page, choose Create fleet metric and complete the creation steps.

4. In step 1 Configure fleet metrics
   - In Query section, enter a query string to specify the things or thing groups you want to perform the aggregate search. The query string consists of an attribute and a value. For Properties, choose the attribute you want, or, if it doesn't appear in the list, enter the attribute in the field. Enter the value after : An example query string can be thingName:TempSensor*. For each query string you enter, press enter in your keyboard. If you enter multiple query strings, specify their relationship by selecting and, or, and not, or or not between them.
   - In Report properties, choose Index name, Aggregation type, and Aggregation field from their respective lists. Next, select the data you want to aggregate in Select data, where you can select multiple data values.
   - Choose Next.

5. In step 2 Specify fleet metric properties
   - In Fleet metric name field, enter a name for the fleet metric you’re creating.
   - In Description - optional field, enter a description for the fleet metric you’re creating. This field is optional.
   - In Hours and Minutes fields, enter the time (how often) you want the fleet metric to emit data to CloudWatch.
   - Choose Next.

6. In step 3 Review and create
   - Review the settings of step 1 and step 2. To edit the settings, choose Edit.
   - Choose Create fleet metric.

After successful creation, the fleet metric is listed on the Fleet metric page.

Update a fleet metric

1. On the Fleet metric page, choose the fleet metric that you want to update.
2. On the fleet metric Details page, choose Edit. This opens the creation steps where you can update your fleet metric in any of the three steps.
3. After you finish updating the fleet metric, choose Update fleet metric.

Delete a fleet metric

1. On the Fleet metric page, choose the fleet metric that you want to delete.
2. On the next page that shows details of your fleet metric, choose Delete.
3. In the dialog box, enter the name of your fleet metric to confirm deletion.
4. Choose Delete. This step deletes your fleet metric permanently.

Managing fleet metrics (CLI)

The following sections show how to use the AWS CLI to manage your fleet metrics. You’ve enabled fleet indexing with associated data sources and configurations before creating fleet metrics. To enable fleet indexing for your things or thing groups, follow the instructions in Managing thing indexing (p. 889) or Managing thing group indexing (p. 898).

Create a fleet metric

You can use the create-fleet-metric CLI command to create a fleet metric.
aws iot create-fleet-metric --metric-name "YourFleetMetricName" --query-string "*" --period 60 --aggregation-field "registry.version" --aggregation-type name=Statistics,values=sum

The output of this command contains the name and Amazon Resource Name (ARN) of your fleet metric. The output looks like the following:

```
{
    "metricArn": "arn:aws:iot:us-east-1:111122223333:fleetmetric/YourFleetMetricName",
    "metricName": "YourFleetMetricName"
}
```

**List fleet metrics**

You can use the list-fleet-metric CLI command to list all the fleet metrics in your account.

```
aws iot list-fleet-metrics
```

The output of this command contains all your fleet metrics. The output looks like the following:

```
{
    "fleetMetrics": [
        {
            "metricArn": "arn:aws:iot:us-east-1:111122223333:fleetmetric/YourFleetMetric1",
            "metricName": "YourFleetMetric1"
        },
        {
            "metricArn": "arn:aws:iot:us-east-1:111122223333:fleetmetric/YourFleetMetric2",
            "metricName": "YourFleetMetric2"
        }
    ]
}
```

**Describe a fleet metric**

You can use the describe-fleet-metric CLI command to display more detailed information about a fleet metric.

```
aws iot describe-fleet-metric --metric-name "YourFleetMetricName"
```

The output of command contains the detailed information about the specified fleet metric. The output looks like the following:

```
{
    "queryVersion": "2017-09-30",
    "lastModifiedDate": 1625790642.355,
    "queryString": "*",
    "period": 60,
    "metricArn": "arn:aws:iot:us-east-1:111122223333:fleetmetric/YourFleetMetricName",
    "aggregationField": "registry.version",
    "version": 1,
    "aggregationType": {
        "values": [
            "sum"
        ],
        "name": "Statistics"
}
```
Managing fleet metrics

Update a fleet metric
You can use the update-fleet-metric CLI command to update a fleet metric.

```
aws iot update-fleet-metric --metric-name "YourFleetMetricName" --query-string "*" --period 120 --aggregation-field "registry.version" --aggregation-type name=Statistics,values=sum,count --index-name AWS_Things
```

The update-fleet-metric command doesn't produce any output. You can use the describe-fleet-metric CLI command to see the result.

```
{
  "queryVersion": "2017-09-30",
  "lastModifiedDate": 1625792300.881,
  "queryString": "*",
  "period": 120,
  "metricArn": "arn:aws:iot:us-east-1:111122223333:fleetmetric/YourFleetMetricName",
  "aggregationField": "registry.version",
  "version": 2,
  "aggregationType": {
    "values": ["sum", "count"],
    "name": "Statistics"
  },
  "indexName": "AWS_Things",
  "creationDate": 1625792300.881,
  "metricName": "YourFleetMetricName"
}
```

Delete a fleet metric
Use the delete-fleet-metric CLI command to delete a fleet metric.

```
aws iot delete-fleet-metric --metric-name "YourFleetMetricName"
```

This command doesn't produce any output if the deletion is successful or if you specify a fleet metric that doesn't exist.

For more information, see Troubleshooting fleet metrics (p. 1448).
MQTT-based file delivery

One option you can use to manage files and transfer them to AWS IoT devices in your fleet is MQTT-based file delivery. With this feature in the AWS Cloud you can create a stream that contains multiple files, you can update stream data (the file list and descriptions), get the stream data, and more. AWS IoT MQTT-based file delivery can transfer data in small blocks to your IoT devices, using the MQTT protocol with support for request and response messages in JSON or CBOR.

For more information on ways to transfer data to and from IoT devices using AWS IoT, see Connecting devices to AWS IoT (p. 81).

Topics
- What is a stream? (p. 919)
- Managing a stream in the AWS Cloud (p. 920)
- Using AWS IoT MQTT-based file delivery in devices (p. 922)
- An example use case in FreeRTOS OTA (p. 928)

What is a stream?

In AWS IoT, a stream is a publicly addressable resource that is an abstraction for a list of files that can be transferred to an IoT device. A typical stream contains the following information:

- An Amazon Resource Name (ARN) that uniquely identifies a stream at a given time. This ARN has the pattern `arn:partition:iot:region:account-ID:stream/stream ID`.
- A stream ID that identifies your stream and is used (and usually required) in AWS Command Line Interface (AWS CLI) or SDK commands.
- A stream description that provides a description of the stream resource.
- A stream version that identifies a particular version of the stream. Because stream data can be modified immediately before devices start the data transfer, the stream version can be used by the devices to enforce a consistency check.
- A list of files that can be transferred to devices. For each file in the list, the stream records a file ID, the file size, and the address information of the file, which consists of, for example, the Amazon S3 bucket name, object key, and object version.
- An AWS Identity and Access Management (IAM) role that grants AWS IoT MQTT-based file delivery the permission to read stream files stored in data storage.

AWS IoT MQTT-based file delivery provides the following functionality so that devices can transfer data from the AWS Cloud:

- Data transfer using the MQTT protocol.
- Support for JSON or CBOR formats.
- The ability to describe a stream (DescribeStream API) to get a stream file list, stream version, and related information.
- The ability to send data in small blocks (GetStream API) so that devices with hardware constraints can receive the blocks.
- Support for a dynamic block size per request, to support devices that have different memory capacities.
- Optimization for concurrent streaming requests when multiple devices request data blocks from the same stream file.
Managing a stream in the AWS Cloud

AWS IoT provides AWS SDK and AWS CLI commands that you can use to manage a stream in the AWS Cloud. You can use these commands to do the following:

- Create a stream. **CLI / SDK**
- Describe a stream to get its information. **CLI / SDK**
- List streams in your AWS account. **CLI / SDK**
- Update the file list or stream description in a stream. **CLI / SDK**
- Delete a stream. **CLI / SDK**

**Note**  
At this time, streams are not visible in the AWS Management Console. You must use the AWS CLI or AWS SDK to manage a stream in AWS IoT. Also, **Embedded C SDK** is the only SDK that supports MQTT-based file transfers.

Before you use AWS IoT MQTT-based file delivery from your devices, you must ensure the following conditions are met for your devices as shown in the next sections:

- A policy reflecting the correct permissions required for transmitting data via MQTT.
- Your device can connect to the AWS IoT Device Gateway.
- A policy statement stating you can tag resources. If `CreateStream` is called with tags, then `iot:TagResource` is required.

Before you use AWS IoT MQTT-based file delivery from your devices, you must follow the steps in the next sections to make sure that your devices are properly authorized and can connect to the AWS IoT Device Gateway.

**Grant permissions to your devices**

You can follow the steps in **Create an AWS IoT policy** to create a device policy or use an existing device policy. Attach the policy to the certificates associated with your devices and add the following permissions to the device policy.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [ "iot:Connect" ],
        },
        {
            "Effect": "Allow",
            "Action": [ "iot:Receive", "iot:Publish" ],
        }
    ]
}
```
Connect your devices to AWS IoT

Devices that use AWS IoT MQTT-based file delivery are required to connect with AWS IoT. AWS IoT MQTT-based file delivery integrates with AWS IoT in the AWS Cloud, so your devices should directly connect to the endpoint of the AWS IoT Data Plane.

**Note**
The endpoint of the AWS IoT data plane is specific to the AWS account and Region. You must use the endpoint for the AWS account and the Region in which your devices are registered in AWS IoT.

See [Connecting to AWS IoT Core](p. 73) for more information.

### TagResource Usage

The CreateStream API action creates a stream for delivering one or more large files in chunks over MQTT.

A successful CreateStream API call requires the following permissions:

- `iot:CreateStream`
- `iot:TagResource` (if CreateStream is with tags)

The policy supporting those two permissions is shown below:

```json
{
    "Version": "2012-10-17",
    "Statement": {
        "Action": [ "iot:CreateStream", "iot:TagResource" ],
        "Effect": "Allow",
        "Resource": "arn:partition:iot:region:accountID:stream/streamId",
    }
}
```

The `iot:TagResource` policy statement action is required to ensure a user can't create or update a tag on a resource without the proper permissions. Without the specific policy statement action of `iot:TagResource`, the CreateStream API call will return an AccessDeniedException if the request comes with tags.

For more information, refer to the following links:

- [CreateStream](#)
- [TagResource](#)
Using AWS IoT MQTT-based file delivery in devices

To initiate the data transfer process, a device must receive an initial data set, which includes a stream ID at minimum. You can use an Jobs (p. 704) to schedule data transfer tasks for your devices by including the initial data set in the job document. When a device receives the initial data set, it should then start the interaction with AWS IoT MQTT-based file delivery. To exchange data with AWS IoT MQTT-based file delivery, a device should:

- Use the MQTT protocol to subscribe to the MQTT-based file delivery topics (p. 122).
- Send requests and then wait to receive the responses using MQTT messages.

You can optionally include a stream file ID and a stream version in the initial data set. Sending a stream file ID to a device can simplify the programming of the device's firmware/software, because it eliminates the need to make a DescribeStream request from the device to get this ID. The device can specify the stream version in a GetStream request to enforce a consistency check in case the stream has been updated unexpectedly.

Use DescribeStream to get stream data

AWS IoT MQTT-based file delivery provides the DescribeStream API to send stream data to a device. The stream data returned by this API includes the stream ID, stream version, stream description and a list of stream files, each of which has a file ID and the file size in bytes. With this information, a device can select arbitrary files to initiate the data transfer process.

**Note**
You don't need to use the DescribeStream API if your device receives all required stream file IDs in the initial data set.

Follow these steps to make a DescribeStream request.

1. Subscribe to the "accepted" topic filter $aws/things/ThingName(streams/StreamId/description/json.
2. Subscribe to the "rejected" topic filter $aws/things/ThingName(streams/StreamId/rejected/json.
3. Publish a DescribeStream request by sending a message to $aws/things/ThingName/streams/StreamId/describe/json.
4. If the request was accepted, your device receives a DescribeStream response on the "accepted" topic filter.
5. If the request was rejected, your device receives the error response on the "rejected" topic filter.

**Note**
If you replace json with cbor in the topics and topic filters shown, your device receives messages in the CBOR format, which is more compact than JSON.

DescribeStream request

A typical DescribeStream request in JSON looks like the following example.

```json
{
    "c": "ec944cfa-1e3c-49ac-97de-9dc4aaad0039"
}
```
Get data blocks from a stream file

You can use the GetStream API so that a device can receive stream files in small data blocks, so it can be used by those devices that have constraints on processing large block sizes. To receive an entire data file, a device might need to send or receive multiple requests and responses until all data blocks are received and processed.

GetStream request

Follow these steps to make a GetStream request.

1. Subscribe to the "accepted" topic filter $aws/things/ThingName/streams/StreamId/data/json.
2. Subscribe to the "rejected" topic filter $aws/things/ThingName/streams/StreamId/rejected/json.
3. Publish a GetStream request to the topic $aws/things/ThingName/streams/StreamId/get/json.
4. If the request was accepted, your device will receive one or more GetStream responses on the "accepted" topic filter. Each response message contains basic information and a data payload for a single block.

DescribeStream response

A DescribeStream response in JSON looks like the following example.

```
{
  "c": "ec944cfb-1e3c-49ac-97de-9dc4aaad0039",
  "s": 1,
  "d": "This is the description of stream ABC.",
  "r": [
    {
      "f": 0,
      "z": 131072
    },
    {
      "f": 1,
      "z": 51200
    }
  ]
}
```

- "c" is the client token field. This is returned if it was given in the DescribeStream request. Use the client token to associate the response with its request.
- "s" is the stream version as an integer. You can use this version to perform a consistency check with your GetStream requests.
- "r" contains a list of the files in the stream.
  - "f" is the stream file ID as an integer.
  - "z" is the stream file size in number of bytes.
- "d" contains the description of the stream.

(Optional) "c" is the client token field.

The client token can't be longer than 64 bytes. A client token that is longer than 64 bytes causes an error response and an InvalidRequest error message.
5. Repeat steps 3 and 4 to receive all data blocks. You must repeat these steps if the amount of data requested is larger than 128 KB. You must program your device to use multiple GetStream requests to receive all of the data requested.

6. If the request was rejected, your device will receive the error response on the "rejected" topic filter.

Note

- If you replace "json" with "cbor" in the topics and topic filters shown, your device will receive messages in the CBOR format, which is more compact than JSON.
- AWS IoT MQTT-based file delivery limits the size of a block to 128 KB. If you make a request for a block that is more than 128 KB, the request will fail.
- You can make a request for multiple blocks whose total size is greater than 128 KB (for example, if you make a request for 5 blocks of 32 KB each for a total of 160 KB of data). In this case, the request doesn't fail, but your device must make multiple requests in order to receive all of the data requested. The service will send additional blocks as your device makes additional requests. We recommend that you continue with a new request only after the previous response has been correctly received and processed.
- Regardless of the total size of data requested, you should program your device to initiate retries when blocks are not received, or not received correctly.

A typical GetStream request in JSON looks like the following example.

```json
{
  "c": "1bb8aaa1-5c18-4d21-80c2-0b44fee10380",
  "s": 1,
  "f": 0,
  "l": 4096,
  "o": 2,
  "n": 100,
  "b": "..."
}
```

- [optional] "c" is the client token field.
  
The client token can be no longer than 64 bytes. A client token that is longer than 64 bytes causes an error response and an InvalidRequest error message.
- [optional] "s" is the stream version field (an integer).
  
  MQTT-based file delivery applies a consistency check based on this requested version and the latest stream version in the cloud. If the stream version sent from a device in a GetStream request doesn't match the latest stream version in the cloud, the service sends an error response and a VersionMismatch error message. Typically, a device receives the expected (latest) stream version in the initial data set or in the response to DescribeStream.
- "f" is the stream file ID (an integer in the range 0 to 255).
  
The stream file ID is required when you create or update a stream using the AWS CLI or SDK. If a device requests a stream file with an ID that doesn't exist, the service sends an error response and a ResourceNot_found error message.
- "l" is the data block size in bytes (an integer in the range 256 to 131,072).
  
  Refer to Build a bitmap for a GetStream request (p. 925) for instructions on how to use the bitmap fields to specify what portion of the stream file will be returned in the GetStream response. If a device specifies a block size that is out of range, the service sends an error response and a BlockSizeOutOfBounds error message.
- [optional] "o" is the offset of the block in the stream file (an integer in the range 0 to 98,304).
Refer to Build a bitmap for a GetStream request (p. 925) for instructions on how to use the bitmap fields to specify what portion of the stream file will be returned in the GetStream response. The maximum value of 98,304 is based on a 24 MB stream file size limit and 256 bytes for the minimum block size. The default is 0 if not specified.

- [optional] "n" is the number of blocks requested (an integer in the range 0 to 98,304).

  The "n" field specifies either (1) the number of blocks requested, or (2) when the bitmap field ("b") is used, a limit on the number of blocks that will be returned by the bitmap request. This second use is optional. If not defined, it defaults to 131072/DataBlockSize.

- [optional] "b" is a bitmap that represents the blocks being requested.

Using a bitmap, your device can request non-consecutive blocks, which makes handling retries following an error more convenient. Refer to Build a bitmap for a GetStream request (p. 925) for instructions on how to use the bitmap fields to specify which portion of the stream file will be returned in the GetStream response. For this field, convert the bitmap to a string representing the bitmap's value in hexadecimal notation. The bitmap must be less than 12,288 bytes.

Important

Either "n" or "b" should be specified. If neither of them is specified, the GetStream request might not be valid when the file size is less than 131072 bytes (128 KB).

GetStream response

A GetStream response in JSON looks like this example for each data block that is requested.

```json
{
  "c": "1bb8aa1-5c18-4d21-80c2-0b44fee10380",
  "f": 0,
  "l": 4096,
  "i": 2,
  "p": "..."
}
```

- "c" is the client token field. This is returned if it was given in the GetStream request. Use the client token to associate the response with its request.
- "f" is the ID of the stream file to which the current data block payload belongs.
- "l" is the size of the data block payload in bytes.
- "i" is the ID of the data block contained in the payload. Data blocks are numbered starting from 0.
- "p" contains the data block payload. This field is a string, which represents the value of the data block in Base64 encoding.

Build a bitmap for a GetStream request

You can use the bitmap field (b) in a GetStream request to get non-consecutive blocks from a stream file. This helps devices with limited RAM capacity deal with network delivery issues. A device can request only those blocks that were not received or not received correctly. The bitmap determines which blocks of the stream file will be returned. For each bit, which is set to 1 in the bitmap, a corresponding block of the stream file will be returned.

Here's an example of how to specify a bitmap and its supporting fields in a GetStream request. For example, you want to receive a stream file in chunks of 256 bytes (the block size). Think of each block of 256 bytes as having a number that specifies its position in the file, starting from 0. So block 0 is the first
block of 256 bytes in the file, block 1 is the second, and so on. You want to request blocks 20, 21, 24 and 43 from the file.

**Block offset**

Because the first block is number 20, specify the offset (field \(o\)) as 20 to save space in the bitmap.

**Number of blocks**

To ensure that your device doesn’t receive more blocks than it can handle with limited memory resources, you can specify the maximum number of blocks that should be returned in each message sent by MQTT-based file delivery. Note that this value is disregarded if the bitmap itself specifies less than this number of blocks, or if it would make the total size of the response messages sent by MQTT-based file delivery greater than the service limit of 128 KB per `GetStream` request.

**Block bitmap**

The bitmap itself is an array of unsigned bytes expressed in hexadecimal notation, and included in the `GetStream` request as a string representation of the number. But to construct this string, let’s start by thinking of the bitmap as a long sequence of bits (a binary number). If a bit in this sequence is set to 1, the corresponding block from the stream file will be sent back to the device. For our example, we want to receive blocks 20, 21, 24, and 43, so we must set bits 20, 21, 24, and 43 in our bitmap. We can use the block offset to save space, so after we subtract the offset from each block number, we want to set bits 0, 1, 4, and 23, like the following example.

```
1 1 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1
```

Taking one byte (8 bits) at a time, this is conventionally written as: "0b00010011", "0b00000000", and "0b100000000". Bit 0 shows up in our binary representation at the end of the first byte, and bit 23 at the beginning of the last. This can be confusing unless you know the conventions. The first byte contains bits 7-0 (in that order), the second byte contains bits 15-8, the third byte contains bits 23-16, and so on. In hexadecimal notation, this converts to "0x130080".

**Tip**

You can convert the standard binary to hexadecimal notation. Take four binary digits at a time and convert these to their hexadecimal equivalent. For example, "0001" becomes "1", "0011" becomes "3" and so on.

**Block bitmap breakdown**

```
<table>
<thead>
<tr>
<th>Byte 0 (blocks 0-7)</th>
<th>Byte 1 (blocks 8-15)</th>
<th>Byte 2 (blocks 16-23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13h</td>
<td>00h</td>
<td>80h</td>
</tr>
</tbody>
</table>

block 24 (4 + 0 + 20)  
block 21 (1 + 0 + 20) 
(no blocks requested) 
block 43 (7 + (2 \* 8) + 20) 
Block offset
```

\[\text{block number} = (\text{bit position} + (\text{byte offset} \times 8) + \text{base offset})\]

Putting this all together, the JSON for our `GetStream` request looks like the following.
Handling errors from AWS IoT MQTT-based file delivery

An error response that is sent to a device for both DescribeStream and GetStream APIs contains a client token, an error code and an error message. A typical error response looks like the following example.

```json
{
    "o": "BlockSizeOutOfBounds",
    "m": "The block size is out of bounds",
    "c": "1bb8aaa1-5c18-4d21-80c2-0b44fee10380"
}
```

- "o" is the error code that indicates the reason an error occurred. Refer to the error codes later in this section for more details.
- "m" is the error message that contains details of the error.
- "c" is the client token field. This may be returned if it was given in the DescribeStream request. You can use the client token to associate the response with its request.

The client token field is not always included in an error response. When the client token given in the request isn't valid or is malformed, it's not returned in the error response.

### Note

For backward compatibility, fields in the error response may be in non-abbreviated form. For example, the error code might be designated by either "code" or "o" fields and the client token field may be designated by either "clientToken" or "c" fields. We recommend that you use the abbreviation form shown above.

**InvalidTopic**

The MQTT topic of the stream message is invalid.

**InvalidJson**

The Stream request is not a valid JSON document.
InvalidCbor

The Stream request is not valid CBOR document.

InvalidRequest

The request is generally identified as malformed. For more information, see the error message.

Unauthorized

The request is not authorized to access the stream data files in the storage medium, such as Amazon S3. For more information, see the error message.

BlockSizeOutOfBounds

The block size is out of bounds. Refer to the "MQTT-based File Delivery" section in AWS IoT Core Service Quotas.

OffsetOutOfBounds

The offset is out of bounds. Refer to the "MQTT-based File Delivery" section in AWS IoT Core Service Quotas.

BlockCountLimitExceeded

The number of request block(s) is out of bounds. Refer to the "MQTT-based File Delivery" section in AWS IoT Core Service Quotas.

BlockBitmapLimitExceeded

The size of the request bitmap is out of bounds. Refer to the "MQTT-based File Delivery" section in AWS IoT Core Service Quotas.

ResourceNotFound

The requested stream, files, file versions or blocks were not found. Refer to the error message for more details.

VersionMismatch

The stream version in the request doesn't match with the stream version in the MQTT-based file delivery feature. This indicates that the stream data had been modified since the stream version was initially received by the device.

ETagMismatch

The S3 ETag in the stream doesn't match with the ETag of the latest S3 object version.

InternalError

An internal error occurred in MQTT-based file delivery.

An example use case in FreeRTOS OTA

The FreeRTOS OTA (over-the-air) agent uses AWS IoT MQTT-based file delivery to transfer FreeRTOS firmware images to FreeRTOS devices. To send the initial data set to a device, it uses the AWS IoT Job service to schedule an OTA update job to FreeRTOS devices.

For a reference implementation of an MQTT-based file delivery client, see FreeRTOS OTA agent codes in the FreeRTOS documentation.
AWS IoT Device Defender

AWS IoT Device Defender is a security service that allows you to audit the configuration of your devices, monitor connected devices to detect abnormal behavior, and mitigate security risks. It gives you the ability to enforce consistent security policies across your AWS IoT device fleet and respond quickly when devices are compromised.

IoT fleets can consist of large numbers of devices that have diverse capabilities, are long-lived, and are geographically distributed. These characteristics make fleet setup complex and error-prone. And because devices are often constrained in computational power, memory, and storage capabilities, this limits the use of encryption and other forms of security on the devices themselves. Also, devices often use software with known vulnerabilities. These factors make IoT fleets an attractive target for hackers and make it difficult to secure your device fleet on an ongoing basis.

AWS IoT Device Defender addresses these challenges by providing tools to identify security issues and deviations from best practices. AWS IoT Device Defender can audit device fleets to ensure they adhere to security best practices and detect abnormal behavior on devices.

AWS training and certification

Take the following course to get started with AWS IoT Device Defender: AWS IoT Device Defender Primer.

Getting started with AWS IoT Device Defender

You can use the following tutorials to work with AWS IoT Device Defender.

Topics

- Setting up (p. 929)
- Audit guide (p. 930)
- ML Detect guide (p. 934)
- Customize when and how you view AWS IoT Device Defender audit results (p. 956)

Setting up

Before you use AWS IoT Device Defender for the first time, complete the following tasks:

Topics

- Sign up for an AWS account (p. 18)
- Create an administrative user (p. 19)

Sign up for an AWS account

If you do not have an AWS account, complete the following steps to create one.
To sign up for an AWS account

2. Follow the online instructions.

   Part of the sign-up procedure involves receiving a phone call and entering a verification code on the phone keypad.

   When you sign up for an AWS account, an AWS account root user is created. The root user has access to all AWS services and resources in the account. As a security best practice, assign administrative access to an administrative user, and use only the root user to perform tasks that require root user access.

AWS sends you a confirmation email after the sign-up process is complete. At any time, you can view your current account activity and manage your account by going to https://aws.amazon.com/ and choosing My Account.

Create an administrative user

After you sign up for an AWS account, create an administrative user so that you don't use the root user for everyday tasks.

Secure your AWS account root user

1. Sign in to the AWS Management Console as the account owner by choosing Root user and entering your AWS account email address. On the next page, enter your password.

   For help signing in by using root user, see Signing in as the root user in the AWS Sign-In User Guide.

2. Turn on multi-factor authentication (MFA) for your root user.

   For instructions, see Enable a virtual MFA device for your AWS account root user (console) in the IAM User Guide.

Create an administrative user

- For your daily administrative tasks, grant administrative access to an administrative user in AWS IAM Identity Center.

   For instructions, see Getting started in the AWS IAM Identity Center User Guide.

Sign in as the administrative user

- To sign in with your IAM Identity Center user, use the sign-in URL that was sent to your email address when you created the IAM Identity Center user.

   For help signing in using an IAM Identity Center user, see Signing in to the AWS access portal in the AWS Sign-In User Guide.

These tasks create an AWS account and a user with administrator privileges for the account.

Audit guide

This tutorial provides instructions on how to configure a recurring audit, setting up alarms, reviewing audit results and mitigating audit issues.
Topics

- Prerequisites (p. 931)
- Enable audit checks (p. 931)
- View audit results (p. 931)
- Creating audit mitigation actions (p. 931)
- Apply mitigation actions to your audit findings (p. 932)
- Creating an AWS IoT Device Defender Audit IAM role (optional) (p. 932)
- Enable SNS notifications (optional) (p. 933)
- Enable logging (optional) (p. 933)

Prerequisites

To complete this tutorial, you need the following:

- An AWS account. If you don't have this, see Setting up.

Enable audit checks

In the following procedure, you enable audit checks that look at account and device settings and policies to ensure security measures are in place. In this tutorial we instruct you to enable all audit checks, but you're able to select whichever checks you wish.

Audit pricing is per device count per month (fleet devices connected to AWS IoT). Therefore, adding or removing audit checks would not affect your monthly bill when using this feature.

1. Open the AWS IoT console. In the navigation pane, expand Security and choose Intro.
2. Choose Automate AWS IoT security audit. Audit checks are automatically turned on.
3. Expand Audit and choose Settings to view your audit checks. Select an audit check name to learn about what the audit check does. For more information about audit checks, see Audit Checks.
4. (Optional) If you already have a role that you want to use, choose Manage service permissions, choose the role from the list, and then choose Update.

View audit results

The following procedure shows you how to view your audit results. In this tutorial, you see the audit results from the audit checks set up in Enable audit checks (p. 931) tutorial.

To view audit results

1. Open the AWS IoT console. In the navigation pane, expand Security, Audit, and then choose Results.
2. Select the Name of the audit schedule you’d like to investigate.
3. In Non-compliant checks, under Mitigation, select the info buttons for information about why it's non-compliant. For guidance on how to make your non-compliant checks compliant, see Audit checks (p. 967).

Creating audit mitigation actions

In the following procedure, you will create an AWS IoT Device Defender Audit Mitigation Action to enable AWS IoT logging. Each audit check has mapped mitigation actions that will affect which Action type you choose for the audit check you want to fix. For more information, see Mitigation actions.
To use the AWS IoT console to create mitigation actions

1. Open the AWS IoT console. In the navigation pane, expand Security, Detect, and then choose Mitigation actions.
2. On the Mitigation actions page, choose Create.
3. On the Create a new mitigation action page, for Action name, enter a unique name for your mitigation action such as EnableErrorLoggingAction.
4. For Action type, choose Enable AWS IoT logging.
5. In Permissions, choose Create role. For Role name, use IoTMitigationActionErrorLoggingRole. Then, choose Create.
6. In Parameters, under Role for logging, choose IoTMitigationActionErrorLoggingRole. For Log level, choose Error.
7. Choose Create.

Apply mitigation actions to your audit findings

The following procedure shows you how to apply mitigation actions to your audit results.

To mitigate non-compliant audit findings

1. Open the AWS IoT console. In the navigation pane, expand Security, Audit, and then choose Results.
2. Choose an audit result that you want to respond to.
3. Check your results.
4. Choose Start mitigation actions.
5. For Logging disabled, choose the mitigation action that you previously created, EnableErrorLoggingAction. You can select the appropriate actions for each non-compliant finding to address the issues.
6. For Select reason codes, choose the reason code that was returned by the audit check.
7. Choose Start task. The mitigation action may take a few minutes to run.

To check that the mitigation action worked

1. In the AWS IoT console, in the navigation pane, choose Settings.
2. In Service log, confirm that the Log level is Error (least verbosity).

Creating an AWS IoT Device Defender Audit IAM role (optional)

In the following procedure, you create an AWS IoT Device Defender Audit IAM role that provides AWS IoT Device Defender read access to AWS IoT.

To create the service role for AWS IoT Device Defender (IAM console)

1. Sign in to the AWS Management Console and open the IAM console at https://console.aws.amazon.com/iam/.
2. In the navigation pane of the IAM console, choose Roles, and then choose Create role.
3. Choose the AWS service role type.
4. In Use cases for other AWS services, choose AWS IoT, and then choose IoT - Device Defender Audit.
5. Choose Next.
6. (Optional) Set a permissions boundary. This is an advanced feature that is available for service roles, but not service-linked roles.

Expand the Permissions boundary section and choose Use a permissions boundary to control the maximum role permissions. IAM includes a list of the AWS managed and customer managed policies in your account. Select the policy to use for the permissions boundary or choose Create policy to open a new browser tab and create a new policy from scratch. For more information, see Creating IAM policies in the IAM User Guide. After you create the policy, close that tab and return to your original tab to select the policy to use for the permissions boundary.

7. Choose Next.

8. Enter a role name to help you identify the purpose of this role. Role names must be unique within your AWS account. They are not distinguished by case. For example, you cannot create roles named both PRODROLE and prodrole. Because various entities might reference the role, you can't edit the name of the role after it has been created.

9. (Optional) For Description, enter a description for the new role.

10. Choose Edit in the Step 1: Select trusted entities or Step 2: Select permissions sections to edit the use cases and permissions for the role.

11. (Optional) Add metadata to the user by attaching tags as key-value pairs. For more information about using tags in IAM, see Tagging IAM resources in the IAM User Guide.

12. Review the role and then choose Create role.

Enable SNS notifications (optional)

In the following procedure, you enable Amazon SNS (SNS) notifications to alert you when your audits identify any non-compliant resources. In this tutorial you will set up notifications for the audit checks enabled in the Enable audit checks (p. 931) tutorial.

1. If you haven't already, attach a policy that provides access to SNS via the AWS Management Console. You can do this by following the instructions in Attaching a policy to an IAM user group in the IAM User Guide and selecting the AWSIoTDeviceDefenderPublishFindingsToSNSMitigationAction policy.

2. Open the AWS IoT console. In the navigation pane, expand Security, Audit, and then choose Settings.

3. At the bottom of the Device Defender audit settings page, choose Enable SNS alerts.

4. Choose Enabled.

5. For Topic, choose Create new topic. Name the topic IoTDDNotifications and choose Create. For Role, choose the role that you created in Creating an AWS IoT Device Defender Audit IAM role (optional) (p. 932).

6. Choose Update.

7. If you'd like to receive email or text in your Ops platforms through Amazon SNS, see Using Amazon Simple Notification Service for user notifications.

Enable logging (optional)

This procedure describes how to enable AWS IoT to log information to CloudWatch Logs. This will allow you to view your audit results. Enabling logging may result in incurred charges.

To enable logging

1. Open the AWS IoT console. On the navigation pane, choose Settings.

2. In Logs, choose Manage logs.
3. For Select role, choose Create role. Name the role AWSIoTLoggingRole and choose Create. A policy is automatically attached.
4. For Log level, choose Debug (most verbosity).
5. Choose Update.

**ML Detect guide**

In this Getting Started guide, you create an ML Detect Security Profile that uses machine learning (ML) to create models of expected behavior based on historical metric data from your devices. While ML Detect is creating the ML model, you can monitor its progress. After the ML model is built, you can view and investigate alarms on an ongoing basis and mitigate identified issues.

For more information about ML Detect and its API and CLI commands, see [ML Detect](#) (p. 1040).

This chapter contains the following sections:
- Prerequisites (p. 934)
- How to use ML Detect in the console (p. 934)
- How to use ML Detect with the CLI (p. 947)

**Prerequisites**

- An AWS account. If you don't have this, see [Setting up](#).

**How to use ML Detect in the console**

**Tutorials**
- [Enable ML Detect](#) (p. 934)
- [Monitor your ML model status](#) (p. 938)
- [Review your ML Detect alarms](#) (p. 939)
- [Fine-tune your ML alarms](#) (p. 941)
- [Mark your alarm's verification state](#) (p. 942)
- [Mitigate identified device issues](#) (p. 943)

**Enable ML Detect**

The following procedures detail how to set up ML Detect in the console.

1. First, make sure your devices will create the minimum datapoints required as defined in [ML Detect minimum requirements](#) (p. 1041) for ongoing training and refreshing of the model. For data collection to progress, ensure your Security Profile is attached to a target, which can be a thing or thing group.
2. In the [AWS IoT console](#), in the navigation pane, expand Defend. Choose Detect, Security profiles, Create security profile, and then Create ML anomaly Detect profile.
3. On the Set basic configurations page, do the following.
   - Under Target, choose your target device groups.
   - Under Security profile name, enter a name for your Security Profile.
   - (Optional) Under Description you can write in a short description for the ML profile.
   - Under Selected metric behaviors in Security Profile, choose the metrics you'd like to monitor.
When you’re done, choose **Next**.

4. On the **Set SNS (optional)** page, specify an SNS topic for alarm notifications when a device violates a behavior in your profile. Choose an IAM role you will use to publish to the selected SNS topic.

If you don’t have an SNS role yet, use the following steps to create a role with the proper permissions and trust relationships required.

- Navigate to the **IAM console**. In the navigation pane, choose **Roles** and then choose **Create role**.
- Under **Select type of trusted entity**, select **AWS Service**. Then, under **Choose a use case**, choose **IoT** and under **Select your use case**, choose **IoT - Device Defender Mitigation Actions**. When you’re done, choose **Next: Permissions**.
- Under **Attached permissions policies**, ensure that **AWSIoTDeviceDefenderPublishFindingsToSNSSMitigationAction** is selected, and then choose **Next: Tags**.
Under *Add tags (optional)*, you can add any tags you’d like to associate with your role. When you’re done, choose *Next: Review*.

Under *Review*, give your role a name and ensure that `AWSIoTDeviceDefenderPublishFindingsToSNSMitigationAction` is listed under *Permissions* and `AWS service: iot.amazonaws.com` is listed under *Trust relationships*. When you’re done, choose *Create role*. 

- **Attached permissions policies**

The type of role that you selected requires the following policy:

- **Set permissions boundary**
5. On the **Edit Metric behavior** page, you can customize your ML behavior settings.

6. When you're done, choose **Next**.

7. On the **Review configuration** page, verify the behaviors you'd like machine learning to monitor, and then choose **Next**.
8. After you've created your Security Profile, you're redirected to the Security Profiles page, where the newly created Security Profile appears.

Note
The initial ML model training and creation takes 14 days to complete. You can expect to see alarms after it's complete, if there is any anomalous activity on your devices.

Monitor your ML model status

While your ML models are in the initial training period, you can monitor their progress at any time by taking the following steps.

1. In the AWS IoT console, in the navigation pane, expand Defend, and then choose Detect, Security profiles.
2. On the Security Profiles page, choose the Security Profile you'd like to review. Then, choose Behaviors and ML training.
3. On the Behaviors and ML training page, check the training progress of your ML models.

After your model status is Active, it'll start making Detect decisions based on your usage and update the profile every day.
**Note**

If your model doesn't progress as expected, make sure your devices are meeting the [Minimum requirements](p. 1041).

**Review your ML Detect alarms**

After your ML models are built and ready for data inference, you can regularly view and investigate alarms that are identified by the models.

1. In the [AWS IoT console](aws-iot-console), in the navigation pane, expand **Defend**, and then choose **Detect, Alarms**.

2. If you navigate to the **History** tab, you can also view details about your devices that are no longer in alarms.
To get more information, under **Manage** choose **Things**, chose the thing you’d like to see more details for, and then navigate to **Defender metrics**. You can access the **Defender metrics graph** and perform your investigation on anything in alarm from the **Active** tab. In this case, the graph shows a spike in message size, which initiated the alarm. You can see the alarm subsequently cleared.
Fine-tune your ML alarms

After your ML models are built and ready for data evaluations, you can update your Security Profile’s ML behavior settings to change the configuration. The following procedure shows you how to update your Security Profile’s ML behavior settings in the AWS CLI.

1. In the AWS IoT console, in the navigation pane, expand **Defend**, and then choose **Detect, Security profiles**.

2. On the **Security Profiles** page, select the check box next to the Security Profile you’d like to review. Then, choose **Actions, Edit**.

3. Under **Set basic configurations**, you can adjust Security Profile target thing groups or change what metrics you want to monitor.
4. You can update any of the following by navigating to **Edit metric behaviors**.

   - Your ML model datapoints required to initiate alarm
   - Your ML model datapoints required to clear alarm
   - Your ML Detect confidence level
   - Your ML Detect notifications (for example, **Not suppressed**, **Suppressed**)

Mark your alarm’s verification state

Mark your alarms by setting the verification state and providing a description of that verification state. This helps you and your team identify alarms that you don’t have to respond to.

1. In the **AWS IoT console**, on the navigation pane, expand **Defend**, and then choose **Detect, Alarms**. Select an alarm to mark its verification state.
2. Choose **Mark verification state**. The verification state modal opens.
3. Choose the appropriate verification state, enter a verification description (optional), and then choose **Mark**. This action assigns a verification state and description to the chosen alarm.

**Mitigate identified device issues**

1. **(Optional)** Before setting up quarantine mitigation actions, let's set up a quarantine group where we'll move the device that's in violation to. You can also use an existing group.
2. Navigate to **Manage, Thing groups**, and then **Create Thing Group**. Name your thing group. For this tutorial, we'll name our thing group **Quarantine_group**. Under **Thing group, Security**, apply the following policy to the thing group.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Deny",
```
When you're done, choose Create thing group.

3. Now that we've created a thing group, let's create a mitigation action that move devices that in alarm into the Quarantine_group.

Under Defend, Mitigation actions, choose Create.

4. On the Create a new mitigation action page, enter the following information.

- **Action name**: Give your mitigation action a name, such as Quarantine_action.
- **Action type**: Choose the type of action. We'll choose Add things to thing group (Audit or Detect mitigation).
- **Action execution role**: Create a role or choose an existing role if you created one earlier.
- **Parameters**: Choose a thing group. We can use Quarantine_group, which we created earlier.
When you're done, choose **Save**. You now have a mitigation action that moves devices in alarm to a quarantine thing group, and a mitigation action to isolate the device while you investigate.

5. **Navigate to Defender, Detect, Alarms.** You can see which devices are in alarm state under **Active**.
Select the device you want to move to the quarantine group and choose **Start Mitigation Actions**.

6. Under **Start mitigation actions**, **Start Actions** select the mitigation action you created earlier. For example, we'll choose **Quarantine_action**, then choose **Start**. The Action Tasks page opens.

7. The device is now isolated in **Quarantine_group** and you can investigate the root cause of the issue that set off the alarm. After you complete the investigation, you can move the device out of the thing group or take further actions.
How to use ML Detect with the CLI

The following shows you how to set up ML Detect using the CLI.

Tutorials
- Enable ML Detect (p. 947)
- Monitor your ML model status (p. 948)
- Review your ML Detect alarms (p. 950)
- Fine-tune your ML alarms (p. 951)
- Mark your alarm’s verification state (p. 953)
- Mitigate identified device issues (p. 953)

Enable ML Detect

The following procedure shows you how to enable ML Detect in the AWS CLI.

1. Make sure your devices will create the minimum datapoints required as defined in ML Detect minimum requirements (p. 1041) for ongoing training and refreshing of the model. For data collection to progress, ensure your things are in a thing group attached to a Security Profile.
2. Create an ML Detect Security Profile by using the `create-security-profile` command. The following example creates a Security Profile named `security-profile-for-smart-lights` that checks for number of messages sent, number of authorization failures, number of connection attempts, and number of disconnects. The example uses `mlDetectionConfig` to establish that the metric will use the ML Detect model.

```bash
aws iot create-security-profile \
  --security-profile-name security-profile-for-smart-lights \
  --behaviors \\
  '[
    {
      "name": "num-messages-sent-ml-behavior",
      "metric": "aws:num-messages-sent",
      "criteria": {
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1,
        "mlDetectionConfig": {
          "confidenceLevel": "HIGH"
        }
      },
      "suppressAlerts": true
    },
    {
      "name": "num-authorization-failures-ml-behavior",
      "metric": "aws:num-authorization-failures",
      "criteria": {
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1,
        "mlDetectionConfig": {
          "confidenceLevel": "HIGH"
        }
      }
    }
  ]
```
"confidenceLevel": "HIGH"
],
"suppressAlerts": true
),
{
"name": "num-connection-attempts-ml-behavior",
"metric": "aws:num-connection-attempts",
"criteria": {
"consecutiveDatapointsToAlarm": 1,
"consecutiveDatapointsToClear": 1,
"mlDetectionConfig": {
"confidenceLevel": "HIGH"
}
},
"suppressAlerts": true
},
{
"name": "num-disconnects-ml-behavior",
"metric": "aws:num-disconnects",
"criteria": {
"consecutiveDatapointsToAlarm": 1,
"consecutiveDatapointsToClear": 1,
"mlDetectionConfig": {
"confidenceLevel": "HIGH"
}
},
"suppressAlerts": true
]]'

Output:

{
"securityProfileName": "security-profile-for-smart-lights",
"securityProfileArn": "arn:aws:iot:eu-west-1:123456789012:securityprofile/security-profile-for-smart-lights"
}

3. Next, associate your Security Profile with one or multiple thing groups. Use the `attach-security-profile` command to attach a thing group to your Security Profile. The following example associates a thing group named `ML_Detect_beta_static_group` with the `security-profile-for-smart-lights` Security Profile.

```bash
aws iot attach-security-profile \
  --security-profile-name security-profile-for-smart-lights \
```

Output:

None.

4. After you've created your complete Security Profile, the ML model begins training. The initial ML model training and building takes 14 days to complete. After 14 days, if there's anomalous activity on your device, you can expect to see alarms.

**Monitor your ML model status**

The following procedure shows you how to monitor your ML models in-progress training.
Use the `get-behavior-model-training-summaries` command to view your ML model's progress. The following example gets the ML model training progress summary for the `security-profile-for-smart-lights` Security Profile. `modelStatus` shows you if a model has completed training or is still pending build for a particular behavior.

```
aws iot get-behavior-model-training-summaries \
--security-profile-name security-profile-for-smart-lights
```

Output:

```
{
  "summaries": [ 
    
    
    
    
    
    
    
    
    
    
    
  ]
}
```
**Note**
If your model doesn't progress as expected, make sure your devices are meeting the Minimum requirements (p. 1041).

**Review your ML Detect alarms**

After your ML models are built and ready for data evaluations, you can regularly view any alarms that are inferred by the models. The following procedure shows you how to view your alarms in the AWS CLI.

- To see all active alarms, use the `list-active-violations` command.

```bash
aws iot list-active-violations
--max-results 2
```

Output:

```json
{
    "activeViolations": []
}
```

Alternatively, you can view all violations discovered during a given time period by using the `list-violation-events` command. The following example lists violation events from September 22, 2020 5:42:13 GMT to October 22, 2020 5:42:13 GMT.

```bash
aws iot list-violation-events
--start-time 1599500533
--end-time 1600796533
--max-results 2
```

Output:

```json
{
    "violationEvents": [
        {
            "violationId": "1448be98c09c3d4ab7cb9b6f3ece65d6",
            "thingName": "lightbulb-1",
            "securityProfileName": "security-profile-for-smart-lights",
            "behavior": {
                "name": "LowConfidence_MladBehavior_MessagesSent",
                "metric": "aws:num-messages-sent",
                "criteria": {
                    "consecutiveDatapointsToAlarm": 1,
                    "consecutiveDatapointsToClear": 1,
                    "mlDetectionConfig": {
                        "confidenceLevel": "HIGH"
                    }
                },
                "suppressAlerts": true
            },
            "violationEventType": "alarm-invalidated",
            "violationEventTime": 1600780245.29
        },
        {
            "violationId": "df4537569ef23efb1c029a433ae84b52",
            "thingName": "lightbulb-2",
            "securityProfileName": "security-profile-for-smart-lights",
            "behavior": {
                "name": "LowConfidence_MladBehavior_MessagesSent",
                "metric": "aws:num-messages-sent",
                "criteria": {
                    "consecutiveDatapointsToAlarm": 1,
                    "consecutiveDatapointsToClear": 1,
                    "mlDetectionConfig": {
                        "confidenceLevel": "HIGH"
                    }
                },
                "suppressAlerts": true
            },
            "violationEventType": "alarm-invalidated",
            "violationEventTime": 1600780245.29
        }
    ]
}
```
Fine-tune your ML alarms

Once your ML models are built and ready for data evaluations, you can update your Security Profile’s ML behavior settings to change the configuration. The following procedure shows you how to update your Security Profile’s ML behavior settings in the AWS CLI.

- To change your Security Profile’s ML behavior settings, use the `update-security-profile` command. The following example updates the `security-profile-for-smart-lights` Security Profile’s behaviors by changing the `confidenceLevel` of a few of the behaviors and unsuppresses notifications for all behaviors.

```bash
aws iot update-security-profile \
  --security-profile-name security-profile-for-smart-lights \
  --behaviors \
  '[[
    "name": "num-messages-sent-ml-behavior",
    "metric": "aws:num-messages-sent",
    "criteria": {
      "mlDetectionConfig": {
        "confidenceLevel": "HIGH"
      }
    },
    "suppressAlerts": false
  },
  {
    "name": "num-authorization-failures-ml-behavior",
    "metric": "aws:authorization-failures",
    "criteria": {
      "mlDetectionConfig": {
        "confidenceLevel": "HIGH"
      }
    },
    "suppressAlerts": false
  },
  {
    "name": "num-connection-attempts-ml-behavior",
    "metric": "aws:connection-attempts",
    "criteria": {}
  }]'
```
"mlDetectionConfig": {
    "confidenceLevel": "HIGH"
},
"suppressAlerts": false
},
{
    "name": "num-disconnects-ml-behavior",
    "metric": "aws:num-disconnects",
    "criteria": {
        "mlDetectionConfig": {
            "confidenceLevel": "LOW"
        }
    }
},
"suppressAlerts": false
"
]

Output:

{  
    "securityProfileName": "security-profile-for-smart-lights",
    "securityProfileArn": "arn:aws:iot:eu-west-1:123456789012:securityprofile/security-profile-for-smart-lights",
    "behaviors": [
        {
            "name": "num-messages-sent-ml-behavior",
            "metric": "aws:num-messages-sent",
            "criteria": {
                "mlDetectionConfig": {
                    "confidenceLevel": "HIGH"
                }
            }
        },
        {
            "name": "num-authorization-failures-ml-behavior",
            "metric": "aws:num-authorization-failures",
            "criteria": {
                "mlDetectionConfig": {
                    "confidenceLevel": "HIGH"
                }
            }
        },
        {
            "name": "num-connection-attempts-ml-behavior",
            "metric": "aws:num-connection-attempts",
            "criteria": {
                "mlDetectionConfig": {
                    "confidenceLevel": "HIGH"
                }
            }
        },
        "suppressAlerts": false
    ],
    "suppressAlerts": true
}
Mark your alarm's verification state

You can mark your alarms with verification states to help classify alarms and investigate anomalies.

- Mark your alarms with a verification state and a description of that state. For example to set an alarm's verification state to False positive, use the following command:

```bash
aws iot put-verification-state-on-violation --violation-id 12345 --verification-state FALSE_POSITIVE --verification-state-description "This is dummy description" --endpoint https://us-east-1.iot.amazonaws.com --region us-east-1
```

Output:

None.

Mitigate identified device issues

1. Use the `create-thing-group` command to create a thing group for the mitigation action. In the following example, we create a thing group called `ThingGroupForDetectMitigationAction`.

```bash
aws iot create-thing-group --thing-group-name ThingGroupForDetectMitigationAction
```

Output:

```json
{
    "thingGroupName": "ThingGroupForDetectMitigationAction",
    "thingGroupArn": "arn:aws:iot:us-east-1:123456789012:thinggroup/ThingGroupForDetectMitigationAction",
    "thingGroupId": "4139cd61-10fa-4c40-b867-0fc6209dca4d"
}
```

2. Next, use the `create-mitigation-action` command to create a mitigation action. In the following example, we create a mitigation action called `detect_mitigation_action` with the ARN of the IAM role that is used to apply the mitigation action. We also define the type of action and the parameters for that action. In this case, our mitigation will move things to our previously created thing group called `ThingGroupForDetectMitigationAction`.

```bash
aws iot create-mitigation-action --action-name detect_mitigation_action --role-arn arn:aws:iam::123456789012:role/MitigationActionValidRole --action-params 
'{
    "addThingsToThingGroupParams": {
        "thingGroupNames": ["ThingGroupForDetectMitigationAction"],
        "overrideDynamicGroups": false
    }
}'
```

Output:

```json
{

```

953
3. Use the **start-detect-mitigation-actions-task** command to start your mitigation actions task. task-id, target and actions are required parameters.

```bash
aws iot start-detect-mitigation-actions-task \
  --task-id taskIdForMitigationAction \
  --target '{ "violationIds" : [ "violationId-1", "violationId-2" ] }' \
  --actions "detect_mitigation_action" \
  --include-only-active-violations \
  --include-suppressed-alerts
```

Output:

```json
{
  "taskId": "taskIdForMitigationAction"
}
```

4. (Optional) To view mitigation action executions included in a task, use the **list-detect-mitigation-actions-executions** command.

```bash
aws iot list-detect-mitigation-actions-executions \
  --task-id taskIdForMitigationAction \
  --max-items 5 \n  --page-size 4
```

Output:

```json
{
  "actionsExecutions": [
    {
      "taskId": "e56ee95e - f4e7 - 459 c - b60a - 2701784290 af",
      "violationId": "214_821e58a8bf8b41c4a2b53675a251551",
      "actionName": "underTest_MAThingGroup71232127",
      "thingName": "cancelDetectMitigationActionsTask143821b",
      "executionStartDate": "Thu Jan 07 18: 35: 21 UTC 2021",
      "executionEndDate": "Thu Jan 07 18: 35: 21 UTC 2021",
      "status": "SUCCESSFUL",
    }
  ]
}
```

5. (Optional) Use the **describe-detect-mitigation-actions-task** command to get information about a mitigation action task.

```bash
aws iot describe-detect-mitigation-actions-task \
  --task-id taskIdForMitigationAction
```

Output:

```json
{
  "taskSummary": {
    "taskId": "taskIdForMitigationAction",
    "taskStatus": "SUCCESSFUL",
    "taskStartTime": 1609988361.224,
    "taskEndTime": 1609988362.281,
  }
}
```
6. (Optional) To get a list of your mitigation actions tasks, use the `list-detect-mitigation-actions-tasks` command.

```bash
aws iot list-detect-mitigation-actions-tasks \
  --start-time 1609985315 \
  --end-time 1609988915 \
  --max-items 5 \
  --page-size 4
```

Output:

```json
{
  "tasks": [
    {
      "taskId": "taskIdForMitigationAction",
      "taskStatus": "SUCCESSFUL",
      "taskStartTime": 1609988361.224,
      "taskEndTime": 1609988362.281,
      "target": {
        "securityProfileName": "security-profile-for-smart-lights",
        "behaviorName": "num-messages-sent-ml-behavior"
      },
      "violationEventOccurrenceRange": {
        "startTime": 1609986633.0,
        "endTime": 1609987833.0
      },
      "onlyActiveViolationsIncluded": true,
      "suppressedAlertsIncluded": true,
      "actionsDefinition": [ ]
    }
  ]
}
```
Customize when and how you view AWS IoT Device Defender audit results

AWS IoT Device Defender audit provides periodic security checks to confirm AWS IoT devices and resources are following best practices. For each check, the audit results are categorized as compliant or non-compliant, where non-compliance results in console warning icons. To reduce noise from repeating known issues, the audit finding suppression feature allows you to temporarily silence these non-compliance notifications.

You can suppress select audit checks for a specific resource or account for a predetermined time period. An audit check result that has been suppressed is categorized as a suppressed finding, separate from the compliant and non-compliant categories. This new category doesn't trigger an alarm like a non-compliant result. This allows you to reduce non-compliance notification disturbances during known maintenance periods or until an update is scheduled to be completed.

Getting started

The following sections detail how you can use audit finding suppressions to suppress a Device certificate expiring check in the console and CLI. If you'd like to follow either of the demonstrations, you must first create two expiring certificates for Device Defender to detect.

Use the following to create your certificates.

- Create and register a CA certificate (p. 305)
- Create a client certificate using your CA certificate. In step 3, set your days parameter to 1.
If you're using the CLI to create your certificates, enter the following command.

```
openssl x509 -req \
    -in device_cert_csr_filename \
    -CA root_ca_pem_filename \
    -CAkey root_ca_key_filename \
    -CAcreateserial \
    -out device_cert_pem_filename \
    -days 1 -sha256
```

**Customize your audit findings in the console**

The following walkthrough uses an account with two expired device certificates that trigger a non-compliant audit check. In this scenario, we want to disable the warning because our developers are testing a new feature that'll address the problem. We create an audit finding suppression for each certificate to stop the audit result from being non-compliant for the next week.

1. We will first run an on-demand audit to show that the expired device certificate check is non-compliant.

   From the AWS IoT console, choose Defend from the left sidebar, then Audit, and then Results. On the Audit Results page, choose Create. The Create a new audit window opens. Choose Create.

   From the on-demand audit results, we can see that "Device certificate expiring" is non-compliant for two resources.

2. Now, we’d like to disable the "Device certificate expiring" non-compliant check warning because our developers are testing new features that will fix the warning.

   From the left sidebar under Defend, choose Audit, and then choose Finding suppressions. On the Audit finding suppressions page, choose Create.
3. On the **Create an audit finding suppression** window, we need to fill out the following.

- **Audit check**: We select *Device certificate expiring*, because that is the audit check we'd like to suppress.
- **Resource identifier**: We input the device certificate ID of one of the certificates we'd like to suppress audit findings for.
- **Suppression duration**: We select *1 week*, because that's how long we'd like to suppress the *Device certificate expiring* audit check for.
- **Description (optional)**: We add a note that describes why we're suppressing this audit finding.
Create an audit finding suppression

Suppressing an audit finding on a specified resource makes that resource non-compliant to the resource for the specified audit check will no longer report the resource as compliant.

Audit check

Device certificate expiring

Resource identifier

Device certificate id

```
b4490bd64c5cf85182f3182f1c03e70017e483f17b
``` 

Suppression duration

1 week

Description (optional)

Developer updates
After we've filled out the fields, choose **Create**. We see a success banner after the audit finding suppression has been created.

4. We've suppressed an audit finding for one of the certificates and now we need to suppress the audit finding for the second certificate. We could use the same suppression method that we used in step 3, but we will be using a different method for demonstration purposes.

   From the left sidebar under **Defend**, choose **Audit**, and then choose **Results**. On the **Audit results** page, choose the audit with the non-compliant resource. Then, select the resource under **Non-compliant checks**. In our case, we select "Device certificate expiring".

5. On the **Device certificate expiring** page, under **Non-compliant policy** choose the option button next to the finding that needs to be suppressed. Next, choose the **Actions** dropdown menu, and then choose the duration for which you'd like finding to be suppressed. In our case, we choose 1 week as we did for the other certificate. On the **Confirm suppression** window, choose **Enable suppression**.
Mitigation

Consult your security best practices for how to proceed:
1. Provision a new certificate and attach it to the device.
2. Verify that the new certificate is valid and the device is using the new certificate.
3. Mark the old certificate as "INACTIVE" in the AWS IoT Console.
4. Detach the old certificate from the device. (See Device certificates.)

Non-compliant certificate (2)

Finding

- 28022a890964e991852c79a28a83eb89
- dc9b109c705ed7e68588bc54eef86f1c
We see a success banner after the audit finding suppression has been created. Now, both audit findings have been suppressed for 1 week while our developers work on a solution to address the warning.

Customize your audit findings in the CLI

The following walkthrough uses an account with an expired device certificate that trigger a non-compliant audit check. In this scenario, we want to disable the warning because our developers are testing a new feature that'll address the problem. We create an audit finding suppression for the certificate to stop the audit result from being non-compliant for the next week.

We use the following CLI commands.

- `create-audit-suppression`
- `describe-audit-suppression`
- `update-audit-suppression`
- `delete-audit-suppression`
- `list-audit-suppressions`

1. Use the following command to enable the audit.

   ```bash
   aws iot update-account-audit-configuration --audit-check-configurations "{"DEVICE_CERTIFICATE_EXPIRING_CHECK" : {"enabled" : true}}"
   ```

   Output:

   None.

2. Use the following command to run an on-demand audit that targets the `DEVICE_CERTIFICATE_EXPIRING_CHECK` audit check.

   ```bash
   aws iot start-on-demand-audit-task --target-check-names DEVICE_CERTIFICATE_EXPIRING_CHECK
   ```

   Output:

   ```
   {
   "taskId": "787ed873b69cb4d6c8d6ee9696dc5"
   }
   ```

3. Use the `describe-account-audit-configuration` command to describe the audit configuration. We want to confirm that we’ve turned on the audit check for `DEVICE_CERTIFICATE_EXPIRING_CHECK`.

   ```bash
   aws iot describe-account-audit-configuration
   ```

   Output:

   ```
   {
   "roleArn": "arn:aws:iam::<accountid>:role/service-role/project",
   "auditNotificationTargetConfigurations": {
   "SNS": {
   ```
"targetArn": "arn:aws:sns:us-east-1:<accountid>:project_sns",
"roleArn": "arn:aws:iam::<accountid>:role/service-role/project",
"enabled": true
},
"auditCheckConfigurations": {
  "AUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK": {
    "enabled": false
  },
  "CA_CERTIFICATE_EXPIRING_CHECK": {
    "enabled": false
  },
  "CA_CERTIFICATE_KEY_QUALITY_CHECK": {
    "enabled": false
  },
  "CONFLICTING_CLIENT_IDS_CHECK": {
    "enabled": false
  },
  "DEVICE_CERTIFICATE_EXPIRING_CHECK": {
    "enabled": true
  },
  "DEVICE_CERTIFICATE_KEY_QUALITY_CHECK": {
    "enabled": false
  },
  "DEVICE_CERTIFICATE_SHARED_CHECK": {
    "enabled": false
  },
  "IOT_POLICY_OVERLY_PERMISSIVE_CHECK": {
    "enabled": true
  },
  "IOT_ROLE_ALIAS_ALLOWS_ACCESS_TO_UNUSED_SERVICES_CHECK": {
    "enabled": false
  },
  "IOT_ROLE_ALIAS_OVERLY_PERMISSIVE_CHECK": {
    "enabled": false
  },
  "LOGGING_DISABLED_CHECK": {
    "enabled": false
  },
  "REVOKED_CA_CERTIFICATE_STILL_ACTIVE_CHECK": {
    "enabled": false
  },
  "REVOKED_DEVICE_CERTIFICATE_STILL_ACTIVE_CHECK": {
    "enabled": false
  },
  "UNAUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK": {
    "enabled": false
  }
}

DEVICE_CERTIFICATE_EXPIRING_CHECK should have a value of true.

4. Use the `list-audit-task` command to identify the completed audit tasks.

```bash
aws iot list-audit-tasks \
  --task-status "COMPLETED" \
  --start-time 2020-07-31 \
  --end-time 2020-08-01
```

Output:

```json
{
}
```
The taskId of the audit you ran in step 1 should have a taskStatus of COMPLETED.

5. Use the describe-audit-task command to get details about the completed audit using the taskId output from the previous step. This command lists details about your audit.

```
aws iot describe-audit-task \
--task-id "787ed873b69cb4d6c6c8ae6ddd06996c5"
```

Output:

```
{
  "taskId": "787ed873b69cb4d6c6c8ae6ddd06996c5",
  "taskType": "SCHEDULED_AUDIT_TASK",
  "taskStartTimestamp": 1596168096.157,
  "taskStatistics": {
    "totalChecks": 1,
    "inProgressChecks": 0,
    "waitingForDataCollectionChecks": 0,
    "compliantChecks": 0,
    "nonCompliantChecks": 1,
    "failedChecks": 0,
    "cancelledChecks": 0,
    "totalResourcesCount": 195,
    "nonCompliantResourcesCount": 2
  },
  "scheduledAuditName": "AWSIoTDeviceDefenderDailyAudit",
  "auditDetails": {
    "DEVICE_CERTIFICATE_EXPIRING_CHECK": {
      "checkRunStatus": "COMPLETED_NON_COMPLIANT",
      "checkCompliant": false,
      "totalResourcesCount": 195,
      "nonCompliantResourcesCount": 2
    }
  }
}
```

6. Use the list-audit-findings command to find the non-compliant certificate ID so that we can suspend the audit alerts for this resource.

```
aws iot list-audit-findings \
--start-time 2020-07-31 \
--end-time 2020-08-01
```

Output:

```
{
  "findings": [
    {
      "findingId": "296cc3d39f806bf9d8f8de20d0ce533a1",
      "taskId": "787ed873b69cb4d6c6c8ae6ddd06996c5",
      "checkName": "DEVICE_CERTIFICATE_EXPIRING_CHECK",
      "taskStartTimestamp": 1596168096.157,
      "findingTime": 1596168096.651,
      "severity": "MEDIUM",
```

964
7. Use the `create-audit-suppression` command to suppress notifications for the `DEVICE_CERTIFICATE_EXPIRING_CHECK` audit check for a device certificate with the id `c7691e<shortened>` until 2020-08-20.

```bash
aws iot create-audit-suppression \
--check-name DEVICE_CERTIFICATE_EXPIRING_CHECK \ 
--resource-identifier deviceCertificateId="c7691e<shortened>" \
--no-suppress-indefinitely \ 
--expiration-date 2020-08-20
```

8. Use the `list-audit-suppression` command to confirm the audit suppression setting and get details about the suppression.

```bash
aws iot list-audit-suppressions
```

Output:

```
{
    "suppressions": [
        {
            "checkName": "DEVICE_CERTIFICATE_EXPIRING_CHECK",
            "resourceIdentifier": {
                "deviceCertificateId": "c7691e<shortened>"
            },
            "expirationDate": 1597881600.0,
            "suppressIndefinitely": false
        }
    ]
}
```
9. The `update-audit-suppression` command can be used to update the audit finding suppression. The example below updates the expiration-date to 08/21/20.

```bash
aws iot update-audit-suppression
   --check-name DEVICE_CERTIFICATE_EXPIRING_CHECK
   --resource-identifier deviceCertificateId=c7691e<shortened>
   --expiration-date 2020-08-21
```

10. The `delete-audit-suppression` command can be used to remove an audit finding suppression.

```bash
aws iot delete-audit-suppression
   --check-name DEVICE_CERTIFICATE_EXPIRING_CHECK
   --resource-identifier deviceCertificateId="c7691e<shortened>"
```

To confirm deletion, use the `list-audit-suppressions` command.

```bash
aws iot list-audit-suppressions
```

Output:

```json
{
   "suppressions": []
}
```

In this tutorial, we showed you how to suppress a Device certificate expiring check in the console and CLI. For more information about audit finding suppressions, see [Audit finding suppressions](p. 1022)

---

**Audit**

An AWS IoT Device Defender audit looks at account- and device-related settings and policies to ensure security measures are in place. An audit can help you detect any drifts from security best practices or access policies (for example, multiple devices using the same identity, or overly permissive policies that allow one device to read and update data for many other devices). You can run audits as needed (on-demand audits) or schedule them to be run periodically (scheduled audits).

An AWS IoT Device Defender audit runs a set of predefined checks for common IoT security best practices and device vulnerabilities. Examples of predefined checks include policies that grant permission to read or update data on multiple devices, devices that share an identity (X.509 certificate), or certificates that are expiring or have been revoked but are still active.

**Issue severity**

Issue severity indicates the level of concern associated with each identified instance of noncompliance and the recommended time to remediation.
Critical

Non compliant audit checks with this severity identify issues that require urgent attention. Critical issues often allow bad actors with little sophistication and no insider knowledge or special credentials to easily gain access to or control of your assets.

High

Non compliant audit checks with this severity require urgent investigation and remediation planning after critical issues are addressed. Like critical issues, high severity issues often provide bad actors with access to or control of your assets. However, high severity issues are often more difficult to exploit. They might require special tools, insider knowledge, or specific setups.

Medium

Non compliant audit checks with this severity present issues that need attention as part of your continuous security posture maintenance. Medium severity issues might cause negative operational impact, such as unplanned outages due to malfunction of security controls. These issues might also provide bad actors with limited access to or control of your assets, or might facilitate parts of their malicious actions.

Low

Non compliant audit checks with this severity often indicate security best practices were overlooked or bypassed. Although they might not cause an immediate security impact on their own, these lapses can be exploited by bad actors. Like medium severity issues, low severity issues require attention as part of your continuous security posture maintenance.

Next steps

To understand the types of audit checks that can be performed, see Audit checks (p. 967). For information about service quotas that apply to audits, see Service Quotas.

Audit checks

Note

When you enable a check, data collection starts immediately. If there is a large amount of data in your account to collect, results of the check might not be available for some time after you enabled it.

The following audit checks are supported:

- Intermediate CA revoked for active device certificates check (p. 968)
- Revoked CA certificate still active (p. 969)
- Device certificate shared (p. 969)
- Device certificate key quality (p. 970)
- CA certificate key quality (p. 971)
- Unauthenticated Cognito role overly permissive (p. 972)
- Authenticated Cognito role overly permissive (p. 978)
- AWS IoT policies overly permissive (p. 984)
- AWS IoT policy potentially misconfigured (p. 988)
- Role alias overly permissive (p. 991)
- Role alias allows access to unused services (p. 992)
- CA certificate expiring (p. 992)
**Intermediate CA revoked for active device certificates check**

Use this check to identify all related device certificates that are still active despite revoking an intermediate CA.

This check appears as INTERMEDIATE_CA_REVOKED_FOR_ACTIVE_DEVICE_CERTIFICATES_CHECK in the CLI and API.

**Severity:** Critical

**Details**

The following reason codes are returned when this check finds noncompliance:

- INTERMEDIATE_CA_REVOKED_BY_ISSUER

**Why it matters**

The intermediate CA revoked for active device certificates check assess device identity and trust, by determining if there are active device certificates in AWS IoT Core where the intermediate issuing CAs have been revoked in the CA chain.

A revoked intermediate CA should no longer be used to sign any other CA or device certificates in CA chain. Newly added devices with certificates signed using this CA certificate after the intermediate CA is revoked will pose a security threat.

**How to fix it**

Review the device certificate registration activity for the time after the CA certificate was revoked. Follow your security best practices to mitigate the situation. You might want to:

1. Provision new certificates, that are signed by a different CA, for the affected devices.
2. Verify that the new certificates are valid, and that the devices can use them to connect.
3. Use UpdateCertificate to mark the old certificate as REVOKED in AWS IoT. You can also use mitigation actions to:
   - Apply the UPDATE_DEVICE_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the ADD_THINGS_TO_THING_GROUP mitigation action to add the device to a group where you can take action on it.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.
   - Review the device certificate registration activity for the time after the intermediate CA certificate was revoked and consider revoking any device certificates that might have been issued with it during this time. You can use ListRelatedResourcesForAuditFinding to list the device certificates signed by the CA certificate and UpdateCertificate to revoke a device certificate.
   - Detach the old certificate from the device. (See DetachThingPrincipal.)

For more information, see Mitigation actions (p. 1081).
Revoked CA certificate still active

A CA certificate was revoked, but is still active in AWS IoT.

This check appears as REVOKE_CA_CERTIFICATE_STILL_ACTIVE_CHECK in the CLI and API.

Severity: Critical

Details

A CA certificate is marked as revoked in the certificate revocation list maintained by the issuing authority, but is still marked as ACTIVE or PENDING_TRANSFER in AWS IoT.

The following reason codes are returned when this check finds a noncompliant CA certificate:

- CERTIFICATE_REVOKED_BY_ISSUER

Why it matters

A revoked CA certificate should no longer be used to sign device certificates. It might have been revoked because it was compromised. Newly added devices with certificates signed using this CA certificate might pose a security threat.

How to fix it

1. Use UpdateCACertificate to mark the CA certificate as INACTIVE in AWS IoT. You can also use mitigation actions to:
   - Apply the UPDATE_CA_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action to implement a custom response in response to the Amazon SNS message.

   For more information, see Mitigation actions (p. 1081).

2. Review the device certificate registration activity for the time after the CA certificate was revoked and consider revoking any device certificates that might have been issued with it during this time. You can use ListCertificatesByCA to list the device certificates signed by the CA certificate and UpdateCertificate to revoke a device certificate.

Device certificate shared

Multiple, concurrent connections use the same X.509 certificate to authenticate with AWS IoT.

This check appears as DEVICE_CERTIFICATE_SHARED_CHECK in the CLI and API.

Severity: Critical

Details

When performed as part of an on-demand audit, this check looks at the certificates and client IDs that were used by devices to connect during the 31 days before the start of the audit up to 2 hours before the check is run. For scheduled audits, this check looks at data from 2 hours before the last time the audit was run to 2 hours before the time this instance of the audit started. If you have taken steps to mitigate this condition during the time checked, note when the concurrent connections were made to determine if the problem persists.

The following reason codes are returned when this check finds a noncompliant certificate:

- CERTIFICATE_SHARED_BY_MULTIPLE_DEVICES
In addition, the findings returned by this check include the ID of the shared certificate, the IDs of the clients using the certificate to connect, and the connect/disconnect times. Most recent results are listed first.

**Why it matters**

Each device should have a unique certificate to authenticate with AWS IoT. When multiple devices use the same certificate, this might indicate that a device has been compromised. Its identity might have been cloned to further compromise the system.

**How to fix it**

Verify that the device certificate has not been compromised. If it has, follow your security best practices to mitigate the situation.

If you use the same certificate on multiple devices, you might want to:

1. Provision new, unique certificates and attach them to each device.
2. Verify that the new certificates are valid and the devices can use them to connect.
3. Use `updateCertificate` to mark the old certificate as REVOKED in AWS IoT. You can also use mitigation actions to do the following:
   - Apply the UPDATE_DEVICE_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the ADD_THINGS_TO_THING_GROUP mitigation action to add the device to a group where you can take action on it.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.

   For more information, see [Mitigation actions (p. 1081)](Mitigation actions (p. 1081)).
4. Detach the old certificate from each of the devices.

**Device certificate key quality**

AWS IoT customers often rely on TLS mutual authentication using X.509 certificates for authenticating to AWS IoT message broker. These certificates and their certificate authority certificates must be registered in their AWS IoT account before they are used. AWS IoT performs basic sanity checks on these certificates when they are registered. These checks include:

- They must be in a valid format.
- They must be signed by a registered certificate authority.
- They must still be within their validity period (in other words, they haven't expired).
- Their cryptographic key sizes must meet a minimum required size (for RSA keys, they must be 2048 bits or larger).

This audit check provides the following additional tests of the quality of your cryptographic key:

- CVE-2008-0166 – Check whether the key was generated using OpenSSL 0.9.8c-1 up to versions before 0.9.8g-9 on a Debian-based operating system. Those versions of OpenSSL use a random number generator that generates predictable numbers, making it easier for remote attackers to conduct brute force guessing attacks against cryptographic keys.
- CVE-2017-15361 – Check whether the key was generated by the Infineon RSA library 1.02.013 in Infineon Trusted Platform Module (TPM) firmware, such as versions before 0000000000000422 – 4.34, before 000000000000062b – 6.43, and before 00000000000008521 – 133.33. That library mishandles RSA key generation, making it easier for attackers to defeat some cryptographic protection
mechanisms through targeted attacks. Examples of affected technologies include BitLocker with TPM 1.2, YubiKey 4 (before 4.3.5) PGP key generation, and the Cached User Data encryption feature in Chrome OS.

AWS IoT Device Defender reports certificates as noncompliant if they fail these tests. This check appears as DEVICE_CERTIFICATE_KEY_QUALITY_CHECK in the CLI and API.

**Severity:** Critical

**Details**

This check applies to device certificates that are ACTIVE or PENDING_TRANSFER.

The following reason codes are returned when this check finds a noncompliant certificate:

- CERTIFICATE_KEY_VULNERABILITY_CVE-2017-15361
- CERTIFICATE_KEY_VULNERABILITY_CVE-2008-0166

**Why it matters**

When a device uses a vulnerable certificate, attackers can more easily compromise that device.

**How to fix it**

Update your device certificates to replace those with known vulnerabilities.

If you are using the same certificate on multiple devices, you might want to:

1. Provision new, unique certificates and attach them to each device.
2. Verify that the new certificates are valid and the devices can use them to connect.
3. Use UpdateCertificate to mark the old certificate as REVOKED in AWS IoT. You can also use mitigation actions to:
   - Apply the UPDATE_DEVICE_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the ADD_THINGS_TO_THING_GROUP mitigation action to add the device to a group where you can take action on it.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.

   For more information, see Mitigation actions (p. 1081).
4. Detach the old certificate from each of the devices.

**CA certificate key quality**

AWS IoT customers often rely on TLS mutual authentication using X.509 certificates for authenticating to AWS IoT message broker. These certificates and their certificate authority certificates must be registered in their AWS IoT account before they are used. AWS IoT performs basic sanity checks on these certificates when they are registered, including:

- The certificates are in a valid format.
- The certificates are within their validity period (in other words, not expired).
- Their cryptographic key sizes meet a minimum required size (for RSA keys, they must be 2048 bits or larger).
This audit check provides the following additional tests of the quality of your cryptographic key:

- **CVE-2008-0166** – Check whether the key was generated using OpenSSL 0.9.8c-1 up to versions before 0.9.8g-9 on a Debian-based operating system. Those versions of OpenSSL use a random number generator that generates predictable numbers, making it easier for remote attackers to conduct brute force guessing attacks against cryptographic keys.

- **CVE-2017-15361** – Check whether the key was generated by the Infineon RSA library 1.02.013 in Infineon Trusted Platform Module (TPM) firmware, such as versions before 0000000000000422 – 4.34, before 0000000000000062b – 6.43, and before 0000000000008521 – 133.33. That library mishandles RSA key generation, making it easier for attackers to defeat some cryptographic protection mechanisms through targeted attacks. Examples of affected technologies include BitLocker with TPM 1.2, YubiKey 4 (before 4.3.5) PGP key generation, and the Cached User Data encryption feature in Chrome OS.

AWS IoT Device Defender reports certificates as noncompliant if they fail these tests.

This check appears as **CA_CERTIFICATE_KEY_QUALITY_CHECK** in the CLI and API.

**Severity:** Critical

**Details**

This check applies to CA certificates that are ACTIVE or PENDING_TRANSFER.

The following reason codes are returned when this check finds a noncompliant certificate:

- CERTIFICATE_KEY_VULNERABILITY_CVE-2017-15361
- CERTIFICATE_KEY_VULNERABILITY_CVE-2008-0166

**Why it matters**

Newly added devices signed using this CA certificate might pose a security threat.

**How to fix it**

1. Use **UpdateCACertificate** to mark the CA certificate as INACTIVE in AWS IoT. You can also use mitigation actions to:
   - Apply the UPDATE_CA_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.

   For more information, see Mitigation actions (p. 1081).

2. Review the device certificate registration activity for the time after the CA certificate was revoked and consider revoking any device certificates that might have been issued with it during this time. (Use **ListCertificatesByCA** to list the device certificates signed by the CA certificate and **UpdateCertificate** to revoke a device certificate.)

**Unauthenticated Cognito role overly permissive**

A policy attached to an unauthenticated Amazon Cognito identity pool role is considered too permissive because it grants permission to perform any of the following AWS IoT actions:

- Manage or modify things.
- Read thing administrative data.
- Manage non-thing related data or resources.
Or, because it grants permission to perform the following AWS IoT actions on a broad set of devices:

- Use MQTT to connect, publish, or subscribe to reserved topics (including shadow or job execution data).
- Use API commands to read or modify shadow or job execution data.

In general, devices that connect using an unauthenticated Amazon Cognito identity pool role should have only limited permission to publish and subscribe to thing-specific MQTT topics or use the API commands to read and modify thing-specific data related to shadow or job execution data.

This check appears as UNAUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK in the CLI and API.

Severity: Critical

Details

For this check, AWS IoT Device Defender audits all Amazon Cognito identity pools that have been used to connect to the AWS IoT message broker during the 31 days before the audit execution. All Amazon Cognito identity pools from which either an authenticated or unauthenticated Amazon Cognito identity connected are included in the audit.

The following reason codes are returned when this check finds a noncompliant unauthenticated Amazon Cognito identity pool role:

- ALLOWS_ACCESS_TO_IOT_ADMIN_ACTIONS
- ALLOWS_BROAD_ACCESS_TO_IOT_DATA_PLANE_ACTIONS

Why it matters

Because unauthenticated identities are never authenticated by the user, they pose a much greater risk than authenticated Amazon Cognito identities. If an unauthenticated identity is compromised, it can use administrative actions to modify account settings, delete resources, or gain access to sensitive data. Or, with broad access to device settings, it can access or modify shadows and jobs for all devices in your account. A guest user might use the permissions to compromise your entire fleet or launch a DDOS attack with messages.

How to fix it

A policy attached to an unauthenticated Amazon Cognito identity pool role should grant only those permissions required for a device to do its job. We recommend the following steps:

1. Create a new compliant role.
2. Create a Amazon Cognito identity pool and attach the compliant role to it.
3. Verify that your identities can access AWS IoT using the new pool.
4. After verification is complete, attach the compliant role to the Amazon Cognito identity pool that was flagged as noncompliant.

You can also use mitigation actions to:

- Apply the PUBLISH_FINDINGS_TO_SNS mitigation action to implement a custom response in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).
Manage or modify things

The following AWS IoT API actions are used to manage or modify things. Permission to perform these actions should not be granted to devices that connect through an unauthenticated Amazon Cognito identity pool.

- AddThingToThingGroup
- AttachThingPrincipal
- CreateThing
- DeleteThing
- DetachThingPrincipal
- ListThings
- ListThingsInThingGroup
- RegisterThing
- RemoveThingFromThingGroup
- UpdateThing
- UpdateThingGroupsForThing

Any role that grants permission to perform these actions on even a single resource is considered noncompliant.

Read thing administrative data

The following AWS IoT API actions are used to read or modify thing data. Devices that connect through an unauthenticated Amazon Cognito identity pool should not be given permission to perform these actions.

- DescribeThing
- ListJobExecutionsForThing
- ListThingGroupsForThing
- ListThingPrincipals

Example

- noncompliant:

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "iot:DescribeThing",
            "iot:ListJobExecutionsForThing",
            "iot:ListThingGroupsForThing",
            "iot:ListThingPrincipals"
         ],
         "Resource": [
            "arn:aws:iot:region:account-id::/thing/MyThing"
         ]
      }
   ]
}
```
This allows the device to perform the specified actions even though it is granted for one thing only.

Manage non-things

Devices that connect through an unauthenticated Amazon Cognito identity pool should not be given permission to perform AWS IoT API actions other than those discussed in these sections. You can manage your account with an application that connects through an unauthenticated Amazon Cognito identity pool by creating a separate identity pool not used by devices.

Subscribe/publish to MQTT topics

MQTT messages are sent through the AWS IoT message broker and are used by devices to perform many actions, including accessing and modifying shadow state and job execution state. A policy that grants permission to a device to connect, publish, or subscribe to MQTT messages should restrict these actions to specific resources as follows:

Connect

- noncompliant:

```
arn:aws:iot:region:account-id:client/*
```

The wildcard * allows any device to connect to AWS IoT.

```
arn:aws:iot:region:account-id:client/${iot:ClientId}
```

Unless `iot:Connection.Thing.IsAttached` is set to true in the condition keys, this is equivalent to the wildcard * in the previous example.

- compliant:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [ "iot:Connect" ],
      "Condition": {
        "Bool": { "iot:Connection.Thing.IsAttached": "true" }
      }
    }
  ]
}
```

The resource specification contains a variable that matches the device name used to connect. The condition statement further restricts the permission by checking that the certificate used by the MQTT client matches that attached to the thing with the name used.

Publish

- noncompliant:

```
```

This allows the device to update the shadow of any device (* = all devices).
This allows the device to read, update, or delete the shadow of any device.

- compliant:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [ "iot:Publish" ],
            "Resource": [
            ]
        }
    ]
}
```

The resource specification contains a wildcard, but it only matches any shadow-related topic for the device whose thing name is used to connect.

**Subscribe**

- noncompliant:

```json
arn:aws:iot:region:account-id:topicfilter/$aws/things/*
```

This allows the device to subscribe to reserved shadow or job topics for all devices.

```json
arn:aws:iot:region:account-id:topicfilter/$aws/things/*
```

The same as the previous example, but using the # wildcard.

```json
```

This allows the device to see shadow updates on any device (+ = all devices).

- compliant:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [ "iot:Subscribe" ],
            "Resource": [
            ]
        }
    ]
}
```

The resource specifications contain wildcards, but they only match any shadow-related topic and any job-related topic for the device whose thing name is used to connect.
Receive

- compliant:

```
arn:aws:iot:region:account-id:topicfilter/$aws/things/*
```

This is allowed because the device can receive messages only from topics on which it has permission to subscribe.

Read/modify shadow or job data

A policy that grants permission to a device to perform an API action to access or modify device shadows or job execution data should restrict these actions to specific resources. The following are the API actions:

- DeleteThingShadow
- GetThingShadow
- UpdateThingShadow
- DescribeJobExecution
- GetPendingJobExecutions
- StartNextPendingJobExecution
- UpdateJobExecution

Example

- noncompliant:

```
arn:aws:iot:region:account-id:thing/*/  
```

This allows the device to perform the specified action on any thing.

- compliant:

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "iot:DeleteThingShadow",
            "iot:GetThingShadow",
            "iot:UpdateThingShadow",
            "iot:DescribeJobExecution",
            "iot:GetPendingJobExecutions",
            "iot:StartNextPendingJobExecution",
            "iot:UpdateJobExecution"
         ],
         "Resource": [
            "arn:aws:iot:region:account-id:/thing/MyThing1",
            "arn:aws:iot:region:account-id:/thing/MyThing2"
         ]
      }
   ]
}
```

This allows the device to perform the specified actions on two things only.
Authenticated Cognito role overly permissive

A policy attached to an authenticated Amazon Cognito identity pool role is considered too permissive because it grants permission to perform the following AWS IoT actions:

- Manage or modify things.
- Manage non-thing related data or resources.

Or, because it grants permission to perform the following AWS IoT actions on a broad set of devices:

- Read thing administrative data.
- Use MQTT to connect/publish/subscribe to reserved topics (including shadow or job execution data).
- Use API commands to read or modify shadow or job execution data.

In general, devices that connect using an authenticated Amazon Cognito identity pool role should have only limited permission to read thing-specific administrative data, publish and subscribe to thing-specific MQTT topics, or use the API commands to read and modify thing-specific data related to shadow or job execution data.

This check appears as AUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK in the CLI and API.

Severity: Critical

Details

For this check, AWS IoT Device Defender audits all Amazon Cognito identity pools that have been used to connect to the AWS IoT message broker during the 31 days before the audit execution. All Amazon Cognito identity pools from which either an authenticated or unauthenticated Amazon Cognito identity connected are included in the audit.

The following reason codes are returned when this check finds a noncompliant authenticated Amazon Cognito identity pool role:

- ALLOWS_BROAD_ACCESS_TO_IOT_THING_ADMIN_READ_ACTIONS
- ALLOWS_ACCESS_TO_IOT_NON_THING_ADMIN_ACTIONS
- ALLOWS_ACCESS_TO_IOT_THING_ADMIN_WRITE_ACTIONS

Why it matters

If an authenticated identity is compromised, it can use administrative actions to modify account settings, delete resources, or gain access to sensitive data.

How to fix it

A policy attached to an authenticated Amazon Cognito identity pool role should grant only those permissions required for a device to do its job. We recommend the following steps:

1. Create a new compliant role.
2. Create a Amazon Cognito identity pool and attach the compliant role to it.
3. Verify that your identities can access AWS IoT using the new pool.
4. After verification is complete, attach the role to the Amazon Cognito identity pool that was flagged as noncompliant.
You can also use mitigation actions to:

- Apply the PUBLISH_FINDINGS_TO_SNS mitigation action to implement a custom response in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).

**Manage or modify things**

The following AWS IoT API actions are used to manage or modify things so permission to perform these should not be granted to devices connecting through an authenticated Amazon Cognito identity pool:

- AddThingToThingGroup
- AttachThingPrincipal
- CreateThing
- DeleteThing
- DetachThingPrincipal
- ListThings
- ListThingsInThingGroup
- RegisterThing
- RemoveThingFromThingGroup
- UpdateThing
- UpdateThingGroupsForThing

Any role that grants permission to perform these actions on even a single resource is considered noncompliant.

**Manage non-things**

Devices that connect through an authenticated Amazon Cognito identity pool should not be given permission to perform AWS IoT API actions other than those discussed in these sections. To manage your account with an application that connects through an authenticated Amazon Cognito identity pool, create a separate identity pool not used by devices.

**Read thing administrative data**

The following AWS IoT API actions are used to read thing data, so devices that connect through an authenticated Amazon Cognito identity pool should be given permission to perform these on a limited set of things only:

- DescribeThing
- ListJobExecutionsForThing
- ListThingGroupsForThing
- ListThingPrincipals

- noncompliant:

```
arn:aws:iot:region:account-id:thing/*
```

This allows the device to perform the specified action on any thing.
• compliant:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:DescribeThing",
        "iot:ListJobExecutionsForThing",
        "iot:ListThingGroupsForThing",
        "iot:ListThingPrincipals"
      ],
      "Resource": [
        "arn:aws:iot:region:account-id:/thing/MyThing"
      ]
    }
  ]
}
```

This allows the device to perform the specified actions on only one thing.

• compliant:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:DescribeThing",
        "iot:ListJobExecutionsForThing",
        "iot:ListThingGroupsForThing",
        "iot:ListThingPrincipals"
      ],
      "Resource": [
        "arn:aws:iot:region:account-id:/thing/MyThing*"
      ]
    }
  ]
}
```

This is compliant because, although the resource is specified with a wildcard (*), it is preceded by a specific string, and that limits the set of things accessed to those with names that have the given prefix.

• noncompliant:

```
arn:aws:iot:region:account-id:thing/*
```

This allows the device to perform the specified action on any thing.

• compliant:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:DescribeThing",
```

980
Audit checks

"iot:ListJobExecutionsForThing",
"iot:ListThingGroupsForThing",
"iot:ListThingPrincipals"
],
"Resource": [
"arn:aws:iot:region:account-id:/thing/MyThing"
]
}

This allows the device to perform the specified actions on only one thing.

- compliant:

{
 "Version": "2012-10-17",
 "Statement": [
  {
   "Effect": "Allow",
   "Action": ["iot:DescribeThing",
               "iot:ListJobExecutionsForThing",
               "iot:ListThingGroupsForThing",
               "iot:ListThingPrincipals"
             ],
   "Resource": [
                "arn:aws:iot:region:account-id:/thing/MyThing*"
               ]
  }
]
}

This is compliant because, although the resource is specified with a wildcard (*), it is preceded by a specific string, and that limits the set of things accessed to those with names that have the given prefix.

Subscribe/publish to MQTT topics

MQTT messages are sent through the AWS IoT message broker and are used by devices to perform many different actions, including accessing and modifying shadow state and job execution state. A policy that grants permission to a device to connect, publish, or subscribe to MQTT messages should restrict these actions to specific resources as follows:

Connect

- noncompliant:

```
arn:aws:iot:region:account-id:client/*
```

The wildcard * allows any device to connect to AWS IoT.

```
arn:aws:iot:region:account-id:client/${iot:ClientId}
```

Unless `iot:Connection.Thing.IsAttached` is set to true in the condition keys, this is equivalent to the wildcard * in the previous example.

- compliant:

```
{...
```
"Version": "2012-10-17",
"Statement": [
  {
    "Effect": "Allow",
    "Action": [ "iot:Connect" ],
    "Condition": {
      "Bool": { "iot:Connection.Thing.IsAttached": "true" }
    }
  }
]

The resource specification contains a variable that matches the device name used to connect, and the condition statement further restricts the permission by checking that the certificate used by the MQTT client matches that attached to the thing with the name used.

**Publish**

- noncompliant:


  This allows the device to update the shadow of any device (* = all devices).


  This allows the device to read/update/delete the shadow of any device.

- compliant:

  {
    "Version": "2012-10-17",
    "Statement": [
      {
        "Effect": "Allow",
        "Action": [ "iot:Publish" ],
        "Condition": {}
      }
    ]
  }

  The resource specification contains a wildcard, but it only matches any shadow-related topic for the device whose thing name is used to connect.

**Subscribe**

- noncompliant:

  arn:aws:iot:region:account-id:topicfilter/$aws/things/*

  This allows the device to subscribe to reserved shadow or job topics for all devices.


  The same as the previous example, but using the # wildcard.
Audit checks

This allows the device to see shadow updates on any device (+ = all devices).

- compliant:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [ "iot:Subscribe" ],
                      ],
        }
    ]
}
```

The resource specifications contain wildcards, but they only match any shadow-related topic and any job-related topic for the device whose thing name is used to connect.

**Receive**

- compliant:

```
arn:aws:iot:region:account-id:topicfilter/$aws/things/*
```

This is compliant because the device can receive messages only from topics on which it has permission to subscribe.

**Read or modify shadow or job data**

A policy that grants permission to a device to perform an API action to access or modify device shadows or job execution data should restrict these actions to specific resources. The following are the API actions:

- DeleteThingShadow
- GetThingShadow
- UpdateThingShadow
- DescribeJobExecution
- GetPendingJobExecutions
- StartNextPendingJobExecution
- UpdateJobExecution

**Examples**

- noncompliant:

```
arn:aws:iot:region:account-id:thing/*
```

This allows the device to perform the specified action on any thing.
• compliant:

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Action": [
            "iot:DeleteThingShadow",
            "iot:GetThingShadow",
            "iot:UpdateThingShadow",
            "iot:DescribeJobExecution",
            "iot:GetPendingJobExecutions",
            "iot:StartNextPendingJobExecution",
            "iot:UpdateJobExecution"
         ],
         "Resource": [
            "arn:aws:iot:region:account-id:/thing/MyThing1",
            "arn:aws:iot:region:account-id:/thing/MyThing2"
         ]
      }
   ]
}
```

This allows the device to perform the specified actions on only two things.

**AWS IoT policies overly permissive**

An AWS IoT policy gives permissions that are too broad or unrestricted. It grants permission to send or receive MQTT messages for a broad set of devices, or grants permission to access or modify shadow and job execution data for a broad set of devices.

In general, a policy for a device should grant access to resources associated with just that device and no or very few other devices. With some exceptions, using a wildcard (for example, "*") to specify resources in such a policy is considered too broad or unrestricted.

This check appears as **IOT_POLICY_OVERLY_PERMISSIVE_CHECK** in the CLI and API.

**Severity:** Critical

**Details**

The following reason code is returned when this check finds a noncompliant AWS IoT policy:

• **ALLOWS_BROAD_ACCESS_TO_IOT_DATA_PLANE_ACTIONS**

**Why it matters**

A certificate, Amazon Cognito identity, or thing group with an overly permissive policy can, if compromised, impact the security of your entire account. An attacker could use such broad access to read or modify shadows, jobs, or job executions for all your devices. Or an attacker could use a compromised certificate to connect malicious devices or launch a DDOS attack on your network.

**How to fix it**

Follow these steps to fix any noncompliant policies attached to things, thing groups, or other entities:

1. Use CreatePolicyVersion to create a new, compliant version of the policy. Set the setAsDefault flag to true. (This makes this new version operative for all entities that use the policy.)
2. Use `ListTargetsForPolicy` to get a list of targets (certificates, thing groups) that the policy is attached to and determine which devices are included in the groups or which use the certificates to connect.

3. Verify that all associated devices are able to connect to AWS IoT. If a device is unable to connect, use `SetPolicyVersion` to roll back the default policy to the previous version, revise the policy, and try again.

You can use mitigation actions to:

- Apply the `REPLACE_DEFAULT_POLICY_VERSION` mitigation action on your audit findings to make this change.
- Apply the `PUBLISH_FINDINGS_TO_SNS` mitigation action if you want to implement a custom response in response to the Amazon SNS message.

For more information, see [Mitigation actions (p. 1081)](https://docs.aws.amazon.com/iot/latest/developerguide/mitigation-actions.html).

Use [AWS IoT policy variables (p. 340)](https://docs.aws.amazon.com/iot/latest/developerguide/policy-variables.html) to dynamically reference AWS IoT resources in your policies.

**MQTT permissions**

MQTT messages are sent through the AWS IoT message broker and are used by devices to perform many actions, including accessing and modifying shadow state and job execution state. A policy that grants permission to a device to connect, publish, or subscribe to MQTT messages should restrict these actions to specific resources as follows:

**Connect**

- **noncompliant:**
  ```
  arn:aws:iot:region:account-id:client/*
  
  The wildcard * allows any device to connect to AWS IoT.
  
  arn:aws:iot:region:account-id:client/${iot:ClientId}
  
  Unless `iot:Connection.Thing.IsAttached` is set to true in the condition keys, this is equivalent to the wildcard * as in the previous example.
  
  - **compliant:**
  ```
  ```javascript
  ```

  The resource specification contains a variable that matches the device name used to connect. The condition statement further restricts the permission by checking that the certificate used by the MQTT client matches that attached to the thing with the name used.
Publish

- noncompliant:


  This allows the device to update the shadow of any device (* = all devices).


  This allows the device to read, update, or delete the shadow of any device.

- compliant:

  ```json
  {
    "Version": "2012-10-17",
    "Statement": [
      {
        "Effect": "Allow",
        "Action": [ "iot:Publish" ],
      }
    ]
  }
  
  The resource specification contains a wildcard, but it only matches any shadow-related topic for the device whose thing name is used to connect.

Subscribe

- noncompliant:

  arn:aws:iot:region:account-id:topicfilter/$aws/things/*

  This allows the device to subscribe to reserved shadow or job topics for all devices.

  arn:aws:iot:region:account-id:topicfilter/$aws/things/*

  The same as the previous example, but using the # wildcard.


  This allows the device to see shadow updates on any device (+ = all devices).

- compliant:

  ```json
  {
    "Version": "2012-10-17",
    "Statement": [
      {
        "Effect": "Allow",
        "Action": [ "iot:Subscribe" ],
      }
    ]
  }
  ```
The resource specifications contain wildcards, but they only match any shadow-related topic and any job-related topic for the device whose thing name is used to connect.

Receive

- compliant:


  This is compliant because the device can only receive messages from topics on which it has permission to subscribe.

Shadow and job permissions

A policy that grants permission to a device to perform an API action to access or modify device shadows or job execution data should restrict these actions to specific resources. The following are the API actions:

- `DeleteThingShadow`
- `GetThingShadow`
- `UpdateThingShadow`
- `DescribeJobExecution`
- `GetPendingJobExecutions`
- `StartNextPendingJobExecution`
- `UpdateJobExecution`

Examples

- noncompliant:

  `arn:aws:iot:region:account-id:thing/*`

  This allows the device to perform the specified action on any thing.

- compliant:

  ```json
  {
    "Version": "2012-10-17",
    "Statement": [
      {
        "Effect": "Allow",
        "Action": [
          "iot:DeleteThingShadow",
          "iot:GetThingShadow",
          "iot:UpdateThingShadow",
          "iot:DescribeJobExecution",
          "iot:GetPendingJobExecutions",
          "iot:StartNextPendingJobExecution",
          "iot:UpdateJobExecution"
        ],
        "Resource": [
          "arn:aws:iot:region:account-id:/thing/MyThing1",
          ...
        ]
      }
    ]
  }
  ```
This allows the device to perform the specified actions on only two things.

**AWS IoT policy potentially misconfigured**

An AWS IoT policy was identified as potentially misconfigured. Misconfigured policies, including overly permissive policies, can cause security incidents like allowing devices access to unintended resources.

The **AWS IoT policy potentially misconfigured** check is a warning for you to make sure that only intended actions are allowed before updating the policy.

In the CLI and API, this check appears as IOT_POLICY_POTENTIAL_MISCONFIGURATION.Check.

**Severity:** Medium

**Details**

AWS IoT returns the following reason code when this check finds a potentially misconfigured AWS IoT policy:

- POLICY_CONTAINS_MQTT_WILDCARDS_IN_DENY_STATEMENT
- TOPIC_FILTERS_INTENDED_TO_DENY_ALLOWED_USING_WILDCARDS

**Why it matters**

Misconfigured policies can lead to unintended consequences by providing more permissions to devices than required. We recommend careful consideration of the policy to limit access to resources and prevent security threats.

**Policy contains MQTT wildcards in deny statement example**

The **AWS IoT policy potentially misconfigured** check inspects for MQTT wildcard characters (+ or #) in deny statements. Wildcards are treated as literal strings by AWS IoT policies and can make the policy overly permissive.

The following example is intended to deny subscribing to topics related to building/control_room by using the MQTT wildcard # in policies. However, MQTT wildcards don't have a wildcard meaning in AWS IoT policies and devices can subscribe to building/control_room/data1.

The **AWS IoT policy potentially misconfigured** check will flag this policy with reason code POLICY_CONTAINS_MQTT_WILDCARDS_IN_DENY_STATEMENT.

```json
{
  "Version": "2012-10-17",
  "Statement": [ {
    "Effect": "Allow",
    "Action": "iot:Subscribe",
  }, {
    "Effect": "Deny",
    "Action": "iot:Subscribe",
    "Resource": "arn:aws:iot:region:account-id:/thing/MyThing2"
  }
]
}
```
The following is an example of a properly configured policy. Devices don't have permission to subscribe to subtopics of `building/control_room/` and don't have permissions to receive messages from subtopics of `building/control_room/`.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iot:Subscribe",
    },
    {
      "Effect": "Deny",
      "Action": "iot:Subscribe",
      "Resource": "arn:aws:iot:region:account-id:topicfilter/building/control_room/*"
    },
    {
      "Effect": "Allow",
      "Action": "iot:Receive",
    },
    {
      "Effect": "Deny",
      "Action": "iot:Receive",
      "Resource": "arn:aws:iot:region:account-id:topic/building/control_room/*"
    }
  ]
}
```

**Topic filters intended to deny allowed using wildcards example**

The following example policy is intended to deny subscribing to topics related to `building/control_room` by denying the resource `building/control_room/*`. However, devices can send requests to subscribe to `building/#` and receive messages from all topics related to `building`, including `building/control_room/data1`.

The **AWS IoT policy potentially misconfigured** check will flag this policy with reason code `TOPIC_FILTERS_INTENDED_TO_DENY_ALLOWED_USING_WILDCARDS`.

The following example policy has permissions to receive message on `building/control_room` topics:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iot:Subscribe",
    }
  ]
}
```
The following is an example of a properly configured policy. Devices don’t have permission to subscribe to subtopics of `building/control_room/` and don’t have permissions to receive messages from subtopics of `building/control_room/`.

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "iot:Subscribe",
    },
    {
      "Effect": "Deny",
      "Action": "iot:Subscribe",
      "Resource": "arn:aws:iot:region:account-id:topicfilter/building/control_room/\*"
    },
    {
      "Effect": "Allow",
      "Action": "iot:Receive",
    },
    {
      "Effect": "Deny",
      "Action": "iot:Receive",
      "Resource": "arn:aws:iot:region:account-id:topic/building/control_room/\*"
    }
  ]
}
```

**Note**

This check might report false positives. We recommend that you evaluate any flagged policies and mark false positives resources using audit suppressions.

**How to fix it**

This check flags potentially misconfigured policies so there might be false positives. Mark any false positives using [audit suppressions](p. 1022) so they aren't flagged in the future.

You can also follow these steps to fix any noncompliant policies attached to things, thing groups, or other entities:

1. Use [CreatePolicyVersion](#) to create a new, compliant version of the policy. Set the `setAsDefault` flag to true. (This makes this new version operative for all entities that use the policy.)

For examples of creating AWS IoT policies for common use cases, see Publish/Subscribe policy examples (p. 353) in the AWS IoT Core Developer Guide.

2. Verify that all associated devices are able to connect to AWS IoT. If a device is unable to connect, use [SetPolicyVersion](#) to roll back the default policy to the previous version, revise the policy, and try again.
You can use mitigation actions to:

- Apply the `REPLACE_DEFAULT_POLICY_VERSION` mitigation action on your audit findings to make this change.
- Apply the `PUBLISH_FINDINGS_TO_SNS` mitigation action if you want to implement a custom response in response to the Amazon SNS message.

For more information, see [Mitigation actions](p. 1081).

Use [AWS IoT policy variables](p. 340) to dynamically reference AWS IoT resources in your policies.

**Role alias overly permissive**

AWS IoT role alias provides a mechanism for connected devices to authenticate to AWS IoT using X.509 certificates and then obtain short-lived AWS credentials from an IAM role that is associated with an AWS IoT role alias. The permissions for these credentials must be scoped down using access policies with authentication context variables. If your policies are not configured correctly, you could leave yourself exposed to an escalation of privilege attack. This audit check ensures that the temporary credentials provided by AWS IoT role aliases are not overly permissive.

This check is triggered if one of the following conditions are found:

- The policy provides administrative permissions to any services used in the past year by this role alias (for example, "iot:*", "dynamodb:*", "iam:*", and so on).
- The policy provides broad access to thing metadata actions, access to restricted AWS IoT actions, or broad access to AWS IoT data plane actions.
- The policy provides access to security auditing services such as "iam", "cloudtrail", "guardduty", "inspector", or "trustedadvisor".

This check appears as `IOT_ROLE_ALIAS_OVERLY_PERMISSIVE_CHECK` in the CLI and API.

**Severity:** Critical

**Details**

The following reason codes are returned when this check finds a noncompliant IoT policy:

- ` ALLOWS_BROAD_ACCESS_TO_USED_SERVICES`
- ` ALLOWS_ACCESS_TO_SECURITY_AUDITING_SERVICES`
- ` ALLOWS_BROAD_ACCESS_TO_IOT_THING_ADMIN_READ_ACTIONS`
- ` ALLOWS_ACCESS_TO_IOT_NON_THING_ADMIN_ACTIONS`
- ` ALLOWS_ACCESS_TO_IOT_THING_ADMIN_WRITE_ACTIONS`
- ` ALLOWS_BROAD_ACCESS_TO_IOT_DATA_PLANE_ACTIONS`

**Why it matters**

By limiting permissions to those that are required for a device to perform its normal operations, you reduce the risks to your account if a device is compromised.

**How to fix it**

Follow these steps to fix any noncompliant policies attached to things, thing groups, or other entities:

1. Follow the steps in [Authorizing direct calls to AWS services using AWS IoT Core credential provider](p. 379) to apply a more restrictive policy to your role alias.
You can use mitigation actions to:

- Apply the `PUBLISH_FINDINGS_TO_SNS` mitigation action if you want to implement a custom action in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).

**Role alias allows access to unused services**

AWS IoT role alias provides a mechanism for connected devices to authenticate to AWS IoT using X.509 certificates and then obtain short-lived AWS credentials from an IAM role that is associated with an AWS IoT role alias. The permissions for these credentials must be scoped down using access policies with authentication context variables. If your policies are not configured correctly, you could leave yourself exposed to an escalation of privilege attack. This audit check ensures that the temporary credentials provided by AWS IoT role aliases are not overly permissive.

This check is triggered if the role alias has access to services that haven't been used for the AWS IoT device in the last year. For example, the audit reports if you have an IAM role linked to the role alias that has only used AWS IoT in the past year but the policy attached to the role also grants permission to "iam:getRole" and "dynamodb:PutItem".

This check appears as `IOT_ROLE_ALIAS_ALLOWS_ACCESS_TO_UNUSED_SERVICES_CHECK` in the CLI and API.

Severity: **Medium**

**Details**

The following reason codes are returned when this check finds a noncompliant AWS IoT policy:

- ALLOWS_ACCESS_TO_UNUSED_SERVICES

**Why it matters**

By limiting permissions to those services that are required for a device to perform its normal operations, you reduce the risks to your account if a device is compromised.

**How to fix it**

Follow these steps to fix any noncompliant policies attached to things, thing groups, or other entities:

1. Follow the steps in Authorizing direct calls to AWS services using AWS IoT Core credential provider (p. 379) to apply a more restrictive policy to your role alias.

You can use mitigation actions to:

- Apply the `PUBLISH_FINDINGS_TO_SNS` mitigation action if you want to implement a custom action in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).

**CA certificate expiring**

A CA certificate is expiring within 30 days or has expired.

This check appears as `CA_CERTIFICATE_EXPIRING_CHECK` in the CLI and API.
Severity: **Medium**

**Details**

This check applies to CA certificates that are ACTIVE or PENDING_TRANSFER.

The following reason codes are returned when this check finds a noncompliant CA certificate:

- CERTIFICATE_APPROACHING_EXPIRATION
- CERTIFICATE_PAST_EXPIRATION

**Why it matters**

An expired CA certificate should not be used to sign new device certificates.

**How to fix it**

Consult your security best practices for how to proceed. You might want to:

1. Register a new CA certificate with AWS IoT.
2. Verify that you are able to sign device certificates using the new CA certificate.
3. Use `UpdateCACertificate` to mark the old CA certificate as INACTIVE in AWS IoT. You can also use mitigation actions to do the following:
   - Apply the UPDATE_CA_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).

**Conflicting MQTT client IDs**

Multiple devices connect using the same client ID.

This check appears as CONFLICTING_CLIENT_IDS_CHECK in the CLI and API.

Severity: **High**

**Details**

Multiple connections were made using the same client ID, causing an already connected device to be disconnected. The MQTT specification allows only one active connection per client ID, so when another device connects using the same client ID, it knocks the previous one off the connection.

When performed as part of an on-demand audit, this check looks at how client IDs were used to connect during the 31 days prior to the start of the audit. For scheduled audits, this check looks at data from the last time the audit was run to the time this instance of the audit started. If you have taken steps to mitigate this condition during the time checked, note when the connections/disconnections were made to determine if the problem persists.

The following reason codes are returned when this check finds noncompliance:

- DUPLICATE_CLIENT_ID_ACROSS_CONNECTIONS

The findings returned by this check also include the client ID used to connect, principal IDs, and disconnect times. The most recent results are listed first.
Why it matters

Devices with conflicting IDs are forced to constantly reconnect, which might result in lost messages or leave a device unable to connect.

This might indicate that a device or a device's credentials have been compromised, and might be part of a DDoS attack. It is also possible that devices are not configured correctly in the account or a device has a bad connection and is forced to reconnect several times per minute.

How to fix it

Register each device as a unique thing in AWS IoT, and use the thing name as the client ID to connect. Or use a UUID as the client ID when connecting the device over MQTT. You can also use mitigation actions to:

- Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).

Device certificate expiring

A device certificate is expiring within 30 days or has expired.

This check appears as DEVICE_CERTIFICATE_EXPIRING_CHECK in the CLI and API.

Severity: Medium

Details

This check applies to device certificates that are ACTIVE or PENDING_TRANSFER.

The following reason codes are returned when this check finds a noncompliant device certificate:

- CERTIFICATE_APPROACHING_EXPIRATION
- CERTIFICATE_PAST_EXPIRATION

Why it matters

A device certificate should not be used after it expires.

How to fix it

Consult your security best practices for how to proceed. You might want to:

1. Provision a new certificate and attach it to the device.
2. Verify that the new certificate is valid and the device is able to use it to connect.
3. Use UpdateCertificate to mark the old certificate as INACTIVE in AWS IoT. You can also use mitigation actions to:
   - Apply the UPDATE_DEVICE_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the ADD_THINGS_TO_THING_GROUP mitigation action to add the device to a group where you can take action on it.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.
Revoked device certificate still active

A revoked device certificate is still active.

This check appears as REVOKED_DEVICE_CERTIFICATE_STILL_ACTIVE_CHECK in the CLI and API.

Severity: Medium

Details

A device certificate is in its CA's certificate revocation list, but it is still active in AWS IoT.

This check applies to device certificates that are ACTIVE or PENDING_TRANSFER.

The following reason codes are returned when this check finds noncompliance:

- CERTIFICATE_REVOLED_BY_ISSUER

Why it matters

A device certificate is usually revoked because it has been compromised. It is possible that it has not yet been revoked in AWS IoT due to an error or oversight.

How to fix it

Verify that the device certificate has not been compromised. If it has, follow your security best practices to mitigate the situation. You might want to:

1. Provision a new certificate for the device.
2. Verify that the new certificate is valid and the device is able to use it to connect.
3. Use UpdateCertificate to mark the old certificate as REVOKED in AWS IoT. You can also use mitigation actions to:
   - Apply the UPDATE_DEVICE_CERTIFICATE mitigation action on your audit findings to make this change.
   - Apply the ADD_THINGS_TO_THING_GROUP mitigation action to add the device to a group where you can take action on it.
   - Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).

4. Detach the old certificate from the device. (See DetachThingPrincipal.)

Logging disabled

AWS IoT logs are not enabled in Amazon CloudWatch. Verifies both V1 and V2 logging.

This check appears as LOGGING_DISABLED_CHECK in the CLI and API.

Severity: Low
Details

The following reason codes are returned when this check finds noncompliance:

- LOGGING_DISABLED

Why it matters

AWS IoT logs in CloudWatch provide visibility into behaviors in AWS IoT, including authentication failures and unexpected connects and disconnects that might indicate that a device has been compromised.

How to fix it

Enable AWS IoT logs in CloudWatch. See Monitoring Tools (p. 425). You can also use mitigation actions to:

- Apply the ENABLE_IOT_LOGGING mitigation action on your audit findings to make this change.
- Apply the PUBLISH_FINDINGS_TO_SNS mitigation action if you want to implement a custom response in response to the Amazon SNS message.

For more information, see Mitigation actions (p. 1081).

Audit commands

Manage audit settings

Use UpdateAccountAuditConfiguration to configure audit settings for your account. This command allows you to enable those checks you want to be available for audits, set up optional notifications, and configure permissions.

Check these settings with DescribeAccountAuditConfiguration.

Use DeleteAccountAuditConfiguration to delete your audit settings. This restores all default values, and effectively disables audits because all checks are disabled by default.

UpdateAccountAuditConfiguration

Configures or reconfigures the Device Defender audit settings for this account. Settings include how audit notifications are sent and which audit checks are enabled or disabled.

Synopsis

```
aws iot update-account-audit-configuration
  [--role-arn <value>]
  [--audit-notification-target-configurations <value>]
  [--audit-check-configurations <value>]
  [--cli-input-json <value>]
  [--generate-cli-skeleton]
```

cli-input-json format

```
{
  "roleArn": "string",
  "auditNotificationTargetConfigurations": {
    "string": {
      "targetArn": "string",
```
```json
{
    "roleArn": "string",
    "enabled": "boolean"
}
,
"auditCheckConfigurations": {
    "string": {
        "enabled": "boolean"
    }
}
}
```

### cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roleArn</td>
<td>string</td>
<td>The ARN of the role that grants permission to AWS IoT to access information about your devices, policies, certificates, and other items when performing an audit.</td>
</tr>
<tr>
<td>auditNotificationTargetConfigurations</td>
<td>map</td>
<td>Information about the targets to which audit notifications are sent.</td>
</tr>
<tr>
<td>targetArn</td>
<td>string</td>
<td>The ARN of the target (SNS topic) to which audit notifications are sent.</td>
</tr>
<tr>
<td>roleArn</td>
<td>string</td>
<td>The ARN of the role that grants permission to send notifications to the target.</td>
</tr>
<tr>
<td>enabled</td>
<td>boolean</td>
<td>True if notifications to the target are enabled.</td>
</tr>
<tr>
<td>auditCheckConfigurations</td>
<td>map</td>
<td>Specifies which audit checks are enabled and disabled for this account. Use DescribeAccountAuditConfiguration to see the list of all checks, including those that are currently enabled. Some data collection might start immediately when certain checks are enabled. When a check is disabled, any data collected so far in relation to the check is deleted. You cannot disable a check if it is used by any scheduled audit. You must first delete the check from the scheduled audit or delete the scheduled audit itself. On the first call to UpdateAccountAuditConfiguration, this parameter is required.</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>enabled</td>
<td>boolean</td>
<td>True if this audit check is enabled for this account.</td>
</tr>
</tbody>
</table>

and must specify at least one enabled check.

Output

None

Errors

InvalidRequestException

The contents of the request were invalid.

ThrottlingException

The rate exceeds the limit.

InternalFailureException

An unexpected error has occurred.

DescribeAccountAuditConfiguration

Gets information about the Device Defender audit settings for this account. Settings include how audit notifications are sent and which audit checks are enabled or disabled.

Synopsis

```bash
aws iot describe-account-audit-configuration  \\
  [--cli-input-json <value>]  \\
  [--generate-cli-skeleton]
```

cli-input-json format

```json
{
}
```

Output

```json
{
  "roleArn": "string",
  "auditNotificationTargetConfigurations": {
    "string": {
      "targetArn": "string",
      "roleArn": "string",
      "enabled": "boolean"
    }
  },
  "auditCheckConfigurations": {
    "string": {
      "enabled": "boolean"
    }
  }
}```
CLI output fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roleArn</td>
<td>string</td>
<td>The ARN of the role that grants permission to AWS IoT to access information about your devices, policies, certificates, and other items when performing an audit. On the first call to <code>UpdateAccountAuditConfiguration</code>, this parameter is required.</td>
</tr>
<tr>
<td>auditNotificationTargetConfigurations</td>
<td>map</td>
<td>Information about the targets to which audit notifications are sent for this account.</td>
</tr>
<tr>
<td>targetArn</td>
<td>string</td>
<td>The ARN of the target (SNS topic) to which audit notifications are sent.</td>
</tr>
<tr>
<td>roleArn</td>
<td>string</td>
<td>The ARN of the role that grants permission to send notifications to the target.</td>
</tr>
<tr>
<td>enabled</td>
<td>boolean</td>
<td>True if notifications to the target are enabled.</td>
</tr>
<tr>
<td>auditCheckConfigurations</td>
<td>map</td>
<td>Which audit checks are enabled and disabled for this account.</td>
</tr>
<tr>
<td>enabled</td>
<td>boolean</td>
<td>True if this audit check is enabled for this account.</td>
</tr>
</tbody>
</table>

Errors

ThrottlingException

The rate exceeds the limit.

InternalFailureException

An unexpected error has occurred.

DeleteAccountAuditConfiguration

Restores the default settings for Device Defender audits for this account. Any configuration data you entered is deleted and all audit checks are reset to disabled.

Synopsis

```
aws iot delete-account-audit-configuration [ --delete-scheduled-audits | --no-delete-scheduled-audits ] [ --cli-input-json <value> ]
```
Audit commands

[--generate-cli-skeleton]

cli-input-json format

{
    "deleteScheduledAudits": "boolean"
}

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>deleteScheduledAudits</td>
<td>boolean</td>
<td>If true, all scheduled audits are deleted.</td>
</tr>
</tbody>
</table>

Output
None

Errors

InvalidRequestException
   The contents of the request were invalid.
ResourceNotFoundException
   The specified resource does not exist.
ThrottlingException
   The rate exceeds the limit.
InternalFailureException
   An unexpected error has occurred.

Schedule audits

Use CreateScheduledAudit to create one or more scheduled audits. This command allows you to specify the checks you want to perform during an audit and how often the audit should be run.

Keep track of your scheduled audits with ListScheduledAudits and DescribeScheduledAudit.

Change an existing scheduled audit with UpdateScheduledAudit or delete it with DeleteScheduledAudit.

CreateScheduledAudit

Creates a scheduled audit that is run at a specified time interval.

Synopsis

```
aws iot create-scheduled-audit \
   --frequency <value> \n   [--day-of-month <value>] \n   [--day-of-week <value>]
```
Audit commands

```
--target-check-names <value> \
[--tags <value>] \
--scheduled-audit-name <value> \
[--cli-input-json <value>] \
[--generate-cli-skeleton]
```

cli-input-json format

```
{
  "frequency": "string",
  "dayOfMonth": "string",
  "dayOfWeek": "string",
  "targetCheckNames": [\
    "string"
  ],
  "tags": [\
    {
      "Key": "string",
      "Value": "string"
    }
  ],
  "scheduledAuditName": "string"
}
```

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>frequency</td>
<td>string</td>
<td>How often the scheduled audit takes place. Can be one of DAILY, WEEKLY, BIWEEKLY, or MONTHLY. The actual start time of each audit is determined by the system. enum: DAILY</td>
</tr>
<tr>
<td>dayOfMonth</td>
<td>string</td>
<td>The day of the month on which the scheduled audit takes place. Can be 1 through 31 or LAST. This field is required if the frequency parameter is set to MONTHLY. If days 29-31 are specified, and the month does not have that many days, the audit takes place on the LAST day of the month. pattern: ^[1-9][12][0-9]</td>
</tr>
<tr>
<td>dayOfWeek</td>
<td>string</td>
<td>The day of the week on which the scheduled audit takes place. Can be one of SUN, MON, TUE, WED, THU, FRI, or SAT. This field is required if the frequency parameter is set to WEEKLY or BIWEEKLY. enum: SUN</td>
</tr>
</tbody>
</table>
Audit commands

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>targetCheckNames</td>
<td>list</td>
<td>Which checks are performed during the scheduled audit. Checks must be enabled for your account. (Use DescribeAccountAuditConfiguration to see the list of all checks, including those that are enabled or UpdateAccountAuditConfiguration to select which checks are enabled.)</td>
</tr>
<tr>
<td>tags</td>
<td>list</td>
<td>Metadata that can be used to manage the scheduled audit.</td>
</tr>
<tr>
<td></td>
<td>member: Tag</td>
<td></td>
</tr>
<tr>
<td></td>
<td>java class: java.util.List</td>
<td></td>
</tr>
<tr>
<td>Key</td>
<td>string</td>
<td>The tag's key.</td>
</tr>
<tr>
<td>Value</td>
<td>string</td>
<td>The tag's value.</td>
</tr>
<tr>
<td>scheduledAuditName</td>
<td>string</td>
<td>The name you want to give to the scheduled audit. (Maximum of 128 characters)</td>
</tr>
<tr>
<td></td>
<td>length- max:128 min:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pattern: [a-zA-Z0-9-_]+</td>
<td></td>
</tr>
</tbody>
</table>

Output

```json
{
  "scheduledAuditArn": "string"
}
```

**CLI output fields**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>scheduledAuditArn</td>
<td>string</td>
<td>The ARN of the scheduled audit.</td>
</tr>
</tbody>
</table>

**Errors**

- **InvalidRequestException**
  
  The contents of the request were invalid.

- **ThrottlingException**
  
  The rate exceeds the limit.

- **InternalFailureException**
  
  An unexpected error has occurred.

- **LimitExceededException**
  
  A limit has been exceeded.
ListScheduledAudits

Lists all of your scheduled audits.

Synopsis

```bash
aws iot list-scheduled-audits \[--next-token <value>\] \[--max-results <value>\] \[--cli-input-json <value>\] \[--generate-cli-skeleton\]
```

cli-input-json format

```json
{
  "nextToken": "string",
  "maxResults": "integer"
}
```

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>nextToken</td>
<td>string</td>
<td>The token for the next set of results.</td>
</tr>
<tr>
<td>maxResults</td>
<td>integer</td>
<td>The maximum number of results to return at one time. The default is 25.</td>
</tr>
</tbody>
</table>

Output

```json
{
  "scheduledAudits": [
    {
      "scheduledAuditName": "string",
      "scheduledAuditArn": "string",
      "frequency": "string",
      "dayOfMonth": "string",
      "dayOfWeek": "string"
    }
  ],
  "nextToken": "string"
}
```

CLI output fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>scheduledAudits</td>
<td>list</td>
<td>The list of scheduled audits.</td>
</tr>
<tr>
<td></td>
<td>member</td>
<td>ScheduledAuditMetadata</td>
</tr>
<tr>
<td></td>
<td>java class</td>
<td>java.util.List</td>
</tr>
<tr>
<td>scheduledAuditName</td>
<td>string</td>
<td>The name of the scheduled audit.</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>scheduledAuditArn</td>
<td>string</td>
<td>The ARN of the scheduled audit.</td>
</tr>
<tr>
<td>frequency</td>
<td>string</td>
<td>How often the scheduled audit takes place.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: DAILY</td>
</tr>
<tr>
<td>dayOfMonth</td>
<td>string</td>
<td>The day of the month on which the scheduled audit is run (if the frequency is MONTHLY). If days 29-31 are specified, and the month does not have that many days, the audit takes place on the LAST day of the month.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pattern: ^([1-9]</td>
</tr>
<tr>
<td>dayOfWeek</td>
<td>string</td>
<td>The day of the week on which the scheduled audit is run (if the frequency is WEEKLY or BIWEEKLY).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: SUN</td>
</tr>
<tr>
<td>nextToken</td>
<td>string</td>
<td>A token that can be used to retrieve the next set of results, or null if there are no more results.</td>
</tr>
</tbody>
</table>

**Errors**

InvalidRequestException

The contents of the request were invalid.

ThrottlingException

The rate exceeds the limit.

InternalFailureException

An unexpected error has occurred.

**DescribeScheduledAudit**

Gets information about a scheduled audit.

**Synopsis**

```
aws iot describe-scheduled-audit \
  --scheduled-audit-name <value> \
  [--cli-input-json <value>] \
  [--generate-cli-skeleton]
```
cli-input-json format

```json
{
  "scheduledAuditName": "string"
}
```

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>scheduledAuditName</td>
<td>string</td>
<td>The name of the scheduled audit whose information you want to get.</td>
</tr>
<tr>
<td>length- max:128 min:1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pattern: [a-zA-Z0-9-_]+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Output

```json
{
  "frequency": "string",
  "dayOfMonth": "string",
  "dayOfWeek": "string",
  "targetCheckNames": [
    "string"
  ],
  "scheduledAuditName": "string",
  "scheduledAuditArn": "string"
}
```

CLI output fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>frequency</td>
<td>string</td>
<td>How often the scheduled audit takes place. One of DAILY, WEEKLY, BIWEEKLY, or MONTHLY. The actual start time of each audit is determined by the system.</td>
</tr>
<tr>
<td>dayOfMonth</td>
<td>string</td>
<td>The day of the month on which the scheduled audit takes place. Can be 1 through 31 or LAST. If days 29-31 are specified, and the month does not have that many days, the audit takes place on the LAST day of the month.</td>
</tr>
<tr>
<td>dayOfWeek</td>
<td>string</td>
<td>The day of the week on which the scheduled audit takes place. One of SUN, MON, TUE, WED, THU, FRI, or SAT.</td>
</tr>
</tbody>
</table>

1005
Audit commands

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>targetCheckNames</td>
<td>list</td>
<td>Which checks are performed during the scheduled audit. Checks must be enabled for your account. (Use DescribeAccountAuditConfiguration to see the list of all checks, including those that are enabled or use UpdateAccountAuditConfiguration to select which checks are enabled.)</td>
</tr>
<tr>
<td>scheduledAuditName</td>
<td>string</td>
<td>The name of the scheduled audit.</td>
</tr>
<tr>
<td>scheduledAuditArn</td>
<td>string</td>
<td>The ARN of the scheduled audit.</td>
</tr>
</tbody>
</table>

Errors

InvalidRequestException
- The contents of the request were invalid.

ResourceNotFoundException
- The specified resource does not exist.

ThrottlingException
- The rate exceeds the limit.

InternalFailureException
- An unexpected error has occurred.

UpdateScheduledAudit

Updates a scheduled audit, including which checks are performed and how often the audit takes place.

Synopsis

```
aws iot update-scheduled-audit
  [--frequency <value>] \n  [--day-of-month <value>] \n  [--day-of-week <value>] \n  [--target-check-names <value>] \n  --scheduled-audit-name <value> \n  [--cli-input-json <value>] \n  [--generate-cli-skeleton]
```

cli-input-json format

```
{
  "frequency": "string",
  "dayOfMonth": "string",
  "dayOfWeek": "string",
}
cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>frequency</td>
<td>string</td>
<td>How often the scheduled audit takes place. Can be one of DAILY, WEEKLY, BIWEEKLY, or MONTHLY. The actual start time of each audit is determined by the system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: DAILY</td>
</tr>
<tr>
<td>dayOfMonth</td>
<td>string</td>
<td>The day of the month on which the scheduled audit takes place. Can be 1 through 31 or LAST. This field is required if the frequency parameter is set to MONTHLY. If days 29-31 are specified, and the month does not have that many days, the audit takes place on the LAST day of the month.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pattern: ^([1-9]</td>
</tr>
<tr>
<td>dayOfWeek</td>
<td>string</td>
<td>The day of the week on which the scheduled audit takes place. Can be one of SUN, MON, TUE, WED, THU, FRI, or SAT. This field is required if the frequency parameter is set to WEEKLY or BIWEEKLY.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: SUN</td>
</tr>
<tr>
<td>targetCheckNames</td>
<td>list</td>
<td>Which checks are performed during the scheduled audit. Checks must be enabled for your account. (Use DescribeAccountAuditConfiguration to see the list of all checks, including those that are enabled or use UpdateAccountAuditConfiguration to select which checks are enabled.)</td>
</tr>
<tr>
<td></td>
<td>member: AuditCheckName</td>
<td></td>
</tr>
<tr>
<td>scheduledAuditName</td>
<td>string</td>
<td>The name of the scheduled audit. (Maximum of 128 characters)</td>
</tr>
<tr>
<td></td>
<td>length- max:128 min:1</td>
<td>pattern: [a-zA-Z0-9_-]+</td>
</tr>
</tbody>
</table>
Output

```json
{
  "scheduledAuditArn": "string"
}
```

### CLI output fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>scheduledAuditArn</td>
<td>string</td>
<td>The ARN of the scheduled audit.</td>
</tr>
</tbody>
</table>

### Errors

- **InvalidRequestException**
  - The contents of the request were invalid.
- **ResourceNotFoundException**
  - The specified resource does not exist.
- **ThrottlingException**
  - The rate exceeds the limit.
- **InternalFailureException**
  - An unexpected error has occurred.

### DeleteScheduledAudit

Deletes a scheduled audit.

### Synopsis

```bash
aws iot delete-scheduled-audit \
  --scheduled-audit-name <value>  \
  [--cli-input-json <value>] \
  [--generate-cli-skeleton]
```

**cli-input-json format**

```json
{
  "scheduledAuditName": "string"
}
```

### cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>scheduledAuditName</td>
<td>string</td>
<td>The name of the scheduled audit you want to delete.</td>
</tr>
<tr>
<td>length- max:128 min:1 pattern: [a-zA-Z0-9_]++</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Output
None

Errors

InvalidRequestException
   The contents of the request were invalid.
ResourceNotFoundException
   The specified resource does not exist.
ThrottlingException
   The rate exceeds the limit.
InternalFailureException
   An unexpected error has occurred.

Run an On-Demand audit

Use StartOnDemandAuditTask to specify the checks you want to perform and start an audit running right away.

StartOnDemandAuditTask

Starts an on-demand Device Defender audit.

Synopsis

```
aws iot start-on-demand-audit-task \
   --target-check-names <value> \
   [--cli-input-json <value>] \
   [--generate-cli-skeleton]
```

cli-input-json format

```
{
   "targetCheckNames": [
       "string"
   ]
}
```

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>targetCheckNames</td>
<td>list</td>
<td>Which checks are performed during the audit. The checks you specify must be enabled for your account or an exception occurs. Use DescribeAccountAuditConfiguration to see the list of all checks, including those that are enabled or use UpdateAccountAuditConfiguration to select which checks are enabled.</td>
</tr>
<tr>
<td></td>
<td>member: AuditCheckName</td>
<td></td>
</tr>
</tbody>
</table>


Output

```json
{
   "taskId": "string"
}
```

**CLI output fields**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>taskId</td>
<td>string</td>
<td>The ID of the on-demand audit you started.</td>
</tr>
<tr>
<td></td>
<td>length: 40 min:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pattern: [a-zA-Z0-9-]+</td>
<td></td>
</tr>
</tbody>
</table>

**Errors**

- **InvalidRequestException**
  - The contents of the request were invalid.

- **ThrottlingException**
  - The rate exceeds the limit.

- **InternalFailureException**
  - An unexpected error has occurred.

- **LimitExceededException**
  - A limit has been exceeded.

**Manage audit instances**

Use `DescribeAuditTask` to get information about a specific audit instance. If it has already run, the results include which checks failed and which passed, those that the system was unable to complete, and if the audit is still in progress, those it is still working on.

Use `ListAuditTasks` to find the audits that were run during a specified time interval.

Use `CancelAuditTask` to halt an audit in progress.

**DescribeAuditTask**

Gets information about a Device Defender audit.

**Synopsis**

```bash
aws iot describe-audit-task \
   --task-id <value> \
   [--cli-input-json <value>] \
   [--generate-cli-skeleton]
```

**cli-input-json format**

```json
{
   "taskId": "string"
}
```
cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>taskId</td>
<td>string</td>
<td>The ID of the audit whose information you want to get.</td>
</tr>
<tr>
<td></td>
<td>length= max:40 min:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pattern: [a-zA-Z0-9-]+</td>
<td></td>
</tr>
</tbody>
</table>

Output

```json
{
    "taskStatus": "string",
    "taskType": "string",
    "taskStartTime": "timestamp",
    "taskStatistics": {
        "totalChecks": "integer",
        "inProgressChecks": "integer",
        "waitingForDataCollectionChecks": "integer",
        "compliantChecks": "integer",
        "nonCompliantChecks": "integer",
        "failedChecks": "integer",
        "canceledChecks": "integer"
    },
    "scheduledAuditName": "string",
    "auditDetails": {
        "string": {
            "checkRunStatus": "string",
            "checkCompliant": "boolean",
            "totalResourcesCount": "long",
            "nonCompliantResourcesCount": "long",
            "errorCode": "string",
            "message": "string"
        }
    }
}
```

CLI output fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>taskStatus</td>
<td>string</td>
<td>The status of the audit: one of IN_PROGRESS, COMPLETED, FAILED, or CANCELED.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: IN_PROGRESS</td>
</tr>
<tr>
<td>taskType</td>
<td>string</td>
<td>The type of audit: ON_DEMAND_AUDIT_TASK or SCHEDULED_AUDIT_TASK.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: ON_DEMAND_AUDIT_TASK</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>--------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>taskStartTime</td>
<td>timestamp</td>
<td>The time the audit started.</td>
</tr>
<tr>
<td>taskStatistics</td>
<td>TaskStatistics</td>
<td>Statistical information about the audit.</td>
</tr>
<tr>
<td>totalChecks</td>
<td>integer</td>
<td>The number of checks in this audit.</td>
</tr>
<tr>
<td>inProgressChecks</td>
<td>integer</td>
<td>The number of checks in progress.</td>
</tr>
<tr>
<td>waitingForDataCollectionChecks</td>
<td>integer</td>
<td>The number of checks waiting for data collection.</td>
</tr>
<tr>
<td>compliantChecks</td>
<td>integer</td>
<td>The number of checks that found compliant resources.</td>
</tr>
<tr>
<td>nonCompliantChecks</td>
<td>integer</td>
<td>The number of checks that found noncompliant resources.</td>
</tr>
<tr>
<td>failedChecks</td>
<td>integer</td>
<td>The number of checks.</td>
</tr>
<tr>
<td>canceledChecks</td>
<td>integer</td>
<td>The number of checks that did not run because the audit was canceled.</td>
</tr>
<tr>
<td>scheduledAuditName</td>
<td>string</td>
<td>The name of the scheduled audit (only if the audit was a scheduled audit).</td>
</tr>
<tr>
<td></td>
<td>length- max:128 min:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pattern: [a-zA-Z0-9_-]+</td>
<td></td>
</tr>
<tr>
<td>auditDetails</td>
<td>map</td>
<td>Detailed information about each check performed during this audit.</td>
</tr>
<tr>
<td>checkRunStatus</td>
<td>string</td>
<td>The completion status of this check, one of IN_PROGRESS, WAITING_FOR_DATA_COLLECTION, CANCELED, COMPLETED_COMPLIANT, COMPLETED_NON_COMPLIANT, or FAILED.</td>
</tr>
<tr>
<td></td>
<td>enum: IN_PROGRESS</td>
<td>WAITING_FOR_DATA_COLLECTION</td>
</tr>
<tr>
<td>checkCompliant</td>
<td>boolean</td>
<td>True if the check completed and found all resources compliant.</td>
</tr>
<tr>
<td>totalResourcesCount</td>
<td>long</td>
<td>The number of resources on which the check was performed.</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>nonCompliantResourcesCount</td>
<td>long</td>
<td>The number of resources that the check found noncompliant.</td>
</tr>
<tr>
<td>errorCode</td>
<td>string</td>
<td>The code of any error encountered when performing this check during this audit. One of INSUFFICIENT_PERMISSIONS or AUDIT_CHECK_DISABLED.</td>
</tr>
<tr>
<td>message</td>
<td>string</td>
<td>length- max:2048 The message associated with any error encountered when performing this check during this audit.</td>
</tr>
</tbody>
</table>

**Errors**

InvalidRequestException

The contents of the request were invalid.

ResourceNotFoundException

The specified resource does not exist.

ThrottlingException

The rate exceeds the limit.

InternalFailureException

An unexpected error has occurred.

**ListAuditTasks**

Lists the Device Defender audits that have been performed during a given time period.

**Synopsis**

```bash
aws iot list-audit-tasks \   
   --start-time <value> \   
   --end-time <value> \   
   [--task-type <value>] \   
   [--task-status <value>] \   
   [--next-token <value>] \   
   [--max-results <value>] \   
   [--cli-input-json <value>] \   
   [--generate-cli-skeleton]  
```

**cli-input-json format**

```json
{
   "startTime": "timestamp",
   "endTime": "timestamp",
   "taskType": "string",
   "taskStatus": "string",
   "nextToken": "string",
}```
"maxResults": "integer"
}

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>startTime</td>
<td>timestamp</td>
<td>The beginning of the time period. Audit information is retained for a limited time (180 days). Requesting a start time prior to what is retained results in an InvalidRequestException.</td>
</tr>
<tr>
<td>endTime</td>
<td>timestamp</td>
<td>The end of the time period.</td>
</tr>
<tr>
<td>taskType</td>
<td>string</td>
<td>A filter to limit the output to the specified type of audit: can be one of ON_DEMAND_AUDIT_TASK or SCHEDULED_AUDIT_TASK. enum: ON_DEMAND_AUDIT_TASK</td>
</tr>
<tr>
<td>taskStatus</td>
<td>string</td>
<td>A filter to limit the output to audits with the specified completion status: can be one of IN_PROGRESS, COMPLETED, FAILED, or CANCELED. enum: IN_PROGRESS</td>
</tr>
<tr>
<td>nextToken</td>
<td>string</td>
<td>The token for the next set of results.</td>
</tr>
<tr>
<td>maxResults</td>
<td>integer</td>
<td>The maximum number of results to return at one time. The default is 25. range- max:250 min:1</td>
</tr>
</tbody>
</table>

Output

```
{
    "tasks": [
        {
            "taskId": "string",
            "taskStatus": "string",
            "taskType": "string"
        }
    ],
    "nextToken": "string"
}
```
## CLI output fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tasks</td>
<td>list</td>
<td>The audits that were performed during the specified time period.</td>
</tr>
<tr>
<td></td>
<td>member: AuditTaskMetadata</td>
<td></td>
</tr>
<tr>
<td></td>
<td>java class: java.util.List</td>
<td></td>
</tr>
<tr>
<td>taskId</td>
<td>string</td>
<td>The ID of this audit.</td>
</tr>
<tr>
<td></td>
<td>length: max:40 min:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pattern: [a-zA-Z0-9-]+</td>
<td></td>
</tr>
<tr>
<td>taskStatus</td>
<td>string</td>
<td>The status of this audit: one of IN_PROGRESS, COMPLETED, FAILED, or CANCELED.</td>
</tr>
<tr>
<td></td>
<td>enum: IN_PROGRESS</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>COMPLETED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FAILED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CANCELED</td>
</tr>
<tr>
<td>taskType</td>
<td>string</td>
<td>The type of this audit: one of ON_DEMAND_AUDIT_TASK or SCHEDULED_AUDIT_TASK.</td>
</tr>
<tr>
<td></td>
<td>enum: ON_DEMAND_AUDIT_TASK</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SCHEDULED_AUDIT_TASK</td>
</tr>
<tr>
<td>nextToken</td>
<td>string</td>
<td>A token that can be used to retrieve the next set of results, or null if there are no additional results.</td>
</tr>
</tbody>
</table>

### Errors

InvalidRequestException

The contents of the request were invalid.

ThrottlingException

The rate exceeds the limit.

InternalFailureException

An unexpected error has occurred.

### CancelAuditTask

Cancels an audit that is in progress. The audit can be either scheduled or on-demand. If the audit is not in progress, an InvalidRequestException occurs.

### Synopsis

```
aws iot cancel-audit-task \
   --task-id <value> \
```
Audit commands

[--cli-input-json <value>] 
[--generate-cli-skeleton]

cli-input-json format

{
   "taskId": "string"
}

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>taskId</td>
<td>string</td>
<td>The ID of the audit you want to cancel. You can only cancel an audit that is IN_PROGRESS.</td>
</tr>
</tbody>
</table>

Output
None

Errors

ResourceNotFoundException
The specified resource does not exist.

InvalidRequestException
The contents of the request were invalid.

ThrottlingException
The rate exceeds the limit.

InternalFailureException
An unexpected error has occurred.

Check audit results

Use ListAuditFindings to see the results of an audit. You can filter the results by the type of check, a specific resource, or the time of the audit. You can use this information to mitigate any problems that were found.

You can define mitigation actions and apply them to the findings from your audit. For more information, see Mitigation actions (p. 1081).

ListAuditFindings

Lists the findings (results) of a Device Defender audit or of the audits performed during a specified time period. (Findings are retained for 180 days.)

Synopsis

aws iot list-audit-findings 
   [--task-id <value>] 

Audit commands

[--check-name <value>]  
[--resource-identifier <value>]  
[--max-results <value>]  
[--next-token <value>]  
[--start-time <value>]  
[--end-time <value>]  
[--cli-input-json <value>]  
[--generate-cli-skeleton]

cli-input-json format

```
{
  "taskId": "string",
  "checkName": "string",
  "resourceIdentifier": {
    "deviceCertificateId": "string",
    "caCertificateId": "string",
    "cognitoIdentityPoolId": "string",
    "clientId": "string",
    "policyVersionIdentifier": {
      "policyName": "string",
      "policyVersionId": "string"
    },
    "roleAliasArn": "string",
    "account": "string"
  },
  "maxResults": "integer",
  "nextToken": "string",
  "startTime": "timestamp",
  "endTime": "timestamp"
}
```

cli-input-json Fields

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>taskId</td>
<td>string</td>
<td>A filter to limit results to the audit with the specified ID. You must specify either the taskId or the startTime and endTime, but not both.</td>
</tr>
<tr>
<td>checkName</td>
<td>string</td>
<td>A filter to limit results to the findings for the specified audit check.</td>
</tr>
<tr>
<td>resourceIdentifier</td>
<td>Resourcedentifier</td>
<td>Information that identifies the noncompliant resource.</td>
</tr>
<tr>
<td>deviceCertificateId</td>
<td>string</td>
<td>The ID of the certificate attached to the resource.</td>
</tr>
<tr>
<td>caCertificateId</td>
<td>string</td>
<td>The ID of the CA certificate used to authorize the certificate.</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>cognitoIdentityPoolId</td>
<td>string</td>
<td>The ID of the Amazon Cognito identity pool.</td>
</tr>
<tr>
<td>clientId</td>
<td>string</td>
<td>The client ID.</td>
</tr>
<tr>
<td>policyVersionIdentifier</td>
<td>PolicyVersionIdentifier</td>
<td>The version of the policy associated with the resource.</td>
</tr>
<tr>
<td>policyName</td>
<td>string</td>
<td>The name of the policy.</td>
</tr>
<tr>
<td></td>
<td>length- max:128 min:1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pattern: [w+=,.@-]+</td>
<td></td>
</tr>
<tr>
<td>policyVersionId</td>
<td>string</td>
<td>The ID of the version of the policy associated with the resource.</td>
</tr>
<tr>
<td></td>
<td>pattern: [0-9]+</td>
<td></td>
</tr>
<tr>
<td>roleAliasArn</td>
<td>string</td>
<td>The ARN of the role alias that has overly permissive actions.</td>
</tr>
<tr>
<td></td>
<td>length- max:2048 min:1</td>
<td></td>
</tr>
<tr>
<td>account</td>
<td>string</td>
<td>The account with which the resource is associated.</td>
</tr>
<tr>
<td></td>
<td>length- max:12 min:12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pattern: [0-9]+</td>
<td></td>
</tr>
<tr>
<td>maxResults</td>
<td>integer</td>
<td>The maximum number of results to return at one time. The default is 25.</td>
</tr>
<tr>
<td></td>
<td>range- max:250 min:1</td>
<td></td>
</tr>
<tr>
<td>nextToken</td>
<td>string</td>
<td>The token for the next set of results.</td>
</tr>
<tr>
<td>startTime</td>
<td>timestamp</td>
<td>A filter to limit results to those found after the specified time. You must specify either the startTime and endTime or the taskId, but not both.</td>
</tr>
<tr>
<td>endTime</td>
<td>timestamp</td>
<td>A filter to limit results to those found before the specified time. You must specify either the startTime and endTime or the taskId, but not both.</td>
</tr>
</tbody>
</table>

Output

```json
{
    "findings": [
        {
            "taskId": "string",
            "checkName": "string",
            "taskStartTime": "timestamp",
            "findingTime": "timestamp",
            "severity": "string",
```
"nonCompliantResource": { 
  "resourceType": "string",
  "resourceIdentifier": { 
    "deviceCertificateId": "string",
    "caCertificateId": "string",
    "cognitoIdentityPoolId": "string",
    "clientId": "string",
    "policyVersionIdentifier": { 
      "policyName": "string",
      "policyVersionId": "string"
    },
    "account": "string"
  },
  "additionalInfo": { 
    "string": "string"
  }
},
"relatedResources": [ 
  { 
    "resourceType": "string",
    "resourceIdentifier": { 
      "deviceCertificateId": "string",
      "caCertificateId": "string",
      "cognitoIdentityPoolId": "string",
      "clientId": "string",
      "iamRoleArn": "string",
      "policyVersionIdentifier": { 
        "policyName": "string",
        "policyVersionId": "string"
      },
      "account": "string"
    },
    "roleAliasArn": "string",
    "additionalInfo": { 
      "string": "string"
    }
  },
  { "reasonForNonCompliance": "string",
    "reasonForNonComplianceCode": "string"
  }
],
"nextToken": "string"

**CLI output fields**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>findings</td>
<td>list member: AuditFinding</td>
<td>The findings (results) of the audit.</td>
</tr>
<tr>
<td>taskId</td>
<td>string</td>
<td>The ID of the audit that generated this result (finding).</td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>checkName</td>
<td>string</td>
<td>The audit check that generated this result.</td>
</tr>
<tr>
<td>taskStart_time</td>
<td>timestamp</td>
<td>The time the audit started.</td>
</tr>
<tr>
<td>findingTime</td>
<td>timestamp</td>
<td>The time the result (finding) was discovered.</td>
</tr>
<tr>
<td>severity</td>
<td>string</td>
<td>The severity of the result (finding).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: CRITICAL</td>
</tr>
<tr>
<td>nonCompliantResource</td>
<td>NonCompliantResource</td>
<td>The resource that was found to be noncompliant with the audit check.</td>
</tr>
<tr>
<td>resourceType</td>
<td>string</td>
<td>The type of the noncompliant resource.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>enum: DEVICE_CERTIFICATE</td>
</tr>
<tr>
<td>resourceId</td>
<td>ResourceIdentifier</td>
<td>Information that identifies the noncompliant resource.</td>
</tr>
<tr>
<td>deviceCertificateId</td>
<td>string</td>
<td>The ID of the certificate attached to the resource.</td>
</tr>
<tr>
<td></td>
<td>length- max:64 min:64</td>
<td>pattern: (0x)?[a-fA-F0-9]+</td>
</tr>
<tr>
<td>caCertificateId</td>
<td>string</td>
<td>The ID of the CA certificate used to authorize the certificate.</td>
</tr>
<tr>
<td></td>
<td>length- max:64 min:64</td>
<td>pattern: (0x)?[a-fA-F0-9]+</td>
</tr>
<tr>
<td>cognitoIdentityPoolId</td>
<td>string</td>
<td>The ID of the Amazon Cognito identity pool.</td>
</tr>
<tr>
<td>clientId</td>
<td>string</td>
<td>The client ID.</td>
</tr>
<tr>
<td>policyVersionIdentifier</td>
<td>PolicyVersionIdentifier</td>
<td>The version of the policy associated with the resource.</td>
</tr>
<tr>
<td>policyName</td>
<td>string</td>
<td>The name of the policy.</td>
</tr>
<tr>
<td></td>
<td>length- max:128 min:1</td>
<td>pattern: [w+=,.@-]+</td>
</tr>
<tr>
<td>policyVersionId</td>
<td>string</td>
<td>The ID of the version of the policy associated with the resource.</td>
</tr>
<tr>
<td></td>
<td>pattern: [0-9]+</td>
<td></td>
</tr>
<tr>
<td>Name</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>account</td>
<td>string</td>
<td>The account with which the resource is associated.</td>
</tr>
<tr>
<td>length- max:12 min:12</td>
<td>pattern: [0-9]+</td>
<td></td>
</tr>
<tr>
<td>additionalInfo</td>
<td>map</td>
<td>Other information about the noncompliant resource.</td>
</tr>
<tr>
<td>relatedResources</td>
<td>list</td>
<td>The list of related resources.</td>
</tr>
<tr>
<td>resourceType</td>
<td>string</td>
<td>The type of resource.</td>
</tr>
<tr>
<td>enum: DEVICE_CERTIFICATE</td>
<td>CA_CERTIFICATE</td>
<td>IOT_POLICY</td>
</tr>
<tr>
<td>resourceIdentifier</td>
<td>Resourcelfentifier</td>
<td>Information that identifies the resource.</td>
</tr>
<tr>
<td>deviceCertificateId</td>
<td>string</td>
<td>The ID of the certificate attached to the resource.</td>
</tr>
<tr>
<td>length- max:64 min:64</td>
<td>pattern: (0x)?[a-fA-F0-9]+</td>
<td></td>
</tr>
<tr>
<td>caCertificateId</td>
<td>string</td>
<td>The ID of the CA certificate used to authorize the certificate.</td>
</tr>
<tr>
<td>length- max:64 min:64</td>
<td>pattern: (0x)?[a-fA-F0-9]+</td>
<td></td>
</tr>
<tr>
<td>cognitoIdentityPoolId</td>
<td>string</td>
<td>The ID of the Amazon Cognito identity pool.</td>
</tr>
<tr>
<td>clientId</td>
<td>string</td>
<td>The client ID.</td>
</tr>
<tr>
<td>policyVersionIdentifier</td>
<td>PolicyVersionIdentifier</td>
<td>The version of the policy associated with the resource.</td>
</tr>
<tr>
<td>iamRoleArn</td>
<td>string</td>
<td>The ARN of the IAM role that has overly permissive actions.</td>
</tr>
<tr>
<td>length- max:2048 min:20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>policyName</td>
<td>string</td>
<td>The name of the policy.</td>
</tr>
<tr>
<td>length- max:128 min:1</td>
<td>pattern: [w+=,.@-]+</td>
<td></td>
</tr>
<tr>
<td>policyVersionId</td>
<td>string</td>
<td>The ID of the version of the policy associated with the resource.</td>
</tr>
<tr>
<td>pattern: [0-9]+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Audit finding suppressions

When you run an audit, it reports findings for all non-compliant resources. This means your audit reports include findings for resources where you’re working toward mitigating issues and also for resources that are known to be non-compliant, such as test or broken devices. The audit continues to report findings for resources that remain non-compliant in successive audit runs, which may add unwanted information to your reports. Audit finding suppressions enable you to suppress or filter out findings for a defined period of time until the resource is fixed, or indefinitely for a resource associated with a test or broken device.

Note
Mitigation actions won't be available for suppressed audit findings. For more information about mitigation actions, see Mitigation actions (p. 1081).

For information about audit finding suppression quotas, see AWS IoT Device Defender endpoints and quotas.
How audit finding suppressions work

When you create an audit finding suppression for a non-compliant resource, your audit reports and notifications behave differently.

Your audit reports will include a new section that lists all the suppressed findings associated with the report. Suppressed findings won’t be considered when we evaluate whether an audit check is compliant or not. A suppressed resource count is also returned for each audit check when you use the `describe-audit-task` command in the command line interface (CLI).

For audit notifications, suppressed findings aren’t considered when we evaluate whether an audit check is compliant or not. A suppressed resource count is also included in each audit check notification AWS IoT Device Defender publishes to Amazon CloudWatch and Amazon Simple Notification Service (Amazon SNS).

How to use audit finding suppressions in the console

To suppress a finding from an audit report

The following procedure shows you how to create an audit finding suppression in the AWS IoT console.

1. In the [AWS IoT console](aws.amazon.com), in the navigation pane, expand **Defend**, and then choose **Audit, Results**.
2. Select an audit report you’d like to review.

3. In the **Non-compliant checks** section, under **Check name**, choose the audit check that you’re interested in.
4. On the audit check details screen, if there are findings you don't want to see, select the option button next to the finding. Next, choose Actions, and then choose the amount of time you'd like your audit finding suppression to persist.

**Note**
In the console, you can select 1 week, 1 month, 3 months, 6 months, or Indefinitely as expiration dates for your audit finding suppression. If you want to set a specific expiration date, you can do so only in the CLI or API. Audit finding suppressions can also be canceled anytime regardless of expiration date.
5. Confirm the suppression details, and then choose **Enable suppression**.

6. After you've created the audit finding suppression, a banner appears confirming your audit finding suppression was created.
To view your suppressed findings in an audit report

1. In the AWS IoT console, in the navigation pane, expand Defend, and then choose Audit, Results.
2. Select an audit report you'd like to review.
3. In the Suppressed findings section, view which audit findings have been suppressed for your chosen audit report.
To list your audit finding suppressions

- In the AWS IoT console, in the navigation pane, expand Defend, and then choose Audit, Finding suppressions.
To edit your audit finding suppression

1. In the AWS IoT console, in the navigation pane, expand Defend, and then choose Audit, Finding suppressions.
2. Select the option button next to the audit finding suppression you’d like to edit. Next, choose Actions, Edit.
3. On the Edit audit finding suppression window, you can change the Suppression duration or Description (optional).
After you've made your changes, choose **Save**. The **Finding suppressions** window opens.

**To delete an audit finding suppression**

1. In the [AWS IoT console](https://console.aws.amazon.com/iot), in the navigation pane, expand **Defend**, and then choose **Audit, Finding suppressions**.
2. Select the option button next to the audit finding suppression you’d like to delete, and then choose **Actions, Delete**.
3. On the **Delete audit finding suppression** window, enter **delete** in the text box to confirm your deletion, and then choose **Delete**. The **Finding suppressions** window opens.
How to use audit finding suppressions in the CLI

You can use the following CLI commands to create and manage audit finding suppressions.

- `create-audit-suppression`
- `describe-audit-suppression`
- `update-audit-suppression`
- `delete-audit-suppression`
- `list-audit-suppressions`

The `resource-identifier` you input depends on the `check-name` you're suppressing findings for. The following table details which checks require which `resource-identifier` for creating and editing suppressions.

**Note**
The suppression commands do not indicate turning off an audit. Audits will still run on your AWS IoT devices. Suppressions are only applicable to the audit findings.

<table>
<thead>
<tr>
<th>check-name</th>
<th>resource-identifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTHENTICATE_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK</td>
<td>cognitoIdentityPoolId</td>
</tr>
<tr>
<td>CA_CERT_APPROACHING_EXPIRATION_CHECK</td>
<td>caCertificateId</td>
</tr>
<tr>
<td>CA_CERTIFICATE_KEY_QUALITY_CHECK</td>
<td>caCertificateId</td>
</tr>
<tr>
<td>CONFLICTING_CLIENT_IDS_CHECK</td>
<td>clientId</td>
</tr>
<tr>
<td>DEVICE_CERT_APPROACHING_EXPIRATION_CHECK</td>
<td>deviceCertificateId</td>
</tr>
<tr>
<td>DEVICE_CERTIFICATE_KEY_QUALITY_CHECK</td>
<td>deviceCertificateId</td>
</tr>
<tr>
<td>DEVICE_CERTIFICATE_SHARED_CHECK</td>
<td>deviceCertificateId</td>
</tr>
<tr>
<td>IOT_POLICY_OVERLY_PERMISSIVE_CHECK</td>
<td>policyVersionIdentifier</td>
</tr>
<tr>
<td>IOT_ROLE_ALIAS_ALLOWS_ACCESS_TO_UNUSED_SERVICES_CHECK</td>
<td>roleAliasArn</td>
</tr>
</tbody>
</table>
To create and apply an audit finding suppression

The following procedure shows you how to create an audit finding suppression in the AWS CLI.

- Use the `create-audit-suppression` command to create an audit finding suppression. The following example creates an audit finding suppression for AWS account 123456789012 on the basis of the check **Logging disabled**.

```bash
aws iot create-audit-suppression \
  --check-name LOGGING_DISABLED_CHECK \
  --resource-identifier account=123456789012 \
  --client-request-token 28ac32c3-384c-487a-a368-c7bd481f554 \
  --suppress-indefinitely \
  --description "Suppresses logging disabled check because I don’t want to enable logging for now."
```

There is no output for this command.

**Audit finding suppressions APIs**

The following APIs can be used to create and manage audit finding suppressions.

- `CreateAuditSuppression`
- `DescribeAuditSuppression`
- `UpdateAuditSuppression`
- `DeleteAuditSuppression`
- `ListAuditSuppressions`

To filter for specific audit findings, you can use the `ListAuditFindings` API.

**Detect**

AWS IoT Device Defender Detect lets you identify unusual behavior that might indicate a compromised device by monitoring the behavior of your devices. Using a combination of cloud-side metrics (from AWS IoT) and device-side metrics (from agents that you install on your devices) you can detect:

- Changes in connection patterns.
- Devices that communicate to unauthorized or unrecognized endpoints.
- Changes in inbound and outbound device traffic patterns.
You create security profiles, which contain definitions of expected device behaviors, and assign them to a group of devices or to all the devices in your fleet. AWS IoT Device Defender Detect uses these security profiles to detect anomalies and send alarms through Amazon CloudWatch metrics and Amazon Simple Notification Service notifications.

AWS IoT Device Defender Detect can detect security issues frequently found in connected devices:

- Traffic from a device to a known malicious IP address or to an unauthorized endpoint that indicates a potential malicious command and control channel.
- Anomalous traffic, such as a spike in outbound traffic, that indicates a device is participating in a DDoS.
- Devices with remote management interfaces and ports that are remotely accessible.
- A spike in the rate of messages sent to your account (for example, from a rogue device that can result in excessive per-message charges).

Use cases:

Measure attack surface

You can use AWS IoT Device Defender Detect to measure the attack surface of your devices. For example, you can identify devices with service ports that are often the target of attack campaigns (telnet service running on ports 23/2323, SSH service running on port 22, HTTP/S services running on ports 80/443/8080/8081). While these service ports might have legitimate reasons to be used on the devices, they are also usually part of the attack surface for adversaries and carry associated risks. After AWS IoT Device Defender Detect alarms you to the attack surface, you can minimize it (by eliminating unused network services) or run additional assessments to identify security weaknesses (for example, telnet configured with common, default, or weak passwords).

Detect device behavioral anomalies with possible security root causes

You can use AWS IoT Device Defender Detect to alarm you to unexpected device behavioral metrics (the number of open ports, number of connections, an unexpected open port, connections to unexpected IP addresses) that might indicate a security breach. For example, a higher than expected number of TCP connections might indicate a device is being used for a DDoS attack. A process listening on a port other than the one you expect might indicate a backdoor installed on a device for remote control. You can use AWS IoT Device Defender Detect to probe the health of your device fleets and verify your security assumptions (for example, no device is listening on port 23 or 2323).

You can enable machine learning (ML)-based threat detection to automatically identify potential threats.

Detect an incorrectly configured device

A spike in the number or size of messages sent from a device to your account might indicate an incorrectly configured device. Such a device might increase your per-message charges. Similarly, a device with many authorization failures might require a reconfigured policy.

Monitoring the behavior of unregistered devices

AWS IoT Device Defender Detect makes it possible to identify unusual behaviors for devices that are not registered in the AWS IoT registry. You can define security profiles that are specific to one of the following target types:

- All devices
- All registered devices (things in the AWS IoT registry)
- All unregistered devices
- Devices in a thing group
A security profile defines a set of expected behaviors for devices in your account and specifies the actions to take when an anomaly is detected. Security profiles should be attached to the most specific targets to give you granular control over which devices are being evaluated against that profile.

Unregistered devices must provide a consistent MQTT client identifier or thing name (for devices that report device metrics) over the device lifetime so all violations and metrics are attributed to the same device.

**Important**

Messages reported by devices are rejected if the thing name contains control characters or if the thing name is longer than 128 bytes of UTF-8 encoded characters.

### Security use cases

This section describes the different types of attacks that threaten your device fleet and the recommended metrics you can use to monitor for these attacks. We recommend using metric anomalies as a starting point to investigate security issues, but you should not base your determination of any security threats solely on a metric anomaly.

To investigate an anomaly alarm, correlate the alarm details with other contextual information such as device attributes, device metric historical trends, Security Profile metric historical trends, custom metrics, and logs to determine if a security threat is present.

### Cloud-side use cases

Device Defender can monitor the following use cases on the AWS IoT cloud side.

**Intellectual property theft:**

Intellectual property theft involves stealing a person's or companies' intellectual properties, including trade secrets, hardware, or software. It often occurs during the manufacturing stage of devices. Intellectual property theft can come in the form of piracy, device theft, or device certificate theft. Cloud-based intellectual property theft can occur due to the presence of policies that permit unintended access to IoT resources. You should review your IoT policies and turn on Audit overly permissive checks to identify overly permissive policies.

**Related metrics:**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source IP</td>
<td>If device is stolen, then its source IP address would fall outside of the normally expected IP address range for devices circulated in a normal supply chain.</td>
</tr>
<tr>
<td>Number of messages received</td>
<td>Because an attacker may use a device in cloud-based IP theft, metrics related to message counts or message sizes sent to the device from AWS IoT cloud can spike up, indicating a possible security issue.</td>
</tr>
<tr>
<td>Message size</td>
<td></td>
</tr>
</tbody>
</table>

**MQTT-based data exfiltration:**

Data exfiltration occurs when a malicious actor carries out an unauthorized data transfer from an IoT deployment or from a device. The attacker launches this type of attacks through MQTT against cloud-side data sources.
Related metrics:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source IP</td>
<td>If a device is stolen, then its source IP address would fall outside of the normally expected IP address range for devices circulated in a standard supply chain.</td>
</tr>
<tr>
<td>Number of messages received</td>
<td>Because an attacker may use a device in an MQTT-based data exfiltration, metrics related to message counts or message sizes sent to the device from AWS IoT cloud can spike up, indicating a possible security issue.</td>
</tr>
<tr>
<td>Message size</td>
<td></td>
</tr>
</tbody>
</table>

Impersonation:

An impersonation attack is where attackers pose as known or trusted entities in an effort to access AWS IoT cloud-side services, applications, data, or engage in command and control of IoT devices.

Related metrics:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authorization failures</td>
<td>When attackers pose as trusted entities by using stolen identities, connectivity related metrics often spike, as the credentials may no longer be valid or may be used by a trusted device already. Anomalous behaviors in authorization failures, connection attempts, or disconnects point to a potential impersonation scenario.</td>
</tr>
<tr>
<td>Connection attempts</td>
<td></td>
</tr>
<tr>
<td>Disconnects</td>
<td></td>
</tr>
</tbody>
</table>

Cloud Infrastructure abuse:

Abuse to AWS IoT cloud services occurs when publishing or subscribing to topics with a high message volume or with messages in large sizes. Overly permissive policies or device vulnerability exploit for command and control can also cause cloud infrastructure abuse. One of the main objectives of this attack is to increase your AWS bill. You should review your IoT policies and turn on Audit overly permissive checks to identify overly permissive policies.

Related metrics:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of messages received</td>
<td>The objective of this attack is to increase your AWS bill, metrics that monitor activities like message count, messages received and message size will spike up.</td>
</tr>
<tr>
<td>Number of messages sent</td>
<td></td>
</tr>
<tr>
<td>Message size</td>
<td></td>
</tr>
<tr>
<td>Source IP</td>
<td>Suspicious source IP lists may appear, from which attackers generate their messaging volume.</td>
</tr>
</tbody>
</table>

Device-side use cases

Device Defender can monitor the following use cases on your device side.
Denial-of-service attack:

A denial-of-service (DoS) attack is aimed at shutting down a device or network, making the device or network inaccessible to their intended users. DoS attacks block access by flooding the target with traffic, or sending it requests that start a system slow-down or cause the system to fail. Your IoT devices can be used in DoS attacks.

**Related metrics:**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packets out</td>
<td>DoS attacks typically involve higher rates of outbound communication from a given device, and depending on the type of DoS attack, there could be an increase in either or both of the numbers of packets out and bytes out.</td>
</tr>
<tr>
<td>Bytes out</td>
<td></td>
</tr>
<tr>
<td>Destination IP</td>
<td>If you define the IP addresses/CIDR ranges your devices should communicate with, then an anomaly in destination IP can indicate unauthorized IP communication from your devices.</td>
</tr>
<tr>
<td>Listening TCP ports</td>
<td>A DoS attack usually requires a larger command and control infrastructure where malware installed on your devices receives commands and information about who to attack and when to attack. Therefore, in order to receive such information, the malware would typically listen on ports that aren't normally used by your devices.</td>
</tr>
<tr>
<td>Listening TCP port count</td>
<td></td>
</tr>
<tr>
<td>Listening UDP ports</td>
<td></td>
</tr>
<tr>
<td>Listening UDP port count</td>
<td></td>
</tr>
</tbody>
</table>

Lateral threat escalation:

Lateral threat escalation usually begins with an attacker gaining access to one point of a network, for example a connected device. The attacker then tries to increase their level of privileges, or their access to other devices through methods such as stolen credentials or vulnerability exploits.

**Related metrics:**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packets out</td>
<td>In typical situations, the attacker would have to run a scan on the local area network in order to perform reconnaissance and identify the available devices in order to narrow down their attack target selection. This kind of scan could result in a spike of bytes and packets out counts.</td>
</tr>
<tr>
<td>Bytes out</td>
<td></td>
</tr>
<tr>
<td>Destination IP</td>
<td>If a device is supposed to communicate with a known set of IP addresses or CIDRs, you can identify if it attempts to communicate with an abnormal IP address, which would often be a private IP address on the local network in a lateral threat escalation use case.</td>
</tr>
<tr>
<td>Authorization failures</td>
<td>As the attacker tries to increase their level of privileges across an IoT network, they may</td>
</tr>
<tr>
<td>Metric</td>
<td>Rationale</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td>use stolen credentials that have been revoked or have expired, which would cause increased authorization failures.</td>
</tr>
</tbody>
</table>

**Data exfiltration or surveillance:**

Data exfiltration occurs when malware or a malicious actor carries out an unauthorized data transfer from a device or a network endpoint. Data exfiltration normally serves two purposes for the attacker, obtaining data or intellectual property, or conducting reconnaissance of a network. Surveillance means that malicious code is used to monitor user activities for the purpose of stealing credentials and gathering information. The metrics below can provide a starting point of investigating either type of attacks.

**Related metrics:**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packets out</td>
<td>When data exfiltration or surveillance attacks occur, the attacker would often mirror the data being sent from the device rather than simply redirecting the data, which would be identified by the defender when they don't see the intended data coming. Such mirrored data would increase the total amount of data sent from the device significantly, resulting in a spike of packets and bytes out counts.</td>
</tr>
<tr>
<td>Bytes out</td>
<td>Destination IP</td>
</tr>
<tr>
<td></td>
<td>When an attacker is using a device in data exfiltration or surveillance attacks, the data would have to be sent to an abnormal IP address controlled by the attacker. Monitoring the destination IP can help identify such an attack.</td>
</tr>
</tbody>
</table>

**Cryptocurrency mining**

Attackers leverage processing power from devices to mine cryptocurrency. Crypto-mining is a computationally intensive process, typically requiring network communication with other mining peers and pools.

**Related metrics:**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination IP</td>
<td>Network communication is typically a requirement during cryptomining. Having a tightly controlled list of IP addresses the device should communicate with can help identify unintended communication on a device, like cryptocurrency mining.</td>
</tr>
<tr>
<td>CPU usage</td>
<td>custom metric</td>
</tr>
<tr>
<td></td>
<td>Cryptocurrency mining requires intensive computation resulting in high utilization of the device CPU. If you choose to collect and monitor this metric, a higher-than-normal CPU</td>
</tr>
</tbody>
</table>
Metric | Rationale
---|---
| usage could be an indicator of crypto-mining activities.

Command and control, malware and ransomware

Malware or ransomware restricts your control over your devices, and limits your device functionality. In the case of a ransomware attack, data access would be lost due to encryption the ransomware uses.

Related metrics:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Destination IP</strong></td>
<td>Network or remote attacks represent a large portion of attacks on IoT devices. A tightly controlled list of IP addresses the device should communicate with can help identify abnormal destination IPs resulted from a malware or ransomware attack.</td>
</tr>
<tr>
<td><strong>Listening TCP ports</strong></td>
<td>Several malware attacks involve starting a command-and-control server that sends commands to execute on a device. This type of server is critical to a malware or ransomware operation and can be identified by tightly monitoring the open TCP/UDP ports and port counts.</td>
</tr>
<tr>
<td><strong>Listening TCP port count</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Listening UDP ports</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Listening UDP port count</strong></td>
<td></td>
</tr>
</tbody>
</table>

Concepts

AWS IoT Device Defender Detect uses metrics to detect anomalous behavior of devices. AWS IoT Device Defender Detect compares the reported value of a metric with the expected value you provide. These metrics can be taken from two sources: cloud-side metrics and device-side metrics. ML Detect supports 6 cloud-side metrics and 7 device-side metrics. For a list of supported metrics for ML Detect, see [Supported metrics](#) (p. 1042).

Abnormal behavior on the AWS IoT network is detected by using cloud-side metrics such as the number of authorization failures, or the number or size of messages a device sends or receives through AWS IoT.

AWS IoT Device Defender Detect can also collect, aggregate, and monitor metrics data generated by AWS IoT devices (for example, the ports a device is listening on, the number of bytes or packets sent, or the device's TCP connections).

You can use AWS IoT Device Defender Detect with cloud-side metrics alone. To use device-side metrics, you must first deploy the AWS IoT SDK on your AWS IoT connected devices or device gateways to collect the metrics and send them to AWS IoT. See [Sending metrics from devices](#) (p. 1064).

Security Profile

A Security Profile defines anomalous behaviors for a group of devices (a [thing group](#) (p. 276)) or for all devices in your account, and specifies which actions to take when an anomaly is detected. You can use the AWS IoT console or API commands to create a Security Profile and associate it with a
AWS IoT Core Developer Guide
Behaviors

group of devices. AWS IoT Device Defender Detect starts recording security-related data and uses the behaviors defined in the Security Profile to detect anomalies in the behavior of the devices.

behavior

A behavior tells AWS IoT Device Defender Detect how to recognize when a device is doing something anomalous. Any device action that doesn’t match a behavior triggers an alert. A Rules Detect behavior consists of a metric and an absolute-value or statistical threshold with an operator (for example, less than or equal to, greater than or equal to), which describe the expected device behavior. An ML Detect behavior consists of a metric and an ML Detect configuration, which set an ML model to learn the normal behavior of devices.

ML model

An ML model is a machine learning model created to monitor each behavior a customer configures. The model trains on metric data patterns from targeted device groups and generates three anomaly confidence thresholds (high, medium, and low) for the metric-based behavior. It inferences anomalies based on ingested metric data at the device level. In the context of ML Detect, one ML model is created to evaluate one metric-based behavior. For more information, see ML Detect (p. 1040).

confidence level

ML Detect supports three confidence levels: High, Medium, and Low. High confidence means low sensitivity in anomalous behavior evaluation and frequently a lower number of alarms. Medium confidence means medium sensitivity and Low confidence means high sensitivity and frequently a higher number of alarms.

dimension

You can define a dimension to adjust the scope of a behavior. For example, you can define a topic filter dimension that applies a behavior to MQTT topics that match a pattern. For information about defining a dimension for use in a Security Profile, see CreateDimension.

alarm

When an anomaly is detected, an alarm notification can be sent through a CloudWatch metric (see Using AWS IoT metrics (p. 446)) or an SNS notification. An alarm notification is also displayed in the AWS IoT console along with information about the alarm, and a history of alarms for the device. An alarm is also sent when a monitored device stops exhibiting anomalous behavior or when it had been causing an alarm but stops reporting for an extended period.

alarm verification state

After an alarm has been created, you can verify the alarm as True positive, Benign positive, False positive, or Unknown. You can also add a description to your alarm verification state. You can view, organize, and filter AWS IoT Device Defender alarms by using one of the four verification states. You can use alarm verification states and related descriptions to inform members of your team. This helps your team to take follow-up actions, for example, performing mitigation actions on True positive alarms, skipping Benign positive alarms, or continuing investigation on Unknown alarms. The default verification state for all alarms is Unknown.

alarm suppression

Manage Detect alarm SNS notifications by setting behavior notification to on or suppressed. Suppressing alarms doesn't stop Detect from performing device behavior evaluations; Detect continues to flag anomalous behaviors as violation alarms. However, suppressed alarms wouldn't be forwarded for SNS notification. They can only be accessed through the AWS IoT console or API.

Behaviors

A Security Profile contains a set of behaviors. Each behavior contains a metric that specifies the normal behavior for a group of devices or for all devices in your account. Behaviors fall into two categories: Rules
Detect behaviors and ML Detect behaviors. With Rules Detect behaviors, you define how your devices should behave whereas ML Detect uses ML models built on historical device data to evaluate how your devices should behave.

A Security Profile can be one of two threshold types: ML or Rule-based. ML Security Profiles automatically detect device-level operational and security anomalies across your fleet by learning from past data. Rule-based Security Profiles require that you manually set static rules to monitor your device behaviors.

The following describes some of the fields that are used in the definition of a behavior:

**Common to Rules Detect and ML Detect**

**name**
The name for the behavior.

**metric**
The name of the metric used (that is, what is measured by the behavior).

**consecutiveDatapointsToAlarm**
If a device is in violation of the behavior for the specified number of consecutive data points, an alarm occurs. If not specified, the default is 1.

**consecutiveDatapointsToClear**
If an alarm has occurred and the offending device is no longer in violation of the behavior for the specified number of consecutive data points, the alarm is cleared. If not specified, the default is 1.

**threshold type**
A Security Profile can be one of two threshold types: ML or Rules based. ML Security Profiles automatically detect device-level operational and security anomalies across your fleet by learning from past data. Rule-based Security Profiles require that you manually set static rules to monitor your device behaviors.

**alarm suppressions**
You can manage Detect alarm Amazon SNS notifications by setting behavior notification to on or suppressed. Suppressing alarms doesn't stop Detect from performing device behavior evaluations; Detect continues to flag anomalous behaviors as violation alarms. However, suppressed alarms aren't forwarded for Amazon SNS notifications. They can be accessed only through the AWS IoT console or API.

**Rules Detect**

**dimension**
You can define a dimension to adjust the scope of a behavior. For example, you can define a topic filter dimension that applies a behavior to MQTT topics that match a pattern. To define a dimension for use in a Security Profile, see [CreateDimension](https://docs.aws.amazon.com/iotsitecore-dev-guide/latest/app/iot-sitecore-ml-detect-behaviors.html). Applies to Rules Detect only.

**criteria**
The criteria that determine if a device is behaving normally in regard to the metric.

**Note**
In the AWS IoT console, you can choose Alert me to be notified through Amazon SNS when AWS IoT Device Defender detects that a device is behaving anomalously.

**comparisonOperator**
The operator that relates the thing measured (metric) to the criteria (value or statisticalThreshold).
Possible values are: "less-than", "less-than-equals", "greater-than", "greater-than-equals", "in-cidr-set", "not-in-cidr-set", "in-port-set", and "not-in-port-set". Not all operators are valid for every metric. Operators for CIDR sets and ports are only for use with metrics involving such entities.

value

The value to be compared with the metric. Depending on the type of metric, this should contain a count (a value), cidrs (a list of CIDRs), or ports (a list of ports).

statisticalThreshold

The statistical threshold by which a behavior violation is determined. This field contains a statistic field that has the following possible values: "p0", "p0.1", "p0.01", "p1", "p10", "p50", "p90", "p99", "p99.9", "p99.99", or "p100".

This statistic indicates a percentile. It resolves to a value by which compliance with the behavior is determined. Metrics are collected one or more times over the specified duration (durationSeconds) from all reporting devices associated with this Security Profile, and percentiles are calculated based on that data. After that, measurements are collected for a device and accumulated over the same duration. If the resulting value for the device falls above or below (comparisonOperator) the value associated with the percentile specified, then the device is considered to be in compliance with the behavior. Otherwise, the device is in violation of the behavior.

A percentile indicates the percentage of all the measurements considered that fall below the associated value. For example, if the value associated with "p90" (the 90th percentile) is 123, then 90% of all measurements were below 123.

durationSeconds

Use this to specify the period of time over which the behavior is evaluated, for those criteria that have a time dimension (for example, NUM_MESSAGES_SENT). For a statisticalThreshold metric comparison, this is the time period during which measurements are collected for all devices to determine the statisticalThreshold values, and then for each device to determine how its behavior ranks in comparison.

### ML Detect

#### ML Detect confidence

ML Detect supports three confidence levels: High, Medium, and Low. High confidence means low sensitivity in anomalous behavior evaluation and frequently a lower number of alarms, Medium confidence means medium sensitivity, and Low confidence means high sensitivity and frequently a higher number of alarms.

### ML Detect

With machine learning Detect (ML Detect), you create Security Profiles that use machine learning to learn expected device behaviors by automatically creating models based on historical device data, and assign these profiles to a group of devices or all the devices in your fleet. AWS IoT Device Defender then identifies anomalies and triggers alarms using the ML models.

For information about how to get started with ML Detect, see [ML Detect guide](p. 934).

This chapter contains the following sections:

- Use cases of ML Detect (p. 1041)
- How ML Detect works (p. 1041)
Use cases of ML Detect

You can use ML Detect to monitor your fleet devices when it's difficult to set the expected behaviors of devices. For example, to monitor the number of disconnects metric, it might not be clear what is considered an acceptable threshold. In this case, you can enable ML Detect to identify anomalous disconnect metric datapoints based off historical data reported from devices.

Another use case of ML Detect is to monitor device behaviors that change dynamically over time. ML Detect periodically learns the dynamic expected device behaviors based on changing data patterns from devices. For example, device message sent volume could vary between weekdays and weekends, and ML detect will learn this dynamic behavior.

How ML Detect works

Using ML Detect, you can create behaviors to identify operational and security anomalies across 6 cloud-side metrics (p. 1042) and 7 device-side metrics (p. 1042). After the initial model training period, ML Detect refreshes the models daily based on the trailing 14 days of data. It monitors datapoints for these metrics with the ML models and triggers an alarm if an anomaly is detected.

ML Detect works best if you attach a Security Profile to a collection of devices with similar expected behaviors. For example, if some of your devices are used at customers' homes and other devices at business offices, the device behavior patterns might differ significantly between the two groups. You can organize the devices into a home-device thing group and an office-device thing group. For the best anomaly detection efficacy, attach each thing group to a separate ML Detect Security Profile.

While ML Detect is building the initial model, it requires 14 days and a minimum of 25,000 datapoints per metric over the trailing 14-day period to generate a model. Afterwards, it updates the model every day there is a minimum number of metric datapoints. If the minimum requirement isn't met, ML Detect attempts to build the model the next day, and will retry daily for the next 30 days before discontinuing the model for evaluations.

Minimum requirements

For training and creating the initial ML model, ML Detect has the following minimum requirements.

Minimum training period

It takes 14 days for the initial models to be built. After that, the model refreshes every day with metric data from a 14-day trailing period.

Minimum total datapoints

The minimum required datapoints to build an ML model is 25,000 datapoints per metric for the last 14 days. For ongoing training and refreshing of the model, ML Detect requires the minimum datapoints be met from monitored devices. It's roughly the equivalent of the following setups:
• 60 devices connecting and having activity on AWS IoT at 45-minute intervals.
• 40 devices at 30-minute intervals.
• 15 devices at 10-minute intervals.
• 7 devices at 5-minute intervals.

Device group targets

To collect data, you must have things in the target thing groups for the Security Profile.

After the initial model is created, ML models refresh every day and require at least 25,000 datapoints for 14-day trailing period.

Limitations

You can use ML Detect with dimensions on the following cloud-side metrics:

• Authorization failures (aws:num-authorization-failures) (p. 1068)
• Messages received (aws:num-messages-received) (p. 1067)
• Messages sent (aws:num-messages-sent) (p. 1066)
• Message size (aws:message-byte-size) (p. 1065)

The following metrics are not supported with ML Detect.

Cloud-side metrics not supported with ML Detect:

• Source IP (aws:source-ip-address) (p. 1069)

Device-side metrics not supported with ML Detect:

• Destination IPs (aws:destination-ip-addresses) (p. 1056)
• Listening TCP ports (aws:listening-tcp-ports) (p. 1057)
• Listening UDP ports (aws:listening-udp-ports) (p. 1057)

Custom metrics only support the number type.

Marking false positives and other verification states in alarms

If you verify that an ML Detect alarm is a false positive through your investigation, you can set the verification state of the alarm to False positive. This can help you and your team identify alarms you don’t have to respond to. You can also mark alarms as True positive, Benign positive, or Unknown.

You can mark alarms through the AWS IoT Device Defender console or by using the PutVerificationStateOnViolation API action.

Supported metrics

You can use the following cloud-side metrics with ML Detect:

• Authorization failures (aws:num-authorization-failures) (p. 1068)
• Connection attempts (aws:num-connection-attempts) (p. 1070)
• Disconnects (aws:num-disconnects) (p. 1071)
• Message size (aws:message-byte-size) (p. 1065)
• Messages sent (aws:num-messages-sent) (p. 1066)
• Messages received (aws:num-messages-received) (p. 1067)

You can use the following device-side metrics with ML Detect:

• Bytes out (aws:all-bytes-out) (p. 1050)
• Bytes in (aws:all-bytes-in) (p. 1051)
• Listening TCP port count (aws:num-listening-tcp-ports) (p. 1052)
• Listening UDP port count (aws:num-listening-udp-ports) (p. 1053)
• Packets out (aws:all-packets-out) (p. 1054)
• Packets in (aws:all-packets-in) (p. 1055)
• Established TCP connections count (aws:num-established-tcp-connections) (p. 1058)

**Service quotas**

For information about ML Detect service quotas and limits, see [AWS IoT Device Defender endpoints and quotas](#).

**ML Detect CLI commands**

You can use the following CLI commands to create and manage ML Detect.

• create-security-profile
• attach-security-profile
• list-security-profiles
• describe-security-profile
• update-security-profile
• delete-security-profile
• get-behavior-model-training-summaries
• list-active-violations
• list-violation-events

**ML Detect APIs**

The following APIs can be used to create and manage ML Detect Security Profiles.

• CreateSecurityProfile
• AttachSecurityProfile
• ListSecurityProfiles
• DescribeSecurityProfile
• UpdateSecurityProfile
• DeleteSecurityProfile
• GetBehaviorModelTrainingSummaries
• ListActiveViolations
• ListViolationEvents
• PutVerificationStateOnViolation
Pause or delete an ML Detect Security Profile

You can pause your ML Detect Security Profile to stop monitoring device behaviors temporarily, or delete your ML Detect Security Profile to stop monitoring device behaviors for an extended period of time.

Pause ML Detect Security Profile by using the console

To pause an ML Detect Security Profile using the console, you must first have an empty thing group. To create an empty thing group, see Static thing groups (p. 276). If you have created an empty thing group, then set the empty thing group as the target of the ML Detect Security Profile.

Note
You need to set the target of your Security Profile back to a device group with devices within 30 days, or you won't be able to reactivate the Security Profile.

Delete ML Detect Security Profile by using the console

To delete a Security Profile, follow these steps:

1. In the AWS IoT console navigate to the sidebar and choose the Defend section.
2. Under Defend, choose Detect and then Security Profiles.
3. Choose the ML Detect Security Profile you want to delete.
4. Choose Actions, and then from the options, choose Delete.

Note
After an ML Detect Security Profile is deleted, you won't be able to reactivate the Security Profile.

Pause an ML Detect Security Profile by using the CLI

To pause a ML Detect Security Profile by using the CLI, use the detach-security-security-profile command:

```
```

Note
This option is only available in AWS CLI. Similar to the console workflow, you need to set the target of your Security Profile back to a device group with devices within 30 days, or you won't be able to reactivate the Security Profile. To attach a Security Profile to a device group, use the attach-security-profile command.

Delete a ML Detect Security Profile by using the CLI

You can delete a Security Profile by using the delete-security-profile command below:

```
delete-security-profile --security-profile-name SecurityProfileName
```

Note
After an ML Detect Security Profile is deleted, you won't be able to reactivate the Security Profile.

Custom metrics

With AWS IoT Device Defender custom metrics, you can define and monitor metrics that are unique to your fleet or use case, such as number of devices connected to Wi-Fi gateways, charge levels for
batteries, or number of power cycles for smart plugs. Custom metric behaviors are defined in Security Profiles, which specify expected behaviors for a group of devices (a thing group) or for all devices. You can monitor behaviors by setting up alarms, which you can use to detect and respond to issues that are specific to the devices.

This chapter contains the following sections:

- How to use custom metrics in the console (p. 1045)
- How to use custom metrics from the CLI (p. 1046)
- Custom metrics CLI commands (p. 1049)
- Custom metrics APIs (p. 1049)

How to use custom metrics in the console

Tutorials

- AWS IoT Device Defender Agent SDK (Python) (p. 1045)
- Create a custom metric and add it to a Security Profile (p. 1045)
- View custom metric details (p. 1046)
- Update a custom metric (p. 1046)
- Delete a custom metric (p. 1046)

AWS IoT Device Defender Agent SDK (Python)

To get started, download the AWS IoT Device Defender Agent SDK (Python) sample agent. The agent gathers the metrics and publishes reports. Once your device-side metrics are publishing, you can view the metrics being collected and determine thresholds for setting up alarms. Instructions for setting up the device agent are available on the AWS IoT Device Defender Agent SDK (Python) Readme. For more information, see AWS IoT Device Defender Agent SDK (Python).

Create a custom metric and add it to a Security Profile

The following procedure shows you how to create a custom metric in the console.

1. In the AWS IoT console, in the navigation pane, expand Defend, and then choose Detect, Metrics.
2. On the Custom metrics page, choose Create.
3. On the Create custom metric page, do the following.
   1. Under Name, enter a name for your custom metric. You can't modify this name after you create the custom metric.
   2. Under Display name (optional), you can enter a friendly name for your custom metric. It doesn't have to be unique and it can be modified after creation.
   3. Under Type, choose the type of metric you'd like to monitor. Metric types include string-list, ip-address-list, number-list, and number. The type can't be modified after creation.

   Note
   ML Detect only allows the number type.

4. Under Tags, you can select tags to be associated with the resource.

When you're done, choose Confirm.

4. After you've created your custom metric, the Custom metrics page appears, where you can see your newly created custom metric.
5. Next, you need to add your custom metric to a Security Profile. In the AWS IoT console, in the navigation pane, expand **Defend**, and then choose **Detect, Security profiles**.
6. Choose the Security Profile you’d like to add your custom metric to.
7. Choose **Actions, Edit**.
8. Choose **Additional Metrics to retain**, and then choose your custom metric. Choose **Next** on the following screens until you reach the **Confirm** page. Choose **Save** and **Continue**. After your custom metric has been successfully added, the Security Profile details page appears.

   **Note**
   Percentile statistics are not available for metrics when any of the metric values are negative numbers.

**View custom metric details**

The following procedure shows you how to view a custom metric's details in the console.

1. In the AWS IoT console, in the navigation pane, expand **Defend**, and then choose **Detect, Metrics**.
2. Choose the **Metric name** of the custom metric you’d like to view the details of.

**Update a custom metric**

The following procedure shows you how to update a custom metric in the console.

1. In the AWS IoT console, in the navigation pane, expand **Defend**, and then choose **Detect, Metrics**.
2. Choose the option button next to the custom metric you’d like to update. Then, for **Actions**, choose **Edit**.
3. On the **Update custom metric** page, you can edit the display name and remove or add tags.
4. After you’re done, choose **Update**. The **Custom metrics** page.

**Delete a custom metric**

The following procedure shows you how to delete a custom metric in the console.

1. First, remove your custom metric from any Security Profile it's referenced in. You can view which Security Profiles contain your custom metric on your custom metric details page. In the AWS IoT console, in the navigation pane, expand **Defend**, and then choose **Detect, Metrics**.
2. Choose the custom metric you’d like to remove. Remove the custom metric from any Security Profile listed under **Security Profiles** on the custom metric details page.
3. In the AWS IoT console, in the navigation pane, expand **Defend**, and then choose **Detect, Metrics**.
4. Choose the option button next to the custom metric you’d like to delete. Then, for **Actions**, choose **Delete**.
5. On the **Are you sure you want to delete custom metric?** message, choose **Delete custom metric**.

   **Warning**
   After you've deleted a custom metric, you lose all data associated with the metric. This action can't be undone.

**How to use custom metrics from the CLI**

**Tutorials**

- AWS IoT Device Defender Agent SDK (Python) (p. 1047)
- Create a custom metric and add it to a Security Profile (p. 1047)
AWS IoT Device Defender Agent SDK (Python)

To get started, download the AWS IoT Device Defender Agent SDK (Python) sample agent. The agent gathers the metrics and publishes reports. After your device-side metrics are publishing, you can view the metrics being collected and determine thresholds for setting up alarms. Instructions for setting up the device agent are available on the AWS IoT Device Defender Agent SDK (Python) Readme. For more information, see AWS IoT Device Defender Agent SDK (Python).

Create a custom metric and add it to a Security Profile

The following procedure shows you how to create a custom metric and add it to a Security Profile from the CLI.

1. Use the create-custom-metric command to create your custom metric. The following example creates a custom metric that measures battery percentage.

```bash
aws iot create-custom-metric \
  --metric-name "batteryPercentage" \
  --metric-type "number" \
  --display-name "Remaining battery percentage." \
  --region us-east-1 \
  --client-request-token "02ccb92b-33e8-4dfa-a0c1-35b181ed26b0"
```

Output:

```json
{
  "metricName": "batteryPercentage",
  "metricArn": "arn:aws:iot:us-east-1:1234564789012:custommetric/batteryPercentage"
}
```

2. After you’ve created your custom metric, you can either add the custom metric to an existing profile using update-security-profile or create a new security profile to add the custom metric using create-security-profile. Here, we create a new security profile called batteryUsage to add our new batteryPercentage custom metric to. We also add a Rules Detect metric called cellularBandwidth.

```bash
aws iot create-security-profile \
  --security-profile-name batteryUsage \
  --security-profile-description "Shows how much battery is left in percentile." \
  --behaviors "[{
    "name": "great-than-75",
    "metric": "batteryPercentage",
    "criteria": {
      "comparisonOperator": "greater-than",
      "value": {
        "number": 75,
        "consecutiveDatapointsToAlarm": 5,
        "consecutiveDatapointsToClear": 1
      }
    }
  }, {
    "name": "cellularBandwidth",
    "metric": "aws:message-byte-size",
    "criteria": {
      "comparisonOperator": "less-than",
      "value": {
        "count": 128,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
      }
    }
  }]
  --region us-east-1
```

Output:

```json
{
  "securityProfileArn": "arn:aws:iot:us-east-1:1234564789012:securityprofile/batteryUsage",
  "securityProfileName": "batteryUsage"
}
```
Note
Percentile statistics are not available for metrics when any of the metric values are negative numbers.

View custom metric details
The following procedure shows you how to view the details for a custom metric from the CLI.

- Use the `list-custom-metrics` command to view all of your custom metrics.

```
aws iot list-custom-metrics --region us-east-1
```

The output of this command looks like the following.

```
{
    "metricNames": [
        "batteryPercentage"
    ]
}
```

Update a custom metric
The following procedure shows you how to update a custom metric from the CLI.

- Use the `update-custom-metric` command to update a custom metric. The following example updates the display-name.

```
aws iot update-custom-metric --metric-name batteryPercentage --display-name 'remaining battery percentage on device' --region us-east-1
```

The output of this command looks like the following.

```
{
    "metricName": "batteryPercentage",
    "metricArn": "arn:aws:iot:us-east-1:123456789012:custommetric/batteryPercentage",
    "metricType": "number",
    "displayName": "remaining battery percentage on device",
    "creationDate": "2020-11-17T23:01:35.110000-08:00",
    "lastModifiedDate": "2020-11-17T23:02:12.879000-08:00"
}
```

Delete a custom metric
The following procedure shows you how to delete a custom metric from the CLI.

1. To delete a custom metric, first remove it from any Security Profiles that it's attached to. Use the `list-security-profiles` command to view Security Profiles with a certain custom metric.
2. To remove a custom metric from a Security Profile, use the `update-security-profiles` command. Enter all information that you want to keep, but exclude the custom metric.
aws iot update-security-profile \
   --security-profile-name batteryUsage \
   --behaviors "["name": "cellularBandwidth", "metric": "aws:message-byte-size \
       ","criteria": {"comparisonOperator": "less-than","value": {"count": 128}, \
        "consecutiveDatapointsToAlarm": 1, "consecutiveDatapointsToClear": 1}]
"

The output of this command looks like the following.

```
{
   "behaviors": [
      {"name": "cellularBandwidth", 
        "criteria": {"comparisonOperator": "less-than", "value": {"count": 128}, 
        "consecutiveDatapointsToAlarm": 1, 
        "consecutiveDatapointsToClear": 1}]
   }"
}

3. After the custom metric is detached, use the `delete-custom-metric` command to delete the custom metric.

aws iot delete-custom-metric \
   --metric-name batteryPercentage \
   --region us-east-1

The output of this command looks like the following

HTTP 200

**Custom metrics CLI commands**

You can use the following CLI commands to create and manage custom metrics.

- `create-custom-metric`
- `describe-custom-metric`
- `list-custom-metrics`
- `update-custom-metric`
- `delete-custom-metric`
- `list-security-profiles`

**Custom metrics APIs**

The following APIs can be used to create and manage custom metrics.

- `CreateCustomMetric`
- `DescribeCustomMetric`
- `ListCustomMetrics`
- `UpdateCustomMetric`
- `DeleteCustomMetric`
Device-side metrics

When creating a Security Profile, you can specify your IoT device's expected behavior by configuring behaviors and thresholds for metrics generated by IoT devices. The following are device-side metrics, which are metrics from agents that you install on your devices.

Bytes out (aws:all-bytes-out)

The number of outbound bytes from a device during a given time period.

Use this metric to specify the maximum or minimum amount of outbound traffic that a device should send, measured in bytes, in a given period of time.

Compatible with: Rules Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: bytes

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```json
{
  "name": "TCP outbound traffic",
  "metric": "aws:all-bytes-out",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "value": {
      "count": 4096
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
  },
  "suppressAlerts": true
}
```

Example using a statisticalThreshold

```json
{
  "name": "TCP outbound traffic",
  "metric": "aws:all-bytes-out",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "statisticalThreshold": {
      "statistic": "p50"
    },
    "durationSeconds": 900,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
  },
  "suppressAlerts": true
}
```
Example Example using ML Detect

```json
{
    "name": "Outbound traffic ML behavior",
    "metric": "aws:all-bytes-out",
    "criteria": {
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1,
        "mlDetectionConfig": {
            "confidenceLevel": "HIGH"
        }
    },
    "suppressAlerts": true
}
```

**Bytes in (aws:all-bytes-in)**

The number of inbound bytes to a device during a given time period.

Use this metric to specify the maximum or minimum amount of inbound traffic that a device should receive, measured in bytes, in a given period of time.

Compatible with: Rules Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: bytes

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```json
{
    "name": "TCP inbound traffic",
    "metric": "aws:all-bytes-in",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "value": {
            "count": 4096
        },
        "durationSeconds": 300,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    },
    "suppressAlerts": true
}
```

Example Example using a statisticalThreshold

```json
{
    "name": "TCP inbound traffic",
    "metric": "aws:all-bytes-in",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "statisticalThreshold": {
            "statistic": "p90"
        },
        "durationSeconds": 300,
    }
}```
Device-side metrics

Example Example using ML Detect

```json
{
  "name": "Inbound traffic ML behavior",
  "metric": "aws:all-bytes-in",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": true
}
```

Listening TCP port count (aws:num-listening-tcp-ports)

The number of TCP ports the device is listening on.

Use this metric to specify the maximum number of TCP ports that each device should monitor.

Compatible with: Rules Detect | ML Detect

Unit: failures

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: failures

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```json
{
  "name": "Max TCP Ports",
  "metric": "aws:num-listening-tcp-ports",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "value": {
      "count": 5
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```

Example Example using a statisticalThreshold

```json
{
  "name": "Max TCP Ports",
  "metric": "aws:num-listening-tcp-ports",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "value": {
      "count": 5
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```
Example using ML detect

```json
{
  "name": "Max TCP Port ML behavior",
  "metric": "aws:num-listening-tcp-ports",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": true
}
```

Listening UDP port count (aws:num-listening-udp-ports)

The number of UDP ports the device is listening on.

Use this metric to specify the maximum number of UDP ports that each device should monitor.

Compatible with: Rules Detect | ML Detect

Unit: failures

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: failures

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```json
{
  "name": "Max UDP Ports",
  "metric": "aws:num-listening-udp-ports",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "value": {
      "count": 5
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```
Example Example using a statisticalThreshold

```json
{
    "name": "Max UDP Ports",
    "metric": "aws:num-listening-udp-ports",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "statisticalThreshold": {
            "statistic": "p50"
        },
        "durationSeconds": 300,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    },
    "suppressAlerts": true
}
```

Example Example using ML Detect

```json
{
    "name": "Max UPD Port ML behavior",
    "metric": "aws:num-listening-tcp-ports",
    "criteria": {
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1,
        "mlDetectionConfig": {
            "confidenceLevel": "HIGH"
        }
    },
    "suppressAlerts": true
}
```

Packets out (aws:all-packets-out)

The number of outbound packets from a device during a given time period.

Use this metric to specify the maximum or minimum amount of total outbound traffic that a device should send in a given period of time.

Compatible with: Rules Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: packets

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```json
{
    "name": "TCP outbound traffic",
    "metric": "aws:all-packets-out",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "value": {
            "count": 100
        }
    }
}
```
Example Example using a statisticalThreshold

```json
{
  "name": "TCP outbound traffic",
  "metric": "aws:all-packets-out",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "statisticalThreshold": {
      "statistic": "p90"
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```

Example Example using ML Detect

```json
{
  "name": "Outbound sent ML behavior",
  "metric": "aws:all-packets-out",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": true
}
```

Packets in (aws:all-packets-in)

The number of inbound packets to a device during a given time period.

Use this metric to specify the maximum or minimum amount of total inbound traffic that a device should receive in a given period of time.

Compatible with: Rule Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: packets

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800 or 3600 seconds.

Example

```json
{
  "name": "TCP inbound traffic",
  "metric": "aws:all-packets-in",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "statisticalThreshold": {
      "statistic": "p90"
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```
Device-side metrics

Example

Example using a statisticalThreshold

```json
{
  "name": "TCP inbound traffic",
  "metric": "aws:all-packets-in",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "statisticalThreshold": {
      "statistic": "p90"
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```

Example Example using ML Detect

```json
{
  "name": "Inbound sent ML behavior",
  "metric": "aws:all-packets-in",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": true
}
```

Destination IPs (aws:destination-ip-addresses)

A set of IP destinations.

Use this metric to specify a set of allowed (formerly referred to as whitelisted) or denied (formerly referred to as blacklisted) Classless Inter-Domain Routings (CIDR) from which each device must or must not connect to AWS IoT.

Compatible with: Rules Detect

Operators: in-cidr-set | not-in-cidr-set

Values: a list of CIDRs
Units: n/a

Example

```json
{
    "name": "Denied source IPs",
    "metric": "aws:destination-ip-address",
    "criteria": {
        "comparisonOperator": "not-in-cidr-set",
        "value": {
            "cidrs": [ "12.8.0.0/16", "15.102.16.0/24" ]
        }
    },
    "suppressAlerts": true
}
```

Listening TCP ports (aws:listening-tcp-ports)

The TCP ports that the device is listening on.

Use this metric to specify a set of allowed (formerly referred to as whitelisted) or denied (formerly referred to as blacklisted) TCP ports on which each device must or must not listen.

Compatible with: Rules Detect

Operators: in-port-set | not-in-port-set

Values: a list of ports

Units: n/a

Example

```json
{
    "name": "Listening TCP Ports",
    "metric": "aws:listening-tcp-ports",
    "criteria": {
        "comparisonOperator": "in-port-set",
        "value": {
            "ports": [ 443, 80 ]
        }
    },
    "suppressAlerts": true
}
```

Listening UDP ports (aws:listening-udp-ports)

The UDP ports that the device is listening on.

Use this metric to specify a set of allowed (formerly referred to as whitelisted) or denied (formerly referred to as blacklisted) UDP ports on which each device must or must not listen.

Compatible with: Rules Detect

Operators: in-port-set | not-in-port-set

Values: a list of ports

Units: n/a
Example

```json
{
    "name": "Listening UDP Ports",
    "metric": "aws:listening-udp-ports",
    "criteria": {
        "comparisonOperator": "in-port-set",
        "value": {
            "ports": [1025, 2000]
        }
    }
}
```

Established TCP connections count (aws:num-established-tcp-connections)

The number of TCP connections for a device.

Use this metric to specify the maximum or minimum number of active TCP connections that each device should have (All TCP states).

Compatible with: Rules Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: connections

Example

```json
{
    "name": "TCP Connection Count",
    "metric": "aws:num-established-tcp-connections",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "value": {
            "count": 3
        },
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    },
    "suppressAlerts": true
}
```

Example Example using a statisticalThreshold

```json
{
    "name": "TCP Connection Count",
    "metric": "aws:num-established-tcp-connections",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "statisticalThreshold": {
            "statistic": "p90"
        },
        "durationSeconds": 900,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    },
    "suppressAlerts": true
}
Example Example using ML Detect

{
  "name": "Connection count ML behavior",
  "metric": "aws:num-established-tcp-connections",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": true
}

Device metrics document specification

Overall structure

<table>
<thead>
<tr>
<th>Long name</th>
<th>Short name</th>
<th>Required</th>
<th>Type</th>
<th>Constraints</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>header</td>
<td>hed</td>
<td>Y</td>
<td>Object</td>
<td></td>
<td>Complete block required for well-formed report.</td>
</tr>
<tr>
<td>metrics</td>
<td>met</td>
<td>Y</td>
<td>Object</td>
<td></td>
<td>A report can have both or at least one metrics or custom_metrics block.</td>
</tr>
<tr>
<td>custom_metrics</td>
<td>cmet</td>
<td>Y</td>
<td>Object</td>
<td></td>
<td>A report can have both or at least one metrics or custom_metrics block.</td>
</tr>
</tbody>
</table>

Header block

<table>
<thead>
<tr>
<th>Long name</th>
<th>Short name</th>
<th>Required</th>
<th>Type</th>
<th>Constraints</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>report_id</td>
<td>rid</td>
<td>Y</td>
<td>Integer</td>
<td></td>
<td>Monotonically increasing value. Epoch timestamp recommended.</td>
</tr>
<tr>
<td>version</td>
<td>v</td>
<td>Y</td>
<td>String</td>
<td>Major.Minor</td>
<td>Minor increments with addition of field. Major increments</td>
</tr>
</tbody>
</table>
### Metrics block:

**TCP connections**

<table>
<thead>
<tr>
<th>Long name</th>
<th>Short name</th>
<th>Required</th>
<th>Type</th>
<th>Constraints</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>tcp_connections</td>
<td>tc</td>
<td>metrics</td>
<td>N</td>
<td>Object</td>
<td></td>
</tr>
<tr>
<td>established_connections</td>
<td>cs</td>
<td>tcp_connections</td>
<td></td>
<td>List&lt;Object&gt;</td>
<td>Established TCP state</td>
</tr>
<tr>
<td>remote_addr</td>
<td>rad</td>
<td>connections</td>
<td>Y</td>
<td>Number</td>
<td>ip:port</td>
</tr>
<tr>
<td>local_port</td>
<td>lp</td>
<td>connections</td>
<td>N</td>
<td>Number</td>
<td>&gt;= 0</td>
</tr>
<tr>
<td>local_interface</td>
<td>li</td>
<td>connections</td>
<td>N</td>
<td>String</td>
<td>Interface name</td>
</tr>
<tr>
<td>total</td>
<td>t</td>
<td>established_connections</td>
<td>N</td>
<td>Number</td>
<td>&gt;= 0</td>
</tr>
</tbody>
</table>

**Listening TCP ports**

<table>
<thead>
<tr>
<th>Long name</th>
<th>Short name</th>
<th>Parent element</th>
<th>Required</th>
<th>Type</th>
<th>Constraints</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>listening_tcp_ports</td>
<td>pts</td>
<td>metrics</td>
<td>N</td>
<td>Object</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ports</td>
<td>pts</td>
<td>listening_tcp_ports</td>
<td>List&lt;Object&gt;</td>
<td>&gt; 0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>port</td>
<td>pt</td>
<td>ports</td>
<td>N</td>
<td>Number</td>
<td>&gt; 0</td>
<td>ports should be numbers greater than 0</td>
</tr>
<tr>
<td>interface</td>
<td>if</td>
<td>ports</td>
<td>N</td>
<td>String</td>
<td></td>
<td>Interface name</td>
</tr>
<tr>
<td>total</td>
<td>t</td>
<td>listening_tcp_ports</td>
<td></td>
<td>Number</td>
<td>&gt;= 0</td>
<td></td>
</tr>
</tbody>
</table>

**Listening UDP ports**

<table>
<thead>
<tr>
<th>Long name</th>
<th>Short name</th>
<th>Parent element</th>
<th>Required</th>
<th>Type</th>
<th>Constraints</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>listening_udp_ports</td>
<td>pts</td>
<td>metrics</td>
<td>N</td>
<td>Object</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ports</td>
<td>pts</td>
<td>listening_udp_ports</td>
<td>List&lt;Port&gt;</td>
<td>&gt; 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Device-side metrics

<table>
<thead>
<tr>
<th>Long name</th>
<th>Short name</th>
<th>Parent element</th>
<th>Required</th>
<th>Type</th>
<th>Constraints</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>port</td>
<td>pt</td>
<td>ports</td>
<td>N</td>
<td>Number</td>
<td>&gt; 0</td>
<td>Ports should be numbers greater than 0</td>
</tr>
<tr>
<td>interface</td>
<td>if</td>
<td>ports</td>
<td>N</td>
<td>String</td>
<td></td>
<td>Interface name</td>
</tr>
<tr>
<td>total</td>
<td>t</td>
<td>listening_udp_ports</td>
<td>Number</td>
<td>&gt;= 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Network statistics

<table>
<thead>
<tr>
<th>Long name</th>
<th>Short name</th>
<th>Parent element</th>
<th>Required</th>
<th>Type</th>
<th>Constraints</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>network_stats</td>
<td>ns</td>
<td>metrics</td>
<td>N</td>
<td>Object</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bytes_in</td>
<td>bi</td>
<td>network_stats</td>
<td>N</td>
<td>Number</td>
<td>Delta Metric, &gt;= 0</td>
<td></td>
</tr>
<tr>
<td>bytes_out</td>
<td>bo</td>
<td>network_stats</td>
<td>N</td>
<td>Number</td>
<td>Delta Metric, &gt;= 0</td>
<td></td>
</tr>
<tr>
<td>packets_in</td>
<td>pi</td>
<td>network_stats</td>
<td>N</td>
<td>Number</td>
<td>Delta Metric, &gt;= 0</td>
<td></td>
</tr>
<tr>
<td>packets_out</td>
<td>po</td>
<td>network_stats</td>
<td>N</td>
<td>Number</td>
<td>Delta Metric, &gt;= 0</td>
<td></td>
</tr>
</tbody>
</table>

### Example

The following JSON structure uses long names.

```json
{
    "header": {
        "report_id": 1530304554,
        "version": "1.0"
    },
    "metrics": {
        "listening_tcp_ports": {
            "ports": [
                {
                    "interface": "eth0",
                    "port": 24800
                },
                {
                    "interface": "eth0",
                    "port": 22
                },
                {
                    "interface": "eth0",
                    "port": 53
                }
            ],
            "total": 3
        },
        "listening_udp_ports": {
```
"ports": [  {
    "interface": "eth0",
    "port": 5353
  },  
  {
    "interface": "eth0",
    "port": 67
  }
],
"total": 2
},
"network_stats": {  
  "bytes_in": 29358693495,
  "bytes_out": 26485035,
  "packets_in": 10013573555,
  "packets_out": 11382615
},
"tcp_connections": {  
  "established_connections": {  
    "connections": [ 
      {
        "local_interface": "eth0",
        "local_port": 80,
        "remote_addr": "192.168.0.1:8000"
      },
      {
        "local_interface": "eth0",
        "local_port": 80,
        "remote_addr": "192.168.0.1:8000"
      }
    ],
    "total": 2
  }
},
"custom_metrics": {  
  "MyMetricOfType_Number": [  
    {  
      "number": 1
    }
  ],
  "MyMetricOfType_NumberList": [  
    {  
      "number_list": [  
        1,  
        2,  
        3
      ]
    }
  ],
  "MyMetricOfType_StringList": [  
    {  
      "string_list": [  
        "value_1",
        "value_2"
      ]
    }
  ],
  "MyMetricOfType_IpList": [  
    {  
      "ip_list": [  
        "172.0.0.0",
        "172.0.0.10"
      ]
    }
  ]
}
Example JSON structure using short names

```json
{
   "hed": {
      "rid": 1530305228,
      "v": "1.0"
   },
   "met": {
      "tp": {
         "pts": [
            {
               "if": "eth0",
               "pt": 24800
            },
            {
               "if": "eth0",
               "pt": 22
            },
            {
               "if": "eth0",
               "pt": 53
            }
         ],
         "t": 3
      },
      "up": {
         "pts": [
            {
               "if": "eth0",
               "pt": 5353
            },
            {
               "if": "eth0",
               "pt": 67
            }
         ],
         "t": 2
      },
      "ns": {
         "bi": 29359307173,
         "bo": 26490711,
         "pi": 10014614051,
         "po": 11387620
      },
      "tc": {
         "ec": {
            "cs": [
               {
                  "li": "eth0",
                  "lp": 80,
                  "rad": "192.168.0.1:8000"
               },
               {
                  "li": "eth0",
                  "lp": 80,
                  "rad": "192.168.0.1:8000"
               }
            ],
            "t": 2
         }
      }
   }
}
```
Device-side metrics

Sending metrics from devices

AWS IoT Device Defender Detect can collect, aggregate, and monitor metrics data generated by AWS IoT devices to identify devices that exhibit abnormal behavior. This section shows you how to send metrics from a device to AWS IoT Device Defender.

You must securely deploy the AWS IoT SDK version two on your AWS IoT connected devices or device gateways to collect device-side metrics. See the full list of SDKs [here](#).

You can use AWS IoT Device Client to publish metrics as it provides a single agent that covers the features present in both AWS IoT Device Defender and AWS IoT Device Management. These features include jobs, secure tunneling, AWS IoT Device Defender metrics publishing, and more.

You publish device-side metrics to the [reserved topic](#) in AWS IoT for AWS IoT Device Defender to collect and evaluate.

Using the AWS IoT Device Client to publish metrics

To install AWS IoT Device Client, you can download it from [Github](#). After you've installed the AWS IoT Device Client on the device for which you want to collect device-side data, you must configure it to send device-side metrics to AWS IoT Device Defender. Verify that the AWS IoT Device Client [configuration file](#) has the following parameters set in the `device-defender` section:

```json
"device-defender": {
   "enabled": true,
```

---

1064
Warning
You should set the time interval to a minimum of 300 seconds. If you set the time interval to anything less than 300 seconds, your metric data may be throttled.

After you've updated your configuration, you can create security profiles and behaviors in the AWS IoT Device Defender console to monitor the metrics that your devices publish to the cloud. You can find published metrics in the AWS IoT Core console by choosing Defend, Detect, and then Metrics.

Cloud-side metrics

When creating a Security Profile, you can specify your IoT device's expected behavior by configuring behaviors and thresholds for metrics generated by IoT devices. The following are cloud-side metrics, which are metrics from AWS IoT.

Message size (aws:message-byte-size)

The number of bytes in a message. Use this metric to specify the maximum or minimum size (in bytes) of each message transmitted from a device to AWS IoT.

Compatible with: Rules Detect | ML Detect
Operators: less-than | less-than-equals | greater-than | greater-than-equals
Value: a non-negative integer
Units: bytes

Example

```json
{
    "name": "Max Message Size",
    "metric": "aws:message-byte-size",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "value": {
            "count": 1024
        },
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1,
        "suppressAlerts": true
    }
}
```

Example Example using a statisticalThreshold

```json
{
    "name": "Large Message Size",
    "metric": "aws:message-byte-size",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "statisticalThreshold": {
            "statistic": "p90"
        },
        "durationSeconds": 300,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    }
}
```
Example Example using ML Detect

```
{
  "name": "Message size ML behavior",
  "metric": "aws:message-byte-size",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": true
}
```

An alarm occurs for a device if during three consecutive five-minute periods, it transmits messages where the cumulative size is more than that measured for 90 percent of all other devices reporting for this Security Profile behavior.

**Messages sent (aws:num-messages-sent)**

The number of messages sent by a device during a given time period.

Use this metric to specify the maximum or minimum number of messages that can be sent between AWS IoT and each device in a given period of time.

Compatible with: Rules Detect | ML Detect

**Operators:** less-than | less-than-equals | greater-than | greater-than-equals

**Value:** a non-negative integer

**Units:** messages

**Duration:** a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

**Example**

```
{
  "name": "Out bound message count",
  "metric": "aws:num-messages-sent",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "value": {
      "count": 50
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```

Example Example using a statisticalThreshold

```
{
  
}
```
"name": "Out bound message rate",
"metric": "aws:num-messages-sent",
"criteria": {
    "comparisonOperator": "less-than-equals",
    "statisticalThreshold": {
        "statistic": "p99"
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
},
"suppressAlerts": true

Example Example using ML Detect

{
    "name": "Messages sent ML behavior",
    "metric": "aws:num-messages-sent",
    "criteria": {
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1,
        "mlDetectionConfig": {
            "confidenceLevel": "HIGH"
        }
    },
    "suppressAlerts": true
}

Messages received (aws:num-messages-received)

The number of messages received by a device during a given time period.

Use this metric to specify the maximum or minimum number of messages that can be received between AWS IoT and each device in a given period of time.

Compatible with: Rules Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: messages

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

{
    "name": "In bound message count",
    "metric": "aws:num-messages-received",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "value": {
            "count": 50
        },
        "durationSeconds": 300,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    }
}
Example Example using a statisticalThreshold

```json
{
  "name": "In bound message rate",
  "metric": "aws:num-messages-received",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "statisticalThreshold": {
      "statistic": "p99"
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```

Example Example using ML Detect

```json
{
  "name": "Messages received ML behavior",
  "metric": "aws:num-messages-received",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": true
}
```

Authorization failures (aws:num-authorization-failures)

Use this metric to specify the maximum number of authorization failures allowed for each device in a given period of time. An authorization failure occurs when a request from a device to AWS IoT is denied (for example, if a device attempts to publish to a topic for which it does not have sufficient permissions).

Compatible with: Rules Detect | ML Detect

Unit: failures

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```json
{
  "name": "Authorization Failures",
  "metric": "aws:num-authorization-failures",
  "criteria": {
    "comparisonOperator": "less-than",
    "value": {
      "count": 5
    }
  }
}
```
Cloud-side metrics

Example Example using a statisticalThreshold

```json
{
    "name": "Authorization Failures",
    "metric": "aws:num-authorization-failures",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "statisticalThreshold": {
            "statistic": "p50"
        },
        "durationSeconds": 300,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    },
    "suppressAlerts": true
}
```

Example Example using ML Detect

```json
{
    "name": "Authorization failures ML behavior",
    "metric": "aws:num-authorization-failures",
    "criteria": {
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1,
        "mlDetectionConfig": {
            "confidenceLevel": "HIGH"
        }
    },
    "suppressAlerts": true
}
```

Source IP (aws:source-ip-address)

The IP address from which a device has connected to AWS IoT.

Use this metric to specify a set of allowed (formerly referred to as whitelisted) or denied (formerly referred to as blacklisted) Classless Inter-Domain Routings (CIDR) from which each device must or must not connect to AWS IoT.

Compatible with: Rules Detect

Operators: in-cidr-set | not-in-cidr-set

Values: a list of CIDRs

Units: n/a

Example

```json
{
    "name": "Denied source IPs",
    "criteria": {"in-cidr-set": ["source-ip-address"]}
}
```
"metric": "aws:source-ip-address",
"criteria": {
    "comparisonOperator": "not-in-cidr-set",
    "value": {
        "cidrs": [ "12.8.0.0/16", "15.102.16.0/24" ]
    }
},
"suppressAlerts": true

Connection attempts (aws:num-connection-attempts)

The number of times a device attempts to make a connection in a given time period.

Use this metric to specify the maximum or minimum number of connection attempts for each device. Successful and unsuccessful attempts are counted.

Compatible with: Rules Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: connection attempts

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```json
{
    "name": "Connection Attempts",
    "metric": "aws:num-connection-attempts",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "value": {
            "count": 5
        },
        "durationSeconds": 600,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    },
    "suppressAlerts": true
}
```

Example Example using a statisticalThreshold

```json
{
    "name": "Connection Attempts",
    "metric": "aws:num-connection-attempts",
    "criteria": {
        "comparisonOperator": "less-than-equals",
        "statisticalThreshold": {
            "statistic": "p10"
        },
        "durationSeconds": 300,
        "consecutiveDatapointsToAlarm": 1,
        "consecutiveDatapointsToClear": 1
    },
    "suppressAlerts": true
}
```
Example Example using ML Detect

```
{
  "name": "Connection attempts ML behavior",
  "metric": "aws:num-connection-attempts",
  "criteria": {
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1,
    "mlDetectionConfig": {
      "confidenceLevel": "HIGH"
    }
  },
  "suppressAlerts": false
}
```

Disconnects (aws:num-disconnects)

The number of times a device disconnects from AWS IoT during a given time period.

Use this metric to specify the maximum or minimum number of times a device disconnected from AWS IoT during a given time period.

Compatible with: Rules Detect | ML Detect

Operators: less-than | less-than-equals | greater-than | greater-than-equals

Value: a non-negative integer

Units: disconnects

Duration: a non-negative integer. Valid values are 300, 600, 900, 1800, or 3600 seconds.

Example

```
{
  "name": "Disconnections",
  "metric": "aws:num-disconnects",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "value": {
      "count": 5
    },
    "durationSeconds": 600,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  "suppressAlerts": true
}
```

Example Example using a statisticalThreshold

```
{
  "name": "Disconnections",
  "metric": "aws:num-disconnects",
  "criteria": {
    "comparisonOperator": "less-than-equals",
    "statisticalThreshold": {
      "statistic": "p10"
    },
    "durationSeconds": 300,
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  }
}
```
Scoping metrics in security profiles using dimensions

Dimensions are attributes that you can define to get more precise data about metrics and behaviors in your security profile. You define the scope by providing a value or pattern that is used as a filter. For example, you can define a topic filter dimension that applies a metric only to MQTT topics that match a particular value, such as “data/bulb/+/activity”. For information about defining a dimension that you can use in your security profile, see CreateDimension.

Dimension values support MQTT wildcards. MQTT wildcards help you subscribe to multiple topics simultaneously. There are two different kinds of wildcards: single-level (+) and multi-level (#). For example, the dimension value Data/bulb/+/activity creates a subscription that matches all topics that exist on the same level as the +. Dimension values also support the MQTT client ID substitution variable ${iot:ClientId}.

Example Example using ML Detect

```json
{
   "name": "Disconnects ML behavior",
   "metric": "aws:num-disconnects",
   "criteria": {
      "consecutiveDatapointsToAlarm": 1,
      "consecutiveDatapointsToClear": 1,
      "mlDetectionConfig": {
         "confidenceLevel": "HIGH"
      }
   },
   "suppressAlerts": true
}
```

Disconnect duration (aws:disconnect-duration)

The duration for which a device stays disconnected from AWS IoT.

Use this metric to specify the maximum duration for which a device remains disconnected from AWS IoT.

Compatible with: Rules Detect

Operators: less-than | less-than-equals

Value: a non-negative integer (in minutes)

Example

```json
{
   "name": "DisconnectDuration",
   "metric": "aws:disconnect-duration",
   "criteria": {
      "comparisonOperator": "less-than-equals",
      "value": {
         "count": 5
      }
   },
   "suppressAlerts": true
}
```

Scoping metrics in security profiles using dimensions

Disconnect duration (aws:disconnect-duration)

The duration for which a device stays disconnected from AWS IoT.

Use this metric to specify the maximum duration for which a device remains disconnected from AWS IoT.

Compatible with: Rules Detect

Operators: less-than | less-than-equals

Value: a non-negative integer (in minutes)

Example

```json
{
   "name": "DisconnectDuration",
   "metric": "aws:disconnect-duration",
   "criteria": {
      "comparisonOperator": "less-than-equals",
      "value": {
         "count": 5
      }
   },
   "suppressAlerts": true
}
```
Dimensions of type TOPIC_FILTER are compatible with the following set of cloud-side metrics:

- Number of authorization failures
- Message byte size
- Number of messages received
- Number of messages sent
- Source IP address (only available for Rules Detect)

**How to use dimensions in the console**

**To create and apply a dimension to a security profile behavior**

1. Open the [AWS IoT console](https://aws.amazon.com/iot-console). In the navigation pane, expand Security, Detect, and then choose Security profiles.
2. On the Security Profiles page, choose Create Security Profile, and then choose Create Rule-based anomaly Detect profile. Or, to apply a dimension to an existing Rule-based security profile, select the security profile and choose Edit.
3. On the Specify security profile properties page, enter a name for the security profile.
4. Choose the group of devices that you want to target for anomalies.
5. Choose Next.
6. On the Configure metric behaviors page, choose one of the cloud-side metric dimensions under Metric type.
7. For Metric behavior, choose Send an alert (define metric behavior) to define the expected metric behavior.
8. Choose when you want to be notified for unusual device behavior.
9. Choose Next.
10. Review the security profile configuration and choose Create.

**To view your alarms**

1. Open the [AWS IoT console](https://aws.amazon.com/iot-console). In the navigation pane, expand Security, Detect, and then choose Alarms.
2. In the Thing name column, choose the thing to see information about what caused the alarm.

**To view and update your dimensions**

1. Open the [AWS IoT console](https://aws.amazon.com/iot-console). In the navigation pane, expand Security, Detect, and then choose Dimensions.
2. Select the dimension and choose Edit.
3. Edit the dimension and choose Update.

**To delete a dimension**

1. Open the [AWS IoT console](https://aws.amazon.com/iot-console). In the navigation pane, expand Security, Detect, and then choose Dimensions.
2. Before deleting a dimension, you must delete the metric behavior that references the dimension. Confirm that the dimension isn’t attached to a security profile by checking the Security Profiles column. If the dimension is attached to a security profile, open the Security profiles page on the left, and edit the security profile that the dimension is attached to. Then you can proceed with deleting the behavior. If you want to delete another dimension, follow the steps in this section.
3. Select the dimension and choose **Delete**.
4. Enter the dimension name to confirm, and then choose **Delete**.

### How to use dimensions on the AWS CLI

**To create and apply a dimension to a security profile behavior**

1. First create the dimension before attaching it to a security profile. Use the `CreateDimension` command to create a dimension:

   ```bash
   aws iot create-dimension
   --name TopicFilterForAuthMessages
   --type TOPIC_FILTER
   --string-values device/+/*
   ```

   The output of this command looks like the following:

   ```json
   {
     "name": "TopicFilterForAuthMessages"
   }
   ```

2. Either add the dimension to an existing security profile by using `UpdateSecurityProfile`, or add the dimension to a new security profile by using `CreateSecurityProfile`. In the following example, we create a new security profile that checks if messages to `TopicFilterForAuthMessages` are under 128 bytes, and retains the number of messages sent to non-auth topics.

   ```bash
   aws iot create-security-profile
   --security-profile-name ProfileForConnectedDevice
   --security-profile-description "Check to see if messages to TopicFilterForAuthMessages are under 128 bytes and retains the number of messages sent to non-auth topics."
   --behaviors "[ {"name":"CellularBandwidth","metric":"aws:message-byte-size"}, {"name":"Authorization","metric":"aws:num-authorization-failures"} ]" 
   --additional-metrics-to-retain-v2 "[ {"metric": "aws:num-authorization-failures", "metricDimension": {"dimensionName": "TopicFilterForAuthMessages", "operator": "NOT_IN"} } ]"
   ```

   The output of this command looks like the following:

   ```json
   {
     "securityProfileArn": "arn:aws:iot:us-west-2:1234564789012:securityprofile/ProfileForConnectedDevice",
     "securityProfileName": "ProfileForConnectedDevice"
   }
   ```

To save time, you can also load a parameter from a file instead of typing it as a command line parameter value. For more information, see [Loading AWS CLI Parameters from a File](https://docs.aws.amazon.com/cli/latest/topic/cli-configuration-parameters.html). The following shows the `behavior` parameter in expanded JSON format:

```json
[  
  {"criteria": {
    "comparisonOperator": "less-than",
    "value": {"count": 128},
    "consecutiveDatapointsToAlarm": 1,
    "consecutiveDatapointsToClear": 1
  },
  {"name": "Authorization",
   "metric": "aws:num-authorization-failures",
   "criteria": {
     "comparisonOperator": "less-than",
     "value": {"count": 10},
     "durationSeconds": 300,
     "consecutiveDatapointsToAlarm": 1,
     "consecutiveDatapointsToClear": 1
   }
  }
]```
Scoping metrics in security profiles using dimensions

```
"comparisonOperator": "less-than",
"consecutiveDatapointsToAlarm": 1,
"consecutiveDatapointsToClear": 1,
"value": {
    "count": 128
}
},
"metric": "aws:message-byte-size",
"metricDimension": {
    "dimensionName": "TopicFilterForAuthMessages"
},
"name": "CellularBandwidth"
}
```

Or use CreateSecurityProfile using dimension with ML like the following example:

```
aws iot create-security-profile --security-profile-name ProfileForConnectedDeviceML \
    --security-profile-description "Check to see if messages to TopicFilterForAuthMessages are abnormal" \
    --behaviors "["name":"test1","metric":"aws:message-byte-size","metricDimension":{"dimensionName": "TopicFilterForAuthMessages","operator": "IN"},"criteria":{"mlDetectionConfig":{"confidenceLevel":"HIGH"},"consecutiveDatapointsToAlarm":1,"consecutiveDatapointsToClear":1}]" \
    --region us-west-2
```

To view security profiles with a dimension

- Use the ListSecurityProfiles command to view security profiles with a certain dimension:

```
aws iot list-security-profiles \
    --dimension-name TopicFilterForAuthMessages
```

The output of this command looks like the following:

```
{
    "securityProfileIdentifiers": [
        {
            "name": "ProfileForConnectedDevice",
            "arn": "arn:aws:iot:us-west-2:1234564789012:securityprofile/ProfileForConnectedDevice"
        }
    ]
}
```

To update your dimension

- Use the UpdateDimension command to update a dimension:

```
aws iot update-dimension \
    --name TopicFilterForAuthMessages \
    --string-values device/${iot:ClientId}/auth
```

The output of this command looks like the following:

```
{
    "name": "TopicFilterForAuthMessages",
```
To delete a dimension

1. To delete a dimension, first detach it from any security profiles that it's attached to. Use the `ListSecurityProfiles` command to view security profiles with a certain dimension.

2. To remove a dimension from a security profile, use the `UpdateSecurityProfile` command. Enter all information that you want to keep, but exclude the dimension:

   ```bash
   aws iot update-security-profile 
   --security-profile-name ProfileForConnectedDevice 
   --security-profile-description "Check to see if authorization fails 10 times in 5 minutes or if cellular bandwidth exceeds 128"
   --behaviors "\n   [{"name":"metric":"aws:message-byte-size","criteria": {"comparisonOperator":"less-than","value":{"count":128},"consecutiveDatapointsToAlarm":1,"consecutiveDatapointsToClear":1}},{"name ":"Authorization","metric":"aws:num-authorization-failures","criteria": {"durationSeconds":300,"comparisonOperator":"less-than","consecutiveDatapointsToAlarm":1,"consecutiveDatapointsToClear":1,"value": {"count":10}}]"
   
   The output of this command looks like the following:

   ```json
   {
     "behaviors": [
       {
         "metric": "aws:message-byte-size",
         "name": "CellularBandwidth",
         "criteria": {
           "consecutiveDatapointsToClear": 1,
           "comparisonOperator": "less-than",
           "consecutiveDatapointsToAlarm": 1,
           "value": {
             "count": 128
           }
         }
       },
       {
         "metric": "aws:num-authorization-failures",
         "name": "Authorization",
         "criteria": {
           "durationSeconds": 300,
           "comparisonOperator": "less-than",
           "consecutiveDatapointsToClear": 1,
           "consecutiveDatapointsToAlarm": 1,
           "value": {
             "count": 10
           }
         }
       }
     ],
     "securityProfileName": "ProfileForConnectedDevice",
     "lastModifiedDate": 1585956349.12,
     "securityProfileDescription": "Check to see if authorization fails 10 times in 5 minutes or if cellular bandwidth exceeds 128",
   }
Permissions

This section contains information about how to set up the IAM roles and policies required to manage AWS IoT Device Defender Detect. For more information, see the IAM User Guide.

Give AWS IoT Device Defender detect permission to publish alarms to an SNS topic

If you use the alertTargets parameter in CreateSecurityProfile, you must specify an IAM role with two policies: a permissions policy and a trust policy. The permissions policy grants permission to AWS IoT Device Defender to publish notifications to your SNS topic. The trust policy grants AWS IoT Device Defender permission to assume the required role.

Permission policy

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "sns:Publish"
      ],
      "Resource": [
        "arn:aws:sns:region:account-id:your-topic-name"
      ]
    }
  ]
}
```

Trust policy

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "Service": "iot.amazonaws.com"
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```
Pass role policy

You also need an IAM permissions policy attached to the IAM user that allows the user to pass roles. See [Granting a User Permissions to Pass a Role to an AWS Service](#).

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Action": [
        "iam:GetRole",
        "iam:PassRole"
      ],
      "Resource": "arn:aws:iam::account-id:role/Role_To_Pass"
    }
  ]
}
```

## Detect commands

You can use the Detect commands in this section to configure ML Detect or Rules Detect Security Profiles, to identify and monitor unusual behaviors that may indicate a compromised device.

### DetectMitigation action commands

- **Start and manage Detect execution**
  - `CancelDetectMitigationActionsTask`
  - `DescribeDetectMitigationActionsTask`
  - `ListDetectMitigationActionsTasks`
  - `StartDetectMitigationActionsTask`
  - `ListDetectMitigationActionsExecutions`

### Dimension action commands

- **Start and manage Dimension execution**
  - `CreateDimension`
  - `DescribeDimension`
  - `ListDimensions`
  - `DeleteDimension`
  - `UpdateDimension`

### CustomMetric action commands

- **Start and manage CustomMetric execution**
  - `CreateCustomMetric`
AWS IoT Core Developer Guide
How to use AWS IoT Device Defender detect

1. You can use AWS IoT Device Defender Detect with just cloud-side metrics, but if you plan to use device-reported metrics, you must first deploy the AWS IoT SDK on your AWS IoT connected devices or device gateways. For more information, see Sending metrics from devices (p. 1064).

2. Consider viewing the metrics that your devices generate before you define behaviors and create alarms. AWS IoT can collect metrics from your devices so you can first identify usual or unusual behavior for a group of devices, or for all devices in your account. Use CreateSecurityProfile,

---

**Start and manage CustomMetric execution**

- UpdateCustomMetric
- DescribeCustomMetric
- ListCustomMetrics
- DeleteCustomMetric

**Security Profile action commands**

**Start and manage Security Profile execution**

- CreateSecurityProfile
- AttachSecurityProfile
- DetachSecurityProfile
- DeleteSecurityProfile
- DescribeSecurityProfile
- ListTargetsForSecurityProfile
- UpdateSecurityProfile
- ValidateSecurityProfileBehaviors
- ListSecurityProfilesForTarget

**Alarm action commands**

- Manage alarms and targets
- ListActiveViolations
- ListViolationEvents
- PutVerificationStateOnViolation

**ML Detect action commands**

- List ML model training data
- GetBehaviorModelTrainingSummaries
but specify only those `additionalMetricsToRetain` that you're interested in. Don't specify behaviors at this point.

Use the AWS IoT console to look at your device metrics to see what constitutes typical behavior for your devices.

3. Create a set of behaviors for your security profile. Behaviors contain metrics that specify normal behavior for a group of devices or for all devices in your account. For more information and examples, see Cloud-side metrics (p. 1065) and Device-side metrics (p. 1050). After you create a set of behaviors, you can validate them with `ValidateSecurityProfileBehaviors`.

4. Use the `CreateSecurityProfile` action to create a security profile that includes your behaviors. You can use the `alertTargets` parameter to have alarms sent to a target (an SNS topic) when a device violates a behavior. (If you send alarms using SNS, be aware that these count against your AWS account's SNS topic quota. It's possible that a large burst of violations can exceed your SNS topic quota. You can also use CloudWatch metrics to check for violations. For more information, see Using AWS IoT metrics (p. 446).

5. Use the `AttachSecurityProfile` action to attach the security profile to a group of devices (a thing group), all registered things in your account, all unregistered things, or all devices. AWS IoT Device Defender Detect starts checking for abnormal behavior and, if any behavior violations are detected, sends alarms. You might want to attach a security profile to all unregistered things if, for example, you expect to interact with mobile devices that are not in your account's thing registry. You can define different sets of behaviors for different groups of devices to meet your needs.

To attach a security profile to a group of devices, you must specify the ARN of the thing group that contains them. A thing group ARN has the following format.

```
arn:aws:iot:region:account-id:thinggroup/thing-group-name
```

To attach a security profile to all of the registered things in an AWS account (ignoring unregistered things), you must specify an ARN with the following format.

```
arn:aws:iot:region:account-id:all/registered-things
```

To attach a security profile to all unregistered things, you must specify an ARN with the following format.

```
arn:aws:iot:region:account-id:all/unregistered-things
```

To attach a security profile to all devices, you must specify an ARN with the following format.

```
arn:aws:iot:region:account-id:all/things
```

6. You can also keep track of violations with the `ListActiveViolations` action, which lets you to see which violations were detected for a given security profile or target device.

Use the `ListViolationEvents` action to see which violations were detected during a specified time period. You can filter these results by security profile, device, or alarm verification state.

7. You can verify, organize, and manage your alarms, by marking their verification state and providing a description of that verification state, by using the `PutVerificationStateOnViolation` action.

8. If your devices violate the defined behaviors too often, or not often enough, you should fine-tune the behavior definitions.

9. To review the security profiles that you set up and the devices that are being monitored, use the `ListSecurityProfiles`, `ListSecurityProfilesForTarget`, and `ListTargetsForSecurityProfile` actions.

Use the `DescribeSecurityProfile` action to get more details about a security profile.
10. To update a security profile, use the `UpdateSecurityProfile` action. Use the `DetachSecurityProfile` action to detach a security profile from an account or target thing group. Use the `DeleteSecurityProfile` action to delete a security profile entirely.

Mitigation actions

You can use AWS IoT Device Defender to take actions to mitigate issues that were found in an Audit finding or Detect alarm.

**Note**
Mitigation actions won’t be performed on suppressed audit findings. For more information about audit finding suppressions, see [Audit finding suppressions](p. 1022).

Audit mitigation actions

AWS IoT Device Defender provides predefined actions for the different audit checks. You configure those actions for your AWS account and then apply them to a set of findings. Those findings can be:

- All findings from an audit. This option is available in both the AWS IoT console and by using the AWS CLI.
- A list of individual findings. This option is only available by using the AWS CLI.
- A filtered set of findings from an audit.

The following table lists the types of audit checks and the supported mitigation actions for each:

**Audit check to mitigation action mapping**

<table>
<thead>
<tr>
<th>Audit check</th>
<th>Supported mitigation actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVOKE_CA_CERT_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS, UPDATE_CA_CERTIFICATE</td>
</tr>
<tr>
<td>INTERMEDIATE_CA_REVOKED_FOR_ACTIVE_DEVICE_CERTIFICATES</td>
<td>PUBLISH_FINDING_TO_SNS, UPDATE_DEVICE_CERTIFICATE, ADD_THINGS_TO_THING_GROUP</td>
</tr>
<tr>
<td>DEVICE_CERTIFICATE_SHARED_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS, UPDATE_DEVICE_CERTIFICATE, ADD_THINGS_TO_THING_GROUP</td>
</tr>
<tr>
<td>UNAUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS</td>
</tr>
<tr>
<td>AUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS</td>
</tr>
<tr>
<td>IOT_POLICY_OVERLY_PERMISSIVE_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS, REPLACE_DEFAULT_POLICY_VERSION</td>
</tr>
<tr>
<td>IOT_POLICY_POTENTIAL_MISCONFIGURATION_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS, REPLACE_DEFAULT_POLICY_VERSION</td>
</tr>
<tr>
<td>CA_CERTIFICATE_EXPIRING_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS, UPDATE_CA_CERTIFICATE</td>
</tr>
<tr>
<td>CONFLICTING_CLIENT_IDS_CHECK</td>
<td>PUBLISH_FINDING_TO_SNS</td>
</tr>
</tbody>
</table>
Audit check | Supported mitigation actions
--- | ---
DEVICE_CERTIFICATE_EXPIRING_CHECK | PUBLISH_FINDING_TO_SNS, UPDATE_DEVICE_CERTIFICATE, ADD_THINGS_TO_THING_GROUP

REVOKED_DEVICE_CERTIFICATE_STILL_ACTIVE_CHECK | PUBLISH_FINDING_TO_SNS, UPDATE_DEVICE_CERTIFICATE, ADD_THINGS_TO_THING_GROUP

LOGGING_DISABLED_CHECK | PUBLISH_FINDING_TO_SNS, ENABLE_IOT_LOGGING

DEVICE_CERTIFICATE_KEY_QUALITY_CHECK | PUBLISH_FINDING_TO_SNS, UPDATE_DEVICE_CERTIFICATE, ADD_THINGS_TO_THING_GROUP

CA_CERTIFICATE_KEY_QUALITY_CHECK | PUBLISH_FINDING_TO_SNS, UPDATE_CA_CERTIFICATE

IOT_ROLE_ALIAS_OVERLY_PERMISSIVE_CHECK | PUBLISH_FINDING_TO_SNS

IOT_ROLE_ALIAS_ALLOWS_ACCESS_TO_UNUSED_SERVICES_CHECK | PUBLISH_FINDING_TO_SNS

All audit checks support publishing the audit findings to Amazon SNS so you can take custom actions in response to the notification. Each type of audit check can support additional mitigation actions:

**REVOKED_CA_CERT_CHECK**
- Change the state of the certificate to mark it as inactive in AWS IoT.

**DEVICE_CERTIFICATE_SHARED_CHECK**
- Change the state of the device certificate to mark it as inactive in AWS IoT.
- Add the devices that use that certificate to a thing group.

**UNAUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK**
- No additional supported actions.

**AUTHENTICATED_COGNITO_ROLE_OVERLY_PERMISSIVE_CHECK**
- No additional supported actions.

**IOT_POLICY_OVERLY_PERMISSIVE_CHECK**
- Add a blank AWS IoT policy version to restrict permissions.

**IOT_POLICY_POTENTIAL_MISCONFIGURATION_CHECK**
- Identify potential misconfigurations in AWS IoT policies.

**CA_CERT_APPROACHING_EXPIRATION_CHECK**
- Change the state of the certificate to mark it as inactive in AWS IoT.

**CONFLICTING_CLIENT_IDS_CHECK**
- No additional supported actions.

**DEVICE_CERT_APPROACHING_EXPIRATION_CHECK**
- Change the state of the device certificate to mark it as inactive in AWS IoT.
- Add the devices that use that certificate to a thing group.

**DEVICE_CERTIFICATE_KEY_QUALITY_CHECK**
- Change the state of the device certificate to mark it as inactive in AWS IoT.
• Add the devices that use that certificate to a thing group.

**CA_CERTIFICATE_KEY_QUALITY_CHECK**
• Change the state of the certificate to mark it as inactive in AWS IoT.

**REVOKED_DEVICE_CERT_CHECK**
• Change the state of the device certificate to mark it as inactive in AWS IoT.
• Add the devices that use that certificate to a thing group.

**LOGGING_DISABLED_CHECK**
• Enable logging.

AWS IoT Device Defender supports the following types of mitigation actions on Audit findings:

<table>
<thead>
<tr>
<th>Action type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD_THINGS_TO_THING_GROUP</td>
<td>You specify the group to which you want to add the devices. You also specify whether membership in one or more dynamic groups should be overridden if that would exceed the maximum number of groups to which the thing can belong.</td>
</tr>
<tr>
<td>ENABLE_IOT_LOGGING</td>
<td>You specify the logging level and the role with permissions for logging. You cannot specify a logging level of DISABLED.</td>
</tr>
<tr>
<td>PUBLISH_FINDING_TO_SNS</td>
<td>You specify the topic to which the finding should be published.</td>
</tr>
<tr>
<td>REPLACE_DEFAULT_POLICY_VERSION</td>
<td>You specify the template name. Replaces the policy version with a default or blank policy. Only a value of BLANK_POLICY is currently supported.</td>
</tr>
<tr>
<td>UPDATE_CA_CERTIFICATE</td>
<td>You specify the new state for the CA certificate. Only a value of DEACTIVATE is currently supported.</td>
</tr>
<tr>
<td>UPDATE_DEVICE_CERTIFICATE</td>
<td>You specify the new state for the device certificate. Only a value of DEACTIVATE is currently supported.</td>
</tr>
</tbody>
</table>

By configuring standard actions when issues are found during an audit, you can respond to those issues consistently. Using these defined mitigation actions also helps you resolve the issues more quickly and with less chance of human error.

**Important**
Applying mitigation actions that change certificates, add things to a new thing group, or replace the policy can have an impact on your devices and applications. For example, devices might be unable to connect. Consider the implications of the mitigation actions before you apply them. You might need to take other actions to correct the problems before your devices and applications can function normally. For example, you might need to provide updated device certificates. Mitigation actions can help you quickly limit your risk, but you must still take corrective actions to address the underlying issues.

Some actions, such as reactivating a device certificate, can only be performed manually. AWS IoT Device Defender does not provide a mechanism to automatically roll back mitigation actions that have been applied.
Detect mitigation actions

AWS IoT Device Defender supports the following types of mitigation actions on Detect alarms:

<table>
<thead>
<tr>
<th>Action type</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADD_THINGS_TO_THING_GROUP</td>
<td>You specify the group to which you want to add the devices. You also specify whether membership in one or more dynamic groups should be overridden if that would exceed the maximum number of groups to which the thing can belong.</td>
</tr>
</tbody>
</table>

How to define and manage mitigation actions

You can use the AWS IoT console or the AWS CLI to define and manage mitigation actions for your AWS account.

Create mitigation actions

Each mitigation action that you define is a combination of a predefined action type and parameters specific to your account.

To use the AWS IoT console to create mitigation actions

1. Open the Mitigation actions page in the AWS IoT console.
2. On the Mitigation actions page, choose Create.
3. On the Create a new mitigation action page, in Action name, enter a unique name for your mitigation action.
4. In Action type, specify the type of action that you want to define.
5. In Permissions, choose the IAM role under whose permissions the action is applied.
6. Each action type requests a different set of parameters. Enter the parameters for the action. For example, if you choose the Add things to thing group action type, choose the destination group and select or clear Override dynamic groups.
7. Choose Create to save your mitigation action to your AWS account.

To use the AWS CLI to create mitigation actions

- Use the CreateMitigationAction command to create your mitigation action. The unique name that you give the action is used when you apply that action to audit findings. Choose a meaningful name.

To use the AWS IoT console to view and modify mitigation actions

1. Open the Mitigation actions page in the AWS IoT console.
   - The Mitigation actions page displays a list of all of the mitigation actions that are defined for your AWS account.
2. Choose the action name link for the mitigation action that you want to change.
3. Choose Edit and make your changes to the mitigation action. You cannot change the name because the name of the mitigation action is used to identify it.
4. Choose Update to save the changes to the mitigation action to your AWS account.
To use the AWS CLI to list a mitigation action

- Use the `ListMitigationAction` command to list your mitigation actions. If you want to change or delete a mitigation action, make a note of the name.

To use the AWS CLI to update a mitigation action

- Use the `UpdateMitigationAction` command to change your mitigation action.

To use the AWS IoT console to delete a mitigation action

1. Open the `Mitigation actions page in the AWS IoT console`

   The `Mitigation actions` page displays all of the mitigation actions that are defined for your AWS account.

2. Choose the the mitigation action that you want to delete, and then choose `Delete`.

3. In the `Are you sure you want to delete` window, choose `Delete`.

To use the AWS CLI to delete mitigation actions

- Use the `UpdateMitigationAction` command to change your mitigation action.

To use the AWS IoT console to view mitigation action details

1. Open the `Mitigation actions page in the AWS IoT console`

   The `Mitigation actions` page displays all of the mitigation actions that are defined for your AWS account.

2. Choose the action name link for the mitigation action that you want to view.

To use the AWS CLI to view mitigation action details

- Use the `DescribeMitigationAction` command to view details for your mitigation action.

Apply mitigation actions

After you have defined a set of mitigation actions, you can apply those actions to the findings from an audit. When you apply actions, you start an audit mitigation actions task. This task might take some time to complete, depending on the set of findings and the actions that you apply to them. For example, if you have a large pool of devices whose certificates have expired, it might take some time to deactivate all of those certificates or to move those devices to a quarantine group. Other actions, such as enabling logging, can be completed quickly.

You can view the list of action executions and cancel an execution that has not yet been completed. Actions already performed as part of the canceled action execution are not rolled back. If you are applying multiple actions to a set of findings and one of those actions failed, the subsequent actions are skipped for that finding (but are still applied to other findings). The task status for the finding is FAILED. The `taskStatus` is set to failed if one or more of the actions failed when applied to the findings. Actions are applied in the order in which they are specified.

Each action execution applies a set of actions to a target. That target can be a list of findings or it can be all findings from an audit.
The following diagram shows how you can define an audit mitigation task that takes all findings from one audit and applies a set of actions to those findings. A single execution applies one action to one finding. The audit mitigation actions task outputs an execution summary.

![Diagram showing audit mitigation task]

The following diagram shows how you can define an audit mitigation task that takes a list of individual findings from one or more audits and applies a set of actions to those findings. A single execution applies one action to one finding. The audit mitigation actions task outputs an execution summary.

![Diagram showing audit mitigation task with multiple inputs]

The following diagram shows how you can define an audit mitigation task that takes a list of individual findings from one or more audits and applies a set of actions to those findings. A single execution applies one action to one finding. The audit mitigation actions task outputs an execution summary.
Apply mitigation actions

You can use the AWS IoT console or the AWS CLI to apply mitigation actions.

To use the AWS IoT console to apply mitigation actions by starting an action execution

1. Open the Audit results page in the AWS IoT console.
2. Choose the name for the audit to which you want to apply actions.
3. Choose Start mitigation actions. This button is not available if all of your checks are compliant.
4. In Start a new mitigation action, the task name defaults to the audit ID, but you can change it to something more meaningful.
5. For each type of check that had one or more noncompliant findings in the audit, you can choose one or more actions to apply. Only actions that are valid for the check type are displayed.

Note
If you have not configured actions for your AWS account, the list of actions is empty. You can choose the Create mitigation action link to create one or more mitigation actions.
6. When you have specified all of the actions that you want to apply, choose Start task.
To use the AWS CLI to apply mitigation actions by starting an audit mitigation actions execution

1. If you want to apply actions to all findings for the audit, use the `ListAuditTasks` command to find the task ID.
2. If you want to apply actions to selected findings only, use the `ListAuditFindings` command to get the finding IDs.
3. Use the `ListMitigationActions` command and make note of the names of the mitigation actions that you want to apply.
4. Use the `StartAuditMitigationActionsTask` command to apply actions to the target. Make note of the task ID. You can use the ID to check the state of the action execution, review the details, or cancel it.

To use the AWS IoT console to view your action executions

1. Open the **Action tasks page in the AWS IoT console**.

   A list of action tasks shows when each was started and the current status.

2. Choose the **Name** link to see details for the task. The details include all of the actions that are applied by the task, their target, and their status.

   ![Action tasks page](https://example.com)

   **Details**
   - **Status**: COMPLETED
   - **Started at**: Jun 6, 2019 6:09:07 PM -0700
   - **Completed at**: Jun 6, 2019 6:09:09 PM -0700

   **Check summary**
   
<table>
<thead>
<tr>
<th>Check name</th>
<th>Failed</th>
<th>Successful</th>
<th>Skipped</th>
<th>Canceled</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>IoT policies overly permissive</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

   You can use the **Show executions for** filters to focus on types of actions or action states.

3. To see details for the task, in **Executions**, choose **Show**.
To use the AWS CLI to list your started tasks

1. Use `ListAuditMitigationActionsTasks` to view your audit mitigation actions tasks. You can provide filters to narrow the results. If you want to view details of the task, make note of the task ID.
2. Use `ListAuditMitigationActionsExecutions` to view execution details for a particular audit mitigation actions task.
3. Use `DescribeAuditMitigationActionsTask` to view details about the task, such as the parameters specified when it was started.

To use the AWS CLI to cancel a running audit mitigation actions task

1. Use the `ListAuditMitigationActionsTasks` command to find the task ID for the task whose execution you want to cancel. You can provide filters to narrow the results.
2. Use the `ListDetectMitigationActionsExecutions` command, using the task ID, to cancel your audit mitigation actions task. You cannot cancel tasks that have been completed. When you cancel a task, remaining actions are not applied, but mitigation actions that were already applied are not rolled back.

Permissions

For each mitigation action that you define, you must provide the role used to apply that action.

Permissions for mitigation actions

<table>
<thead>
<tr>
<th>Action type</th>
<th>Permissions policy template</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPDATE_DEVICE_CERTIFICATE</td>
<td><code>{ &quot;Version&quot;:&quot;2012-10-17&quot;, &quot;Statement&quot;:[] }</code></td>
</tr>
<tr>
<td>Action type</td>
<td>Permissions policy template</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td><strong>UPDATE_CA_CERTIFICATE</strong></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>&quot;Version&quot;:&quot;2012-10-17&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;Statement&quot;: [</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>&quot;Effect&quot;:&quot;Allow&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;Action&quot;: [</td>
</tr>
<tr>
<td></td>
<td>&quot;iot:UpdateCACertificate&quot;</td>
</tr>
<tr>
<td></td>
<td>}, &quot;Resource&quot;: [</td>
</tr>
<tr>
<td></td>
<td>&quot;*&quot;] ] ]</td>
</tr>
<tr>
<td><strong>ADD_THINGS_TO_THING_GROUP</strong></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>&quot;Version&quot;:&quot;2012-10-17&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;Statement&quot;: [</td>
</tr>
<tr>
<td></td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>&quot;Effect&quot;:&quot;Allow&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;Action&quot;: [</td>
</tr>
</tbody>
</table>
|                             |         "iot:ListPrincipalThings",
|                             |         "iot:AddThingToThingGroup"
<p>|                             |         }, &quot;Resource&quot;: [ |
|                             |         &quot;*&quot;] ] ]         |</p>
<table>
<thead>
<tr>
<th>Action type</th>
<th>Permissions policy template</th>
</tr>
</thead>
</table>
### Action type

<table>
<thead>
<tr>
<th><strong>Action type</strong></th>
<th><strong>Permissions policy template</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>PUBLISH_FINDING_TO_SNS</td>
<td><code>{   &quot;Version&quot;: &quot;2012-10-17&quot;,   &quot;Statement&quot;: [       {       &quot;Effect&quot;: &quot;Allow&quot;,       &quot;Action&quot;: [       &quot;sns:Publish&quot;     ],       &quot;Resource&quot;: [       &quot;&lt;The SNS topic to which the finding is published&gt;&quot;     ]     }   ]   }</code></td>
</tr>
</tbody>
</table>

For all mitigation action types, use the following trust policy template:

```
```

### Mitigation action commands

You can use these mitigation action commands to define a set of actions for your AWS account that you can later apply to one or more sets of audit findings. There are three command categories:

- Those used to define and manage actions.
- Those used to start and manage the application of those actions to Audit findings.
- Those used to start and manage the application of those actions to Detect alarms.
Mitigation action commands

<table>
<thead>
<tr>
<th>Define and manage actions</th>
<th>Start and manage Audit execution</th>
<th>Start and manage Detect execution</th>
</tr>
</thead>
<tbody>
<tr>
<td>CreateMitigationAction</td>
<td>CancelAuditMitigationActionsTask</td>
<td>CancelDetectMitigationActionsTask</td>
</tr>
<tr>
<td>DeleteMitigationAction</td>
<td>DescribeAuditMitigationActionsTask</td>
<td>DescribeDetectMitigationActionsTask</td>
</tr>
<tr>
<td>DescribeMitigationAction</td>
<td>ListAuditMitigationActionsTasks</td>
<td>ListDetectMitigationActionsTasks</td>
</tr>
<tr>
<td>ListMitigationActions</td>
<td>StartAuditMitigationActionsTask</td>
<td>StartDetectMitigationActionsTask</td>
</tr>
<tr>
<td>UpdateMitigationAction</td>
<td>ListAuditMitigationActionsExecutions</td>
<td>ListDetectMitigationActionsExecutions</td>
</tr>
</tbody>
</table>

Using AWS IoT Device Defender with other AWS services

Using AWS IoT Device Defender with devices running AWS IoT Greengrass

AWS IoT Greengrass provides pre-built integration with AWS IoT Device Defender to monitor device behaviors on an ongoing basis.

- [Integrate Device Defender with AWS IoT Greengrass V1](#)
- [Integrate Device Defender with AWS IoT Greengrass V2](#)

Using AWS IoT Device Defender with FreeRTOS and embedded devices

To use AWS IoT Device Defender on a FreeRTOS device, your device must have the [FreeRTOS Embedded C SDK](#) or the [AWS IoT Device Defender library](#) installed. The FreeRTOS Embedded C SDK includes the AWS IoT Device Defender library. For information about how to integrate AWS IoT Device Defender with your FreeRTOS devices, see the following demos:

- [AWS IoT Device Defender for FreeRTOS standard metrics and custom metrics demos](#)
- [Using MQTT agent to submit metrics to AWS IoT Device Defender](#)
- [Using the MQTT core library to submit metrics to AWS IoT Device Defender](#)

To use AWS IoT Device Defender on an embedded device without FreeRTOS, your device must have the [AWS IoT Embedded C SDK](#) or the [AWS IoT Device Defender library](#). The AWS IoT Embedded C SDK includes the AWS IoT Device Defender library. For information about how to integrate AWS IoT Device Defender with your embedded devices, see the following demos, [AWS IoT Device Defender for AWS IoT Embedded SDK standard and custom metrics demos](#).
Using AWS IoT Device Defender with AWS IoT Device Management

You can use AWS IoT Device Management fleet indexing to index, search, and aggregate your AWS IoT Device Defender detect violations. After your Device Defender violations data is indexed in fleet indexing, you can access and query Device Defender violations data from Fleet Hub applications, create fleet alarms based on violations data to monitor anomalies across your fleet of devices, and view fleet alarms in Fleet Hub dashboards.

**Note**
The fleet indexing feature to support indexing AWS IoT Device Defender violations data is in preview release for AWS IoT Device Management and is subject to change.

- Managing fleet indexing
- Query syntax
- Managing fleet indexing for Fleet Hub applications
- Getting started

Integration with AWS Security Hub

AWS Security Hub provides you with a comprehensive view of your security state in AWS and helps you check your environment against security industry standards and best practices. Security Hub collects security data from across AWS accounts, services, and supported third-party products. You can use Security Hub to analyze your security trends and identify the highest priority security issues.

With the AWS IoT Device Defender integration with Security Hub, you can send findings from AWS IoT Device Defender to Security Hub. Security Hub includes those findings in its analysis of your security posture.

**Contents**

- Enabling and configuring the integration (p. 1094)
- How AWS IoT Device Defender sends findings to Security Hub (p. 1095)
  - Types of findings that AWS IoT Device Defender sends (p. 1095)
  - Latency for sending findings (p. 1095)
  - Retrying when Security Hub isn't available (p. 1095)
  - Updating existing findings in Security Hub (p. 1096)
- Typical finding from AWS IoT Device Defender (p. 1096)
- Stopping AWS IoT Device Defender from sending findings to Security Hub (p. 1100)

Enabling and configuring the integration


After you enable both AWS IoT Device Defender and Security Hub, open the Integrations page in the Security Hub console, and then choose Accept findings for Audit, Detect, or both. AWS IoT Device Defender begins sending findings to Security Hub.
How AWS IoT Device Defender sends findings to Security Hub

In Security Hub, security issues are tracked as *findings*. Some findings come from issues that are detected by other AWS services or by third-party products.

Security Hub provides tools to manage findings from across all of these sources. You can view and filter lists of findings and view details for a finding. For more information, see Viewing findings in the AWS Security Hub User Guide. You can also track the status of an investigation into a finding. For more information, see Taking action on findings in the AWS Security Hub User Guide.

All findings in Security Hub use a standard JSON format called the **AWS Security Finding Format (ASFF)**. The ASFF includes details about the source of the issue, the affected resources, and the current status of the finding. For more information about ASFF, see AWS Security Finding Format (ASFF) in the AWS Security Hub User Guide.

AWS IoT Device Defender is one of the AWS services that sends findings to Security Hub.

Types of findings that AWS IoT Device Defender sends

After you enable the Security Hub integration, AWS IoT Device Defender Audit sends the findings it generates (called *check summaries*) to Security Hub. Check summaries are general information for a specific audit check type and a specific audit task. For more information, see Audit checks.

AWS IoT Device Defender Audit sends finding updates to Security Hub for both Audit Check Summaries and Audit Findings in each Audit task. If all resources found in Audit Checks are compliant, or an Audit Task is canceled, Audit updates the Check Summaries in Security Hub to an ARCHIVED record state. If a resource was reported as non-compliant for an Audit Check, but was reported as compliant in the last Audit task, Audit changes it to compliant and also updates the finding in Security Hub to an ARCHIVED record state.

AWS IoT Device Defender Detect sends violation findings to Security Hub. These violation findings include machine learning (ML), statistical, and static behaviors.

To send the findings to Security Hub, AWS IoT Device Defender uses the AWS Security Finding Format (ASFF). In ASFF, the Types field provides the finding type. Findings from AWS IoT Device Defender can have the following values for Types.

**Unusual behaviors**

The finding type for conflicting MQTT client IDs and device certificate shared checks, and the finding type for Detect.

**Software and Configuration Check/Vulnerabilities**

The finding type for all other Audit checks.

Latency for sending findings

When AWS IoT Device Defender Audit creates a new finding, it's immediately sent to Security Hub after the audit task completes. The latency depends on the volume of the findings generated in the audit task. Security Hub typically receives the findings within one hour.

AWS IoT Device Defender Detect sends findings for violations in near real time. After a violation goes into or out of alarm (meaning the alarm is created or deleted), the corresponding Security Hub finding is immediately created or archived.

Retrying when Security Hub isn't available

If Security Hub isn't available, AWS IoT Device Defender Audit and AWS IoT Device Defender Detect retry sending the findings until they're received.
Updating existing findings in Security Hub

After an AWS IoT Device Defender Audit finding is sent to Security Hub, you can identify it by checked resource identifier and audit check type. If a new audit finding is generated with a subsequent audit task for the same resource and audit check, AWS IoT Device Defender Audit sends updates to reflect additional observations of the finding activity to Security Hub. If no additional audit finding is generated with a subsequent audit task for the same resource and audit check, the resource changes to compliant with the audit check. AWS IoT Device Defender Audit then archives the findings in Security Hub.

AWS IoT Device Defender Audit also updates check summaries in Security Hub. If there are non-compliant resources found in an audit check or the check fails, the status of the Security Hub finding becomes active. Otherwise, AWS IoT Device Defender Audit archives the finding in Security Hub.

AWS IoT Device Defender Detect creates a Security Hub finding when there's a violation (for example, in-alarm). That finding is updated only if one of the following criteria is met:

- The finding is expiring soon in Security Hub so AWS IoT Device Defender sends an update to keep the finding current. Findings are deleted 90 days after the most recent update or 90 days after the creation date if no update occurs. For more information, see Security Hub quotas in the AWS Security Hub User Guide.
- The corresponding violation goes out of alarm, so AWS IoT Device Defender updates its finding status to ARCHIVED.

Typical finding from AWS IoT Device Defender

AWS IoT Device Defender uses the AWS Security Finding Format (ASFF) to send findings to Security Hub.

The following example shows a typical finding from Security Hub for an audit finding. The ReportType in ProductFields is AuditFinding.

```json
{
"SchemaVersion": "2018-10-08",
"Id": "336757784525/IOT_POLICY/policyexample/1/IOT_POLICY_OVERLY_PERMISSIVE_CHECK/ALLOWS_BROAD_ACCESS_TO_IOT_DATA_PLANE_ACTIONS",
"ProductName": "IoT Device Defender - Audit",
"CompanyName": "AWS",
"Region": "us-west-2",
"GeneratorId": "1928b07ab338ee2f541f6fab8c41c4f5",
"AwsAccountId": "123456789012",
"Types": ["Software and Configuration Check/Vulnerabilities"],
"CreatedAt": "2022-11-06T22:11:40.941Z",
"UpdatedAt": "2022-11-06T22:11:40.941Z",
"Severity": {
"Label": "CRITICAL",
"Normalized": 90
},
"Title": "IOT_POLICY_OVERLY_PERMISSIVE_CHECK: ALLOWS_BROAD_ACCESS_TO_IOT_DATA_PLANE_ACTIONS",
"Description": "IOT_POLICY policyexample:1 is reported as non-compliant for IOT_POLICY_OVERLY_PERMISSIVE_CHECK by Audit task 9f71b6e90cfe57d4ac671be3a4898e6a. The non-compliant reason is Policy allows broad access to IoT data plane actions: [iot:Connect].",
"ProductFields": {
"CheckName": "IOT_POLICY_OVERLY_PERMISSIVE_CHECK",
```

1096
The following example shows a finding from Security Hub for an audit check summary. The `ReportType` in `ProductFields` is `CheckSummary`.

```
{  
  "SchemaVersion": "2018-10-08",
  "Id": "615243839755/SCHEDULED_AUDIT_TASK/daily_audit_schedule_checks/DEVICE_CERTIFICATE_KEY_QUALITY_CHECK",
  "ProductArn": "arn:aws:securityhub:us-east-1::product/aws/iot-device-defender-audit",
  "ProductName": "IoT Device Defender - Audit",
  "Company Name": "AWS",
  "Region": "us-east-1",
  "GeneratorId": "f3021945485adf92487c273558fcaa51",
  "AwsAccountId": "123456789012",
  "Types": [
    "Software and Configuration Check/Vulnerabilities/CVE"
  ],
  "CreatedAt": "2022-10-18T14:20:13.933Z",
  "UpdatedAt": "2022-10-18T14:20:13.933Z",
}
```
The following example shows a typical finding from Security Hub for an AWS IoT Device Defender Detect violation.

```json
{
    "SchemaVersion": "2018-10-08",
    "Id": "e92a782593c6f5b1fc7cbf6549f6ca51",
    "ProductArn": "arn:aws:securityhub:us-east-1::product/aws/iot-device-defender-detect",
    "ProductName": "IoT Device Defender - Detect",
    "CompanyName": "AWS",
    "Region": "us-east-1",
    "GeneratorId": "arn:aws:iot:us-east-1:123456789012:securityprofile/MySecurityProfile",
    "AwsAccountId": "123456789012",
    "Severity": {
        "Label": "CRITICAL",
        "Normalized": 90
    },
    "Title": "DEVICE_CERTIFICATE_KEY_QUALITY_CHECK Summary: Completed with 2 non-compliant resources",
    "Description": "Task f3021945485adf92487c273558fcaa51 of weekly scheduled Audit daily_audit_schedule_checks completes. 2 non-compliant resources are found for DEVICE_CERTIFICATE_KEY_QUALITY_CHECK out of 1000 resources in the account. The percentage of non-compliant resources is 0.2%.",
    "SourceUrl": "https://us-east-1.console.aws.amazon.com/iot/home?region=us-east-1#/dd/audit/results/f3021945485adf92487c273558fcaa51/DEVICE_CERTIFICATE_KEY_QUALITY_CHECK",
    "ProductFields": {
        "TaskId": "f3021945485adf92487c273558fcaa51",
        "TaskType": "SCHEDULED_AUDIT_TASK",
        "ScheduledAuditName": "daily_audit_schedule_checks",
        "CheckName": "DEVICE_CERTIFICATE_KEY_QUALITY_CHECK",
        "ReportType": "CheckSummary",
        "CheckRunStatus": "COMPLETED_NON_COMPLIANT",
        "NonCompliantResourcesCount": "2",
        "SuppressedNonCompliantResourcesCount": "1",
        "TotalResourcesCount": "1000",
        "aws/securityhub/FindingId": "arn:aws:securityhub:us-east-1::product/aws/iot-device-defender-audit/615243839755/SCHEDULED/daily_audit_schedule_checks/DEVICE_CERTIFICATE_KEY_QUALITY_CHECK",
        "aws/securityhub/ProductName": "IoT Device Defender - Audit",
        "aws/securityhub/CompanyName": "AWS"
    },
    "Resources": [
        {
            "Type": "AwsIotAuditTask",
            "Id": "f3021945485adf92487c273558fcaa51",
            "Region": "us-east-1"
        }
    ],
    "WorkflowState": "NEW",
    "Workflow": {
        "Status": "NEW"
    },
    "RecordState": "ACTIVE",
    "FindingProviderFields": {
        "Severity": {
            "Label": "CRITICAL"
        },
        "Types": [
            "Software and Configuration Check/Vulnerabilities/CVE"
        ]
    }
}
```
"Types": ["Unusual Behaviors"],
"CreatedAt": "2022-11-09T22:45:00Z",
"UpdatedAt": "2022-11-09T22:45:00Z",
"Severity": {
  "Label": "MEDIUM",
  "Normalized": 40
},
"Title": "Registered thing MyThing is in alarm for STATIC behavior MyBehavior.",
"Description": "Registered thing MyThing violates STATIC behavior MyBehavior of security profile MySecurityProfile. Violation was triggered because the device did not conform to aws:num-disconnects less-than 1.",
"ProductFields": {
  "ComparisonOperator": "less-than",
  "BehaviorName": "MyBehavior",
  "ViolationId": "e92a782593c6f5b1fc7cb6a443dc1a12",
  "ViolationStartTime": "1668033900000",
  "SuppressAlerts": "false",
  "ConsecutiveDatapointsToAlarm": "1",
  "ConsecutiveDatapointsToClear": "1",
  "DurationSeconds": "300",
  "Count": "1",
  "MetricName": "aws:num-disconnects",
  "BehaviorCriteriaType": "STATIC",
  "ThingName": "MyThing",
  "SecurityProfileName": "MySecurityProfile",
  "aws/securityhub/FindingId": "arn:aws:securityhub:us-east-1::product/aws/iot-device-defender-detect/e92a782593c6f5b1fc7cb6a443dc1a12",
  "aws/securityhub/ProductName": "IoT Device Defender - Detect",
  "aws/securityhub/CompanyName": "AWS"
},
"Resources": [
{
  "Type": "AwsIotRegisteredThing",
  "Id": "MyThing",
  "Region": "us-east-1",
  "Details": {
    "Other": {
      "IsRegisteredThing": "true",
      "ThingArn": "arn:aws:iot:us-east-1:123456789012:thing/MyThing"
    }
  }
}
],
"WorkflowState": "NEW",
"Workflow": {
  "Status": "NEW"
},
"RecordState": "ACTIVE",
"FindingProviderFields": {
  "Severity": {
    "Label": "MEDIUM"
  },
  "Types": ["Unusual Behaviors"
]}
}
Stopping AWS IoT Device Defender from sending findings to Security Hub

To stop sending findings to Security Hub, you can use either the Security Hub console or the API.

For more information, see Disabling and enabling the flow of findings from an integration (console) or Disabling the flow of findings from an integration (Security Hub API, AWS CLI) in the AWS Security Hub User Guide.

Cross-service confused deputy prevention

The confused deputy problem is a security issue where an entity that doesn't have permission to perform an action can coerce a more-privileged entity to perform the action. In AWS, cross-service impersonation can result in the confused deputy problem. Cross-service impersonation can occur when one service (the calling service) calls another service (the called service). The calling service can be manipulated to use its permissions to act on another customer's resources through the called service in a way it should not otherwise have permission to access. To prevent this, AWS provides tools that help you protect your data for all services with service principals that have been given access to resources in your account.

There are three resources AWS IoT Device Defender accesses from you that can be effected by the confused deputy security issue, running audits, sending SNS notifications for security profile violations and running mitigation actions. For each of these actions, the values for aws:SourceArn must be as follows:

- For resources passed in UpdateAccountAuditConfiguration API (RoleArn and notificationTarget RoleArn attributes) you should scope down the resource policy by using aws:SourceArn as arn:arnPartition:iot:region:accountId:.
- For resources passed in CreateMitigationAction API (The RoleArn attribute) you should scope down the resource policy by using aws:SourceArn as arn:arnPartition:iot:region:accountId:mitigationaction/mitigationActionName.
- For resources passed in CreateSecurityProfile API (the alertTargets attribute) you should scope down the resource policy by using aws:SourceArn as arn:arnPartition:iot:region:accountId:securityprofile/securityprofileName.

The most effective way to protect against the confused deputy problem is to use the aws:SourceArn global condition context key with the full ARN of the resource. If you don't know the full ARN of the resource or if you are specifying multiple resources, use the aws:SourceArn global context condition key with wildcards (*) for the unknown portions of the ARN. For example, arn:aws:servicename:*:123456789012:*

The following example shows how you can use the aws:SourceArn and aws:SourceAccount global condition context keys in AWS IoT Device Defender to prevent the confused deputy problem.

```json
{
   "Version": "2012-10-17",
   "Statement": {
      "Sid": "ConfusedDeputyPreventionExamplePolicy",
      "Effect": "Allow",
      "Principal": {
         "Service": "iot.amazonaws.com"
      },
      "Action": "sts:AssumeRole",
      "Condition": {
         "ArnLike": {
         ...
```
Security best practices for device agents

Least Privilege

The agent process should be granted only the minimum permissions required to perform its duties.

Basic mechanisms

- Agent should be run as non-root user.
- Agent should run as a dedicated user, in its own group.
- User/groups should be granted read-only permissions on the resources required to gather and transmit metrics.
- Example: read-only on /proc /sys for the sample agent.
- For an example of how to set up a process to run with reduced permissions, see the setup instructions that are included with the Python sample agent.

There are a number of well-known Linux mechanisms that can help you further restrict or isolate your agent process:

Advanced mechanisms

- CGroups
- SELinux
- Chroot
- Linux Namespaces

Operational Resiliency

An agent process must be resilient to unexpected operational errors and exceptions and must not crash or exit permanently. The code needs to gracefully handle exceptions and, as a precaution, it must be configured to automatically restart in case of unexpected termination (for example, due to system restarts or uncaught exceptions).

Least Dependencies

An agent must use the least possible number of dependencies (that is, third-party libraries) in its implementation. If use of a library is justified due to the complexity of a task (for example, transport layer security), use only well-maintained dependencies and establish a mechanism to keep them up to date. If the added dependencies contain functionality not used by the agent and active by default (for example, opening ports, domain sockets), disable them in your code or by means of the library's configuration files.

Process Isolation

An agent process must only contain functionality required for performing device metric gathering and transmission. It must not piggyback on other system processes as a container or implement functionality for other out of scope use cases. In addition, the agent process must refrain from creating inbound communication channels such as domain socket and network service ports that
would allow local or remote processes to interfere with its operation and impact its integrity and isolation.

Stealthiness

An agent process must not be named with keywords such as security, monitoring, or audit indicating its purpose and security value. Generic code names or random and unique-per-device process names are preferred. The same principle must be followed in naming the directory in which the agent's binaries reside and any names and values of process arguments.

Least Information Shared

Any agent artifacts deployed to devices must not contain sensitive information such as privileged credentials, debugging and dead code, or inline comments or documentation files that reveal details about server-side processing of agent-gathered metrics or other details about backend systems.

Transport Layer Security

To establish TLS secure channels for data transmission, an agent process must enforce all client-side validations, such as certificate chain and domain name validation, at the application level, if not enabled by default. Furthermore, an agent must use a root certificate store that contains trusted authorities and does not contain certificates belonging to compromised certificate issuers.

Secure Deployment

Any agent deployment mechanism, such as code push or sync and repositories containing its binaries, source code and any configuration files (including trusted root certificates), must be access-controlled to prevent unauthorized code injection or tampering. If the deployment mechanism relies on network communication, then use cryptographic methods to protect the integrity of deployment artifacts in transit.

Further Reading

- Security in AWS IoT (p. 296)
- Understanding the AWS IoT Security Model
- Redhat: A Bite of Python
- 10 common security gotchas in Python and how to avoid them
- What Is Least Privilege & Why Do You Need It?
- OWASP Embedded Security Top 10
- OWASP IoT Project
Device Advisor

Device Advisor is a cloud-based, fully managed test capability for validating IoT devices during device software development. Device Advisor provides pre-built tests that you can use to validate IoT devices for reliable and secure connectivity with AWS IoT Core, before deploying devices to production. Device Advisor’s pre-built tests help you validate your device software against best practices for usage of TLS, MQTT, Device Shadow, and IoT Jobs. You can also download signed qualification reports to submit to the AWS Partner Network to get your device qualified for the AWS Partner Device Catalog without the need to send your device in and wait for it to be tested.

Note
Device Advisor is supported in us-east-1, us-west-2, ap-northeast-1, and eu-west-1 regions.
Device Advisor supports devices and clients that use the MQTT and the MQTT over WebSocket Secure (WSS) protocols to publish and subscribe to messages. All protocols support IPv4 and IPv6.
Device Advisor supports RSA server certificates.

Any device that has been built to connect to AWS IoT Core can take advantage of Device Advisor. You can access Device Advisor from the AWS IoT console, or by using the AWS CLI or SDK. When you’re ready to test your device, register it with AWS IoT Core and configure the device software with the Device Advisor endpoint. Then choose the prebuilt tests, configure them, run the tests on your device, and get the test results along with detailed logs or a qualification report.

Device Advisor is a test endpoint in the AWS cloud. You can test your devices by configuring them to connect to the test endpoint provided by the Device Advisor. After a device is configured to connect to the test endpoint, you can visit the Device Advisor’s console or use the AWS SDK to choose the tests you want to run on your devices. Device Advisor then manages the full lifecycle of a test, including the provisioning of resources, scheduling of the test process, managing the state machine, recording the device behavior, logging the results, and providing the final results in form of a test report.

TLS protocols

Transport Layer Security (TLS) protocol is used to encrypt confidential data over insecure networks like the internet. The TLS protocol is the successor of the Secure Sockets Layer (SSL) protocol.

Device Advisor supports the following TLS protocols:

- TLS 1.3 (recommended)
- TLS 1.2

Protocols, port mappings, and authentication

The device communication protocol is used by a device or a client to connect to the message broker by using a device endpoint. The following table lists the protocols that the Device Advisor endpoints support and the authentication methods and ports used.

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Operations supported</th>
<th>Authentication</th>
<th>Port</th>
<th>ALPN protocol name</th>
</tr>
</thead>
<tbody>
<tr>
<td>MQTT over WebSocket</td>
<td>Publish, Subscribe</td>
<td>Signature Version 4</td>
<td>443</td>
<td>N/A</td>
</tr>
</tbody>
</table>

1103
Setting up

Before you use Device Advisor for the first time, complete the following tasks:

Create an IoT thing

First, create an IoT thing and attach a certificate to that thing. For a tutorial on how to create things, see Create a thing object.

Create an IAM role to use as your device role

**Note**
You can quickly create the device role with the Device Advisor console. To learn how to set up your device role with the Device Advisor console, see [Getting started with the Device Advisor in the console](p. 1109).

1. Go to the AWS Identity and Access Management console and log in to the AWS account you use for Device Advisor testing.
2. In the left navigation pane, chose Policies.
3. Choose Create policy.
4. Under Create policy, do the following:
   a. For Service, choose IoT.
   b. Under Actions, do one of the following:
      - (Recommended) Select actions based on the policy attached to the IoT thing or certificate you created in the previous section.
      - Search for the following actions in the Filter action box and select them:
        - Connect
        - Publish
        - Subscribe
        - Receive

This chapter contains the following sections:

- Setting up (p. 1104)
- Getting started with Device Advisor in the console (p. 1109)
- Device Advisor workflow (p. 1115)
- Device Advisor detailed console workflow (p. 1119)
- Long duration tests console workflow (p. 1129)
- Device Advisor VPC endpoints (AWS PrivateLink) (p. 1135)
- Device Advisor test cases (p. 1138)
Create an IAM role to use as your device role

- RetainPublish
  c. Under **Resources**, restrict the client, topic, and topic resources. Restricting these resources is a security best practice. To restrict resources, do the following:

    i. Choose **Specify client resource ARN for the Connect action**.
    ii. Choose **Add ARN**, then do either of the following:

        Note
        The `clientId` is the MQTT client ID that your device uses to interact with Device Advisor.
        - Specify the **Region**, **accountID**, and **clientID** in the visual ARN editor.
        - Manually enter the Amazon Resource Names (ARNs) of the IoT topics you want to run your test cases with.

    iii. Choose **Add**.
    iv. Choose **Specify topic resource ARN for the Receive and one more action**.
    v. Choose **Add ARN**, then do either of the following:

        Note
        The `topic name` is the MQTT topic that your device publishes messages to.
        - Specify the **Region**, **accountID**, and **Topic name** in the visual ARN editor.
        - Manually enter the ARNs of the IoT topics you want to run your test cases with.

    vi. Choose **Add**.
    vii. Choose **Specify topicFilter resource ARN for the Subscribe action**.
    viii. Choose **Add ARN**, then do either of the following:

        Note
        The `topic name` is the MQTT topic that your device subscribes to.
        - Specify the **Region**, **accountID**, and **Topic name** in the visual ARN editor.
        - Manually enter the ARNs of the IoT topics you want to run your test cases with.

    ix. Choose **Add**.

5. Choose **Next: Tags**.
6. Choose **Next: Review**.
7. Under **Review policy**, enter a **Name** for your policy.
8. Choose **Create policy**.
9. On the left navigation pane, Choose **Roles**.
10. Choose **Create Role**.
11. Under **Select trusted entity**, choose **Custom trust policy**.
12. Enter the following trust policy into the **Custom trust policy** box. To protect against the confused deputy problem, add the global condition context keys `aws:SourceArn` and `aws:SourceAccount` to the policy.

    **Important**
    Your `aws:SourceArn` must comply with the format: `arn:aws:iotdeviceadvisor:` *region:*`account-id:` *. Make sure that `region` matches your AWS IoT Region and `account-id` matches your customer account ID. For more information, see Cross-service confused deputy prevention.

    ```json
    {
    "Version": "2012-10-17",
    "Statement": [
      {
        "Sid": "AllowAwsIoTCoreDeviceAdvisor",
        "Effect": "Allow",
        "Principal": {
    ```

1105
Create a custom-managed policy for an IAM user to use Device Advisor

1. Navigate to the IAM console at https://console.aws.amazon.com/iam/. If prompted, enter your AWS credentials to sign in.
2. In the left navigation pane, choose Policies.
3. Choose Create Policy, then choose the JSON tab.
4. Add the necessary permissions to use Device Advisor. The policy document can be found in the topic Security best practices.
5. Choose Review Policy.
6. Enter a Name and Description.
7. Choose Create Policy.

Create an IAM user to use Device Advisor

Note
We recommend that you create an IAM user to use when you run Device Advisor tests. Running Device Advisor tests from an admin user can pose security risks and isn't recommended.

1. Navigate to the IAM console at https://console.aws.amazon.com/iam/ If prompted, enter your AWS credentials to sign in.
2. In the left navigation pane, Choose Users.
3. Choose Add User.
4. Enter a User name.
5. Users need programmatic access if they want to interact with AWS outside of the AWS Management Console. The way to grant programmatic access depends on the type of user that's accessing AWS.

To grant users programmatic access, choose one of the following options.
**Which user needs programmatic access?** | **To** | **By** |
--- | --- | --- |
Workforce identity (Users managed in IAM Identity Center) | Use temporary credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs. | Following the instructions for the interface that you want to use.  
  - For the AWS CLI, see [Configuring the AWS CLI to use AWS IAM Identity Center](https://docs.aws.amazon.com/cli/latest/index.html) in the **AWS Command Line Interface User Guide**.  
  - For AWS SDKs, tools, and AWS APIs, see [IAM Identity Center authentication](https://docs.aws.amazon.com/IAM/latest/userguide/idc_auth.html) in the **AWS SDKs and Tools Reference Guide**. |
IAM | Use temporary credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs. | Following the instructions in [Using temporary credentials with AWS resources](https://docs.aws.amazon.com/IAM/latest/userguide/idc-auth.html) in the **IAM User Guide**. |
IAM | (Not recommended) Use long-term credentials to sign programmatic requests to the AWS CLI, AWS SDKs, or AWS APIs. | Following the instructions for the interface that you want to use.  
  - For the AWS CLI, see [Authenticating using IAM user credentials](https://docs.aws.amazon.com/cli/latest/index.html) in the **AWS Command Line Interface User Guide**.  
  - For AWS SDKs and tools, see [Authenticate using long-term credentials](https://docs.aws.amazon.com/IAM/latest/userguide/idc-auth.html) in the **AWS SDKs and Tools Reference Guide**.  
  - For AWS APIs, see [Managing access keys for IAM users](https://docs.aws.amazon.com/IAM/latest/userguide/idc-auth.html) in the **IAM User Guide**. |

6. Choose **Next: Permissions**.

7. To provide access, add permissions to your users, groups, or roles:
   - Users and groups in AWS IAM Identity Center:
     
     Create a permission set. Follow the instructions in [Create a permission set](https://docs.aws.amazon.com/IAM/latest/userguide/idc-permissionset.html) in the **AWS IAM Identity Center User Guide**.
   
   - Users managed in IAM through an identity provider:
     
     Create a role for identity federation. Follow the instructions in [Creating a role for a third-party identity provider (federation)](https://docs.aws.amazon.com/IAM/latest/userguide/idc-auth.html) in the **IAM User Guide**.
   
     - IAM users:
       
       - Create a role that your user can assume. Follow the instructions in [Creating a role for an IAM user](https://docs.aws.amazon.com/IAM/latest/userguide/idc-auth.html) in the **IAM User Guide**.
Configure your device

Device Advisor uses the server name indication (SNI) TLS extension to apply TLS configurations. Devices must use this extension when they connect and pass a server name that is identical to the Device Advisor test endpoint.

Device Advisor allows the TLS connection when a test is in the Running state. It denies the TLS connection before and after each test run. For this reason, we recommend that you use the device connect retry mechanism for a fully automated testing experience with Device Advisor. You can run test suites that include more than one test case, such as TLS connect, MQTT connect, and MQTT publish. If you run multiple test cases, we recommend that your device try to connect to our test endpoint every five seconds. You can then automate running multiple test cases in sequence.

Note
To ready your device software for testing, we recommend that you use an SDK that can connect to AWS IoT Core. You should then update the SDK with the Device Advisor test endpoint provided for your AWS account.

Device Advisor supports two types of endpoints: Account-level and Device-level endpoints. Choose the endpoint that best fits your use case. To simultaneously run multiple test suites for different devices, use a Device-level endpoint.

Run the following command to get the Device-level endpoint:

For MQTT customers using X.509 client certificates:

```bash
aws iotdeviceadvisor get-endpoint --thing-arn your-thing-arn
```

or

```bash
aws iotdeviceadvisor get-endpoint --certificate-arn your-certificate-arn
```

For MQTT over WebSocket customers using Signature Version 4:

```bash
aws iotdeviceadvisor get-endpoint --device-role-arn your-device-role-arn --authentication-method SignatureVersion4
```

To run one test suite at a time, choose an Account-level endpoint. Run the following command to get the Account-level endpoint:
Getting started with Device Advisor in the console

This tutorial helps you get started with AWS IoT Core Device Advisor on the console. Device Advisor offers features such as required tests and signed qualification reports. You can use these tests and reports to qualify and list devices in the AWS Partner Device Catalog as detailed in the AWS IoT Core qualification program.

For more information about using Device Advisor, see Device Advisor workflow (p. 1115) and Device Advisor detailed console workflow (p. 1119).

To complete this tutorial, follow the steps outlined in Setting up (p. 1104).

Note

Device Advisor is supported in the following AWS Regions:

- US East (N. Virginia)
- US West (Oregon)
- Asia Pacific (Tokyo)
- Europe (Ireland)

Getting started

1. In the AWS IoT console's navigation pane under Test, choose Device Advisor. Then, choose the Start walkthrough button on the console.

2. The Getting started with Device Advisor page provides an overview of the steps required to create a test suite and run tests against your device. You can also find the Device Advisor test endpoint for your account here. You must configure the firmware or software on the device used for testing to connect to this test endpoint.

   To complete this tutorial, you must first create a thing and certificate. After you review the information under How it works, choose Next.
3. In **Step 1: Select a protocol**, select a protocol from the options listed. Then, choose **Next**.

4. In **Step 2**, you create and configure a custom test suite. A custom test suite must have at least one test group, and each test group must have at least one test case. We've added the **MQTT Connect** test case for you to get started.

Choose **Test suite properties**.

You must supply the test suite properties when you create your test suite. You can configure the following suite-level properties:

- **Test suite name**: Enter a name for your test suite.
- **Timeout** (optional): The timeout (in seconds) for each test case in the current test suite. If you don't specify a timeout value, the default value is used.
- **Tags** (optional): Add tags to the test suite.
When you’ve finished, choose **Update properties**.

5. (Optional) To update the test suite group configuration, choose the **Edit** button next to the test group name.
   - **Name**: Enter a custom name for the test suite group.
   - **Timeout** (optional): The timeout (in seconds) for each test case in the current test suite. If you don’t specify a timeout value, the default value is used.

When finished, choose **Done** to continue.

6. (Optional) To update the test case configuration for a test case, choose the **Edit** button next to the test case name.
   - **Name**: Enter a custom name for the test suite group.
   - **Timeout** (optional): The timeout (in seconds) for the selected test case. If you don’t specify a timeout value, the default value is used.

When finished, choose **Done** to continue.
7. (Optional) To add more test groups to the test suite, choose **Add test group**, then follow the instructions in Step 5.

8. (Optional) To add more test cases, drag the test cases in the **Test cases** section into any of your test groups.

9. You can change the order of your test groups and test cases. To make changes, drag the listed test cases up or down the list. Device Advisor runs tests in the order you listed them in.

After you’ve configured your test suite, choose **Next**.

10. In **Step 3**, select an AWS IoT thing or certificate to test using Device Advisor. If you don’t have any existing things or certificates, see **Setting up**.
11. You can configure a device role that Device Advisor uses to perform AWS IoT MQTT actions on behalf of your test device. For MQTT Connect test case only, the Connect action is selected automatically. This is because the device role requires this permission to run the test suite. For other test cases, the corresponding actions are selected.

Provide the resource values for each of the selected actions. For example, for the Connect action, provide the client ID your device uses to connect to the Device Advisor endpoint. You can provide multiple values with comma separated values, and prefix values with a wildcard (*) character. For example, to provide permission to publish on any topic beginning with MyTopic, enter MyTopic* as the resource value.

To use a previously created device role from Setting up, choose Select an existing role. Then choose your device role under Select role.

Configure your device role with one of the two provided options, and then choose Next.

12. In the Test endpoint section, select the endpoint that best fits your use case. To run multiple test suites simultaneously with the same AWS account, select Device-level endpoint. To run one test suite at a time, select Account-level endpoint.
13. **Step 4** shows an overview of the selected test device, test endpoint, test suite, and test device role configured. To make changes to a section, choose the **Edit** button for the section you want to edit. Once you've confirmed your test configuration, choose **Run** to create the test suite and run your tests.

**Note**
For best results, you can connect your selected test device to the Device Advisor test endpoint before you start the test suite run. We recommend that you have a mechanism built for your device to try connecting to our test endpoint every five seconds for up to one to two minutes.

14. In the navigation pane under **Test**, choose **Device Advisor**, and then choose **Test runs and results**. Select a test suite run to view its run details and logs.
15. To access the Amazon CloudWatch logs for the suite run:
   - Choose **Test suite log** to view the CloudWatch logs for the test suite run.
   - Choose **Test case log** for any test case to view test case-specific CloudWatch logs.

16. Based on your test results, **troubleshoot** your device until all tests pass.

**Device Advisor workflow**

This tutorial explains how to create a custom test suite and run tests against the device you want to test in the console. After the tests are complete, you can view the test results and detailed logs.

**Prerequisites**

Before you begin this tutorial, complete the steps outlined in Setting up (p. 1104).

**Create a test suite definition**

First, **install an AWS SDK**.

**rootGroup syntax**

A root group is a JSON string that specifies which test cases to include in your test suite. It also specifies any necessary configurations for those test cases. Use the root group to structure and order your test suite based on your needs. The hierarchy of a test suite is:

```
test suite # test group(s) # test case(s)
```

A test suite must have at least one test group, and each test group must have at least one test case. Device Advisor runs tests in the order in which you define the test groups and test cases.

Each root group follows this basic structure:

```json
{
   "configuration": {
      // for all tests in the test suite
   }
}
```
In the root group, you define the test suite with a name, configuration, and the tests that the group contains. The tests group contains the definitions of individual tests. You define each test with a name, configuration, and a test block that defines the test cases for that test. Finally, each test case is defined with an id and version.

For information on how to use the "id" and "version" fields for each test case (test block), see Device Advisor test cases (p. 1138). That section also contains information on the available configuration settings.

The following block is an example of a root group configuration. This configurations specifies the MQTT Connect Happy Case and MQTT Connect Exponential Backoff Retries test cases, along with descriptions of the configuration fields.

```json
{
   "configuration": {},  // Suite-level configuration
   "tests": [            // Group definitions should be provided here
      {
         "name": "My_MQTT_Connect_Group",  // Group definition name
         "configuration": {}               // Group definition-level configuration,
         "tests": [                        // Test case definitions should be provided here
            {
               "name": "My_MQTT_Connect_Happy_Case",  // Test case definition name
               "configuration": {
                  "EXECUTION_TIMEOUT": 300        // Test case definition-level configuration, in seconds
               },
               "test": {
                  "id": "MQTT_Connect",              // test case id
                  "version": "0.0.0"                 // test case version
               }
            },
            {
               "name": "My_MQTT_Connect_Jitter_Backoff_Retries",  // Test case definition name
               "configuration": {
                  "EXECUTION_TIMEOUT": 600        // Test case definition-level configuration, in seconds
               },
               "test": {
                  "id": "MQTT_Connect_Jitter_Backoff_Retries",  // test case id
                  "version": "0.0.0"                   // test case version
               }
            }
         ]
      }
   ]
}
```
You must supply the root group configuration when you create your test suite definition. Save the `suiteDefinitionId` that is returned in the response object. You can use this ID to retrieve your test suite definition information and run your test suite.

Here is a Java SDK example:

```java
response = iotDeviceAdvisorClient.createSuiteDefinition(
    CreateSuiteDefinitionRequest.builder()
        .suiteDefinitionConfiguration(SuiteDefinitionConfiguration.builder()
            .suiteDefinitionName("your-suite-definition-name")
            .devices(
                DeviceUnderTest.builder()
                    .thingArn("your-test-device-thing-arn")
                    .certificateArn("your-test-device-certificate-arn")
                    .deviceRoleArn("your-device-role-arn") //if using SigV4 for MQTT over WebSocket
                )
            .rootGroup("your-root-group-configuration")
            .devicePermissionRoleArn("your-device-permission-role-arn")
            .protocol("MqttV3_1_1 || MqttV5 || MqttV3_1_1_OverWebSocket || MqttV5_OverWebSocket")
        )
        .build()
);```

**Get a test suite definition**

After you create your test suite definition, you receive the `suiteDefinitionId` in the response object of the CreateSuiteDefinition API operation.

When the operation returns the `suiteDefinitionId`, you may see new `id` fields within each group and test case definition within the root group. You can use these IDs to run a subset of your test suite definition.

Java SDK example:

```java
response = iotDeviceAdvisorClient.GetSuiteDefinition(
    GetSuiteDefinitionRequest.builder()
        .suiteDefinitionId("your-suite-definition-id")
        .build()
);```

**Get a test endpoint**

Use the GetEndpoint API operation to get the test endpoint used by your device. Select the endpoint that best fits your test. To simultaneously run multiple test suites, use the Device-level endpoint by providing a thing ARN, certificate ARN, or device role ARN. To run a single test suite, provide no arguments to the GetEndpoint operation to choose the Account-level endpoint.

SDK example:

```java
response = iotDeviceAdvisorClient.getEndpoint(GetEndpointRequest.builder()
    .certificateArn("your-test-device-certificate-arn")
    .thingArn("your-test-device-thing-arn")
    .deviceRoleArn("your-device-role-arn") //if using SigV4 for MQTT over WebSocket
    .build());```
Start a test suite run

After you create a test suite definition and configure your test device to connect to your Device Advisor test endpoint, run your test suite with the `StartSuiteRun` API.

For MQTT customers, use either `certificateArn` or `thingArn` to run the test suite. If both are configured, the certificate is used if it belongs to the thing.

For MQTT over WebSocket customers, use `deviceRoleArn` to run the test suite. If the specified role is different from the role specified in the test suite definition, the specified role overrides the defined role.

For `.parallelRun()`, use `true` if you use a Device-level endpoint to run multiple test suites in parallel using one AWS account.

SDK example:

```java
response = iotDeviceAdvisorClient.startSuiteRun(StartSuiteRunRequest.builder()
  .suiteDefinitionId("your-suite-definition-id")
  .suiteRunConfiguration(SuiteRunConfiguration.builder()
    .primaryDevice(DeviceUnderTest.builder()
      .certificateArn("your-test-device-certificate-arn")
      .thingArn("your-test-device-thing-arn")
      .deviceRoleArn("your-device-role-arn") // if using SigV4 for MQTT over WebSocket
    .build())
    .parallelRun(true | false)
    .build())
  .build())

Save the `suiteRunId` from the response. You will use this to retrieve the results of this test suite run.

Get a test suite run

After you start a test suite run, you can check its progress and its results with the `GetSuiteRun` API.

SDK example:

```java
// Using the SDK, call the GetSuiteRun API.
response = iotDeviceAdvisorClient.GetSuiteRun(  
  GetSuiteRunRequest.builder()
    .suiteDefinitionId("your-suite-definition-id")
    .suiteRunId("your-suite-run-id")
  .build())
```

Stop a test suite run

To stop a test suite run that is still in progress, you can call the `StopSuiteRun` API operation. After you call the `StopSuiteRun` operation, the service starts the cleanup process. While the service runs the cleanup process, the test suite run status updates to Stopping. The cleanup process can take several minutes. Once the process is complete, the test suite run status updates to Stopped. After a test run has completely stopped, you can start another test suite run. You can periodically check the suite run status using the `GetSuiteRun` API operation, as shown in the previous section.

SDK example:

```java
// Using the SDK, call the StopSuiteRun API.
response = iotDeviceAdvisorClient.StopSuiteRun(  
```

1118
Get a qualification report for a successful qualification test suite run

If you run a qualification test suite that completes successfully, you can retrieve a qualification report with the GetSuiteRunReport API operation. You use this qualification report to qualify your device with the AWS IoT Core qualification program. To determine whether your test suite is a qualification test suite, check whether the intendedForQualification parameter is set to true. After you call the GetSuiteRunReport API operation, you can download the report from the returned URL for up to 90 seconds. If more than 90 seconds elapse from the previous time you called the GetSuiteRunReport operation, call the operation again to retrieve a new, valid URL.

SDK example:

```java
// Using the SDK, call the getSuiteRunReport API.
response = iotDeviceAdvisorClient.getSuiteRunReport(
    GetSuiteRunReportRequest.builder()
        .suiteDefinitionId("your-suite-definition-id")
        .suiteRunId("your-suite-run-id")
        .build()
)
```

Device Advisor detailed console workflow

In this tutorial, you’ll create a custom test suite and run tests against the device you want to test in the console. After the tests are complete, you can view the test results and detailed logs.

Tutorials

- Prerequisites (p. 1119)
- Create a test suite definition (p. 1119)
- Start a test suite run (p. 1124)
- Stop a test suite run (optional) (p. 1126)
- View test suite run details and logs (p. 1127)
- Download an AWS IoT qualification report (p. 1128)

Prerequisites

To complete this tutorial, you need to create a thing and certificate.

Create a test suite definition

1. In the AWS IoT console, in the navigation pane, expand Test, Device Advisor and then choose Test suites.
1. Choose **Create Test Suite**.

2. Select either **Use the AWS Qualification test suite** or **Create a new test suite**.

   For protocol, choose either **MQTT 3.1.1** or **MQTT 5**.

Select **Use the AWS Qualification test suite** to qualify and list your device to the AWS Partner Device Catalog. By choosing this option, test cases required for qualification of your device to the AWS IoT Core qualification program are pre-selected. Test groups and test cases can't be added or removed. You will still need to configure the test suite properties.

Select **Create a new test suite** to create and configure a custom test suite. We recommend starting with this option for initial testing and troubleshooting. A custom test suite must have at least one test group, and each test group must have at least one test case. For the purpose of this tutorial, we'll select this option and choose **Next**.
3. Choose **Test suite properties**. You must create the test suite properties when you create your test suite.

Under **Test suite properties**, fill out the following:

- **Test suite name**: You can create the suite with a custom name.
- **Timeout** (optional): The timeout in seconds for each test case in the current test suite. If you don’t specify a timeout value, the default value is used.
- **Tags** (optional): Add tags to the test suite.
When you’ve finished, choose **Update properties**.

4. To modify the group level configuration, under **Test group 1**, choose **Edit**. Then, enter a **Name** to give the group a custom name.

   Optionally, you can also enter a **Timeout** value in seconds under the selected test group. If you don’t specify a timeout value, the default value is used.

Choose **Done**.

5. Drag one of the available test cases from **Test cases** into the test group.
6. To modify the test case level configuration for the test case that you added to your test group, choose Edit. Then, enter a Name to give the group a custom name.

Optionally, you can also enter a Timeout value in seconds under the selected test group. If you don't specify a timeout value, the default value is used.

Choose Done.

**Note**
To add more test groups to the test suite, choose Add test group. Follow the preceding steps to create and configure more test groups, or to add more test cases to one or more test groups. Test groups and test cases can be reordered by choosing and dragging a test case to the desired position. Device Advisor runs tests in the order in which you define the test groups and test cases.

7. Choose Next.

8. In Step 3, configure a device role which Device Advisor will use to perform AWS IoT MQTT actions on behalf of your test device.

If you selected MQTT Connect test case only in Step 2, the Connect action will be checked automatically since that permission is required on device role to run this test suite. If you selected other test cases, the corresponding required actions will be checked. Ensure that the resource values values for each of the actions is provided. For example, for the Connect action, provide the client id
that your device will be connecting to the Device Advisor endpoint with. You can provide multiple values by using commas to separate the values, and you can provide prefix values using a wildcard (*) character as well. For example, to provide permission to publish on any topic beginning with MyTopic, you can provide "MyTopic*" as the resource value.

If you already created a device role previously and would like to use that role, select Select an existing role and choose your device role under Select role.

Configure your device role using one of the two provided options and choose Next.

9. In Step 4, make sure the configuration provided in each of the steps is accurate. To edit configuration provided for a particular step, choose Edit for the corresponding step.

After you verify the configuration, choose Create test suite.

The test suite should be created successfully and you'll be redirected to the Test suites page where you can view all the test suite that have been created.

If the test suite creation failed, make sure the test suite, test groups, test cases, and device role have been configured according to the previous instructions.

Start a test suite run

1. In the AWS IoT console, in the navigation pane, expand Test, Device Advisor, and then choose Test suites.

2. Choose the test suite for which you'd like to view the test suite details.
The test suite detail page displays all of the information related to the test suite.

3. Choose Actions, then Run test suite.

4. Under Run configuration, you'll need to select an AWS IoT thing or certificate to test using Device Advisor. If you don't have any existing things or certificates, first create AWS IoT Core resources (p. 1104).

   In Test endpoint section, select the endpoint that best fits your case. If you plan to run multiple test suites simultaneously using the same AWS account in the future, select Device-level endpoint. Otherwise, if you plan to only run one test suite at a time, select Account-level endpoint.

   Configure your test device with the selected Device Advisor's test endpoint.

   After you select a thing or certificate and choose a Device Advisor endpoint, choose Run test.
5. Choose **Go to results** on the top banner for viewing the test run details.

---

**Stop a test suite run (optional)**

1. In the **AWS IoT console**, in the navigation pane, expand **Test, Device Advisor**, and then choose **Test runs and results**.

2. Choose the test suite in progress that you want to stop.
3. Choose Actions, then Stop test suite.

4. The cleanup process will take several minutes to complete. While the cleanup process runs, the test run status will be STOPPING. Wait for the cleanup process to complete and for the test suite status to change to the STOPPED status before starting a new suite run.

View test suite run details and logs

1. In the AWS IoT console, in the navigation pane, expand Test, Device Advisor and then choose Test runs and results.

   This page displays:

   - Number of IoT things
   - Number of IoT certificates
   - Number of test suites currently running
   - All the test suite runs that have been created

2. Choose the test suite for which you’d like to view the run details and logs.
The run summary page displays the status of the current test suite run. This page automatically refreshes every 10 seconds. We recommend that you have a mechanism built for your device to try connecting to our test endpoint every five seconds for one to two minutes. Then you can run multiple test cases in sequence in an automated manner.

3. To access the CloudWatch logs for the test suite run, choose Test suite log.

   To access CloudWatch logs for any test case, choose Test case log.

4. Based on your test results, troubleshoot your device until all tests pass.

Download an AWS IoT qualification report

If you chose the Use the AWS IoT Qualification test suite option while creating a test suite and were able to run a qualification test suite, you can download a qualification report by choosing Download qualification report in the test run summary page.
Long duration tests console workflow

This tutorial helps you get started with the Long duration tests on Device Advisor using the console. To complete the tutorial, follow the steps at Setting up (p. 1104).

1. In the AWS IoT console navigation pane, expand Test, then Device Advisor, then Test suites. On the page, select Create long duration test suite.

2. On the Create test suite page, select Long duration test suite and choose Next.

For protocol, choose either MQTT 3.1.1 or MQTT 5.
3. Do the following on the **Configure test suite** page:
   
a. Update the **Test suite name** field.
   
b. Update the **Test group name** field.
   
c. Choose the **Device operations** the device can perform. This will select the tests to run.
   
d. Select the **Settings** option.

4. (Optional) Input the maximum amount of time Device Advisor must wait for the basic tests to complete. Select **Save**.
5. Do the following in the Advanced tests and Additional settings sections.
   a. Select or deselect the Advanced tests you want to run as part of this test.
   b. Edit the configurations for the tests when applicable.
   c. Configure the Additional execution time under the Additional settings section.
   d. Choose Next to do the next step.

6. In this step, Create a new role or Select an existing role. See Create an IAM role to use as your device role (p. 1104) for details.
7. Review all the configurations created until this step and select **Create test suite**.

8. The created test suite is under the **Test suites** section. Select the suite to view details.
9. To run the created test suite, select Actions then Run test suite.

10. Choose the configuration options in the Run configuration page.
   a. Select the Things or Certificate to run the test on.
   b. Select either the Account-level endpoint or Device-level endpoint.
   c. Choose Run test to run the test.
11. To view the results of the test suite run, select **Test runs and results** in the left navigation pane. Choose the test suite that ran to view the details of the results.

12. The previous step brings up the test summary page. All the details of the test run are displayed in this page. When the console prompts to start the device connection, connect your device to the provided endpoint. The progress of the tests is seen on this page.
13. The Long duration test provides an additional **Test log summary** on the side panel which displays all the important events occurring between the device and the broker in near real time. To view more in-depth detailed logs, click on **Test case log**.

### Device Advisor VPC endpoints (AWS PrivateLink)

You can establish a private connection between your VPC and the AWS IoT Core Device Advisor test endpoint (data plane) by creating an **interface VPC endpoint**. You can use this endpoint to validate AWS IoT devices for reliable and secure connectivity with AWS IoT Core before deploying devices to production. Device Advisor’s pre-built tests helps you validate your device software against best practices for usage of **TLS**, **MQTT**, **Device Shadow**, and **AWS IoT Jobs**.

**AWS PrivateLink** powers the interface endpoints used with your IoT devices. This service helps you access the AWS IoT Core Device Advisor test endpoint privately without an internet gateway, NAT device,
VPN connection, or AWS Direct Connect connection. Instances in your VPC that send TCP and MQTT packets don't need public IP addresses to communicate with AWS IoT Core Device Advisor test endpoints. Traffic between your VPC and AWS IoT Core Device Advisor doesn't leave AWS Cloud. Any TLS and MQTT communication between IoT devices and Device Advisor test cases stay within the resources in your AWS account.

Each interface endpoint is represented by one or more elastic network interfaces in your subnets.

To learn more about using interface VPC endpoints, see Interface VPC endpoints (AWS PrivateLink) in the Amazon VPC User Guide.

Considerations for AWS IoT Core Device Advisor VPC endpoints

Review the interface endpoint properties and limitations in the Amazon VPC User Guide before setting up interface VPC endpoints. Consider the following before you continue:

- AWS IoT Core Device Advisor currently supports making calls to Device Advisor test endpoint (data plane) from your VPC. A message broker uses data plane communications to send and receive data. It does this with the help of TLS and MQTT packets. VPC endpoints for AWS IoT Core Device Advisor connect your AWS IoT device to Device Advisor test endpoints. **Control plane API actions** aren't used by this VPC endpoint. In order to create or run a test suite or other control plane APIs, use the console, an AWS SDK, or AWS Command Line Interface over the public internet.

- The following AWS Regions support VPC endpoints for AWS IoT Core Device Advisor:
  - US East (N. Virginia)
  - US West (Oregon)
  - Asia Pacific (Tokyo)
  - Europe (Ireland)

- Device Advisor supports MQTT with X.509 client certificates and RSA server certificates.

- **VPC endpoint policies** aren't supported at this time.

- Check VPC endpoint prerequisites for instructions on how to create resources that connect VPC endpoints. You must create a VPC and private subnets to use AWS IoT Core Device Advisor VPC endpoints.

- There are quotas on your AWS PrivateLink resources. For more information, see AWS PrivateLink quotas.

- VPC endpoints support only IPv4 traffic.

Create an interface VPC endpoint for AWS IoT Core Device Advisor

To get started with VPC endpoints, create an interface VPC endpoint. Next, select AWS IoT Core Device Advisor as the AWS service. If you are using the AWS CLI, call describe-vpc-endpoint-services to confirm that AWS IoT Core Device Advisor is present in an Availability Zone in your AWS Region. Confirm that the security group attached to the endpoint allows TCP protocol communication for MQTT and TLS traffic. For example, in the US East (N. Virginia) Region, use the following command:

```
aws ec2 describe-vpc-endpoint-services --service-name com.amazonaws.us-east-1.deviceadvisor.iot
```

Note that you can create a VPC endpoint for AWS IoT Core using the following service name:
By default, private DNS is turned on for the endpoint. This ensures that use of the default test endpoint stays within your private subnets. To get your account or device level endpoint, use the console, AWS CLI or an AWS SDK. For example, if you run `get-endpoint` within a public subnet or on the public internet, you can get your endpoint and use it to connect to Device Advisor. For more information, see Accessing a service through an interface endpoint in the Amazon VPC User Guide.

To connect MQTT clients to the VPC endpoint interfaces, the AWS PrivateLink service creates DNS records in a private hosted zone attached to your VPC. These DNS records direct the AWS IoT device's requests to the VPC endpoint.

## Controlling access to AWS IoT Core Device Advisor over VPC endpoints

You can restrict device access to AWS IoT Core Device Advisor and allow access only through VPC endpoints by using VPC condition context keys. AWS IoT Core supports the following VPC related context keys:

- `SourceVpc`
- `SourceVpce`
- `VPCSourceIp`

**Note**

AWS IoT Core Device Advisor doesn't support VPC endpoint policies at this time.

The following policy grants permission to connect to AWS IoT Core Device Advisor using a client ID that matches the thing name. It also publishes to any topic prefixed by the thing name. The policy is conditional on the device connecting to a VPC endpoint with a particular VPC endpoint ID. This policy denies connection attempts to your public AWS IoT Core Device Advisor test endpoint.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Connect"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:client/${iot:Connection.Thing.ThingName}"
      ],
      "Condition": {
        "StringEquals": {
          "aws:SourceVpce": "vpce-1a2b3c4d"
        }
      }
    },
    {
      "Effect": "Allow",
      "Action": [
        "iot:Publish"
      ],
      "Resource": [
        "arn:aws:iot:us-east-1:123456789012:topic/${iot:Connection.Thing.ThingName}/*
```
Device Advisor test cases

Device Advisor provides prebuilt tests in six categories.

- **TLS** (p. 1138)
- **MQTT** (p. 1143)
- **Shadow** (p. 1151)
- **Job execution** (p. 1153)
- **Permissions and policies** (p. 1154)
- **Long duration tests** (p. 1155)

Device Advisor test cases to qualify for the AWS Device Qualification Program.

Your device must pass the following tests to qualify according to the [AWS Device Qualification Program](#).

**Note**
This is a revised list of the qualification tests.

- **TLS Connect** (p. 1139) ("TLS Connect")
- **TLS Incorrect Subject Name Server Cert** (p. 1142) ("Incorrect Subject Common Name (CN) / Subject Alternative Name (SAN)"")
- **TLS Unsecure Server Cert** (p. 1141) ("Not Signed By Recognized CA")
- **TLS Device Support for AWS IoT Cipher Suites** (p. 1140) ("TLS Device Support for AWS IoT recommended Cipher Suites")
- **TLS Receive Maximum Size Fragments** (p. 1139) ("TLS Receive Maximum Size Fragments")
- **TLS Expired Server Cert** (p. 1142) ("Expired server certificate")
- **TLS Large Size Server Cert** (p. 1140) ("TLS large Size Server Certificate")
- **MQTT Connect** (p. 1143) ("Device send CONNECT to AWS IoT Core (Happy case)"")
- **MQTT Subscribe** (p. 1148) ("Can Subscribe (Happy Case)"")
- **MQTT Publish** (p. 1146) ("QoS0 (Happy Case)"")
- **MQTT Connect Jitter Retries** (p. 1144) ("Device connect retries with jitter backoff - No CONNACK response")

**TLS**

Use these tests to determine if the transport layer security protocol (TLS) between your devices and AWS IoT is secure.

**Note**
Device Advisor now supports TLS 1.3.
## Happy Path

### TLS Connect

Validates if the device under test can complete the TLS handshake to AWS IoT. This test doesn't validate the MQTT implementation of the client device.

**Example API test case definition:**

**Note**
EXECUTION_TIMEOUT has a default value of 5 minutes. For best results, we recommend a timeout value of 2 minutes.

```
"tests":
{
  "name": "my_tls_connect_test",
  "configuration": {
    // optional:
    "EXECUTION_TIMEOUT": "300",  // in seconds
  },
  "test": {
    "id": "TLS_Connect",
    "version": "0.0.0"
  }
}
```

**Example Test case outputs:**

- **Pass** — The device under test completed TLS handshake with AWS IoT.
- **Pass with warnings** — The device under test completed TLS handshake with AWS IoT, but there were TLS warning messages from the device or AWS IoT.
- **Fail** — The device under test failed to complete TLS handshake with AWS IoT due to handshake error.

### TLS Receive Maximum Size Fragments

This test case validates that your device can receive and process TLS maximum size fragments. Your test device must subscribe to a pre-configured topic with QoS 1 to receive a large payload. You can customize the payload with the configuration `${payload}`.

**Example API test case definition:**

**Note**
EXECUTION_TIMEOUT has a default value of 5 minutes. For best results, we recommend a timeout value of 2 minutes.

```
"tests":
{
  "name": "TLS Receive Maximum Size Fragments",
  "configuration": {
    // optional:
    "EXECUTION_TIMEOUT": "300",  // in seconds
    "PAYLOAD_FORMAT": "{"message": "$\{payload\}"}",  // A string with a placeholder
    "TRIGGER_TOPIC": "test_1"  // A topic to which a device will subscribe, and to
                              // which a test case will publish a large payload.
  },
  "test": {
```

1139
Cipher Suites

**TLS Device Support for AWS IoT recommended Cipher Suites**

Validates that the cipher suites in the TLS Client Hello message from the device under test contains the recommended AWS IoT cipher suites (p. 386). It provides additional insights into cipher suites supported by the device.

**Example API test case definition:**

> Note
> EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

```
"tests":[
  {
    "name":"my_tls_support.aws_iot_cipher_suites_test",
    "configuration": {
      // optional:
      "EXECUTION_TIMEOUT":"300", // in seconds
    },
    "test":{
      "id":"TLS_Support_AWS_IoT_Cipher_Suites",
      "version":"0.0.0"
    }
  }
]
```

**Example Test case outputs:**

- **Pass** — The device under test cipher suites contain at least one of the recommended AWS IoT cipher suite and don't contain any unsupported cipher suites.
- **Pass with warnings** — The device cipher suites contain at least one AWS IoT cipher suite but:
  1. It doesn't contain any of the recommended cipher suites
  2. It contains cipher suites that aren't supported by AWS IoT.

  We suggest that you verify that any unsupported cipher suites are safe.

- **Fail** — The device under test cipher suites doesn't contain any of the AWS IoT supported cipher suites.

**Larger Size Server Certificate**

**TLS large Size Server Certificate**

Validates at your device can complete the TLS handshake with AWS IoT when it receives and processes a larger size server certificate. The size of the server certificate (in bytes) used by this test is larger than what is currently used in the **TLS Connect** test case and IoT Core by 20. During this test case, AWS IoT tests your device's buffer space for TLS. If the buffer space is large enough, the TLS handshake completes without errors. This test isn't validate the MQTT implementation of the device. The test case ds after the TLS handshake process completes.
Example API test case definition:

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. For best results, we recommend a timeout value of 2 minutes. If this test case fails but the TLS Connect test case passes, we recommend you increase your device's buffer space limit for TLS. Increasing the buffer space limit ensures that your device can process a larger size server certificate in case the size increases.

"tests": [  
    {  
        "name": "my_tls_large_size_server_cert_test",  
        "configuration": {  
            "EXECUTION_TIMEOUT": "300",  // in seconds  
        },  
        "test": {  
            "id": "TLS_Large_Size_Server_Cert",  
            "version": "0.0.0"  
        }  
    }  
]

Example Test case outputs:

- **Pass** — The device under test completed the TLS handshake with AWS IoT.
- **Pass with warnings** — The device under test completed the TLS handshake with AWS IoT, but there are TLS warning messages either from the device or AWS IoT.
- **Fail** — The device under test failed to complete the TLS handshake with AWS IoT because of an error during the handshake process.

**TLS Unsecure Server Cert**

**Not Signed By Recognized CA**

Validates that the device under test closes the connection if it's presented with a server certificate without a valid signature from the ATS CA. A device should only connect to an endpoint that presents a valid certificate.

Example API test case definition:

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

"tests": [  
    {  
        "name": "my_tls_unsecure_server_cert_test",  
        "configuration": {  
            "EXECUTION_TIMEOUT": "300",  // in seconds  
        },  
        "test": {  
            "id": "TLS_Unsecure_Server_Cert",  
            "version": "0.0.0"  
        }  
    }  
]
Example Test case outputs:

- **Pass** — The device under test closed the connection.
- **Fail** — The device under test completed TLS handshake with AWS IoT.

**TLS Incorrect Subject Name Server Cert / Incorrect Subject Common Name (CN) / Subject Alternative Name (SAN)**

Validates that the device under test closes the connection if it's presented with a server certificate for a domain name that is different than the one requested.

**Example API test case definition:**

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

```
"tests": [  
  {    
    "name":"my_tls_incorrect_subject_name_cert_test",    
    "configuration": {      
      // optional:      
      "EXECUTION_TIMEOUT":"300",  // in seconds    
    },    
    "test":{      
      "id":"TLS_Incorrect_Subject_Name_Server_Cert",      
      "version":"0.0.0"    
    }  
  }  
]
```

Example Test case outputs:

- **Pass** — The device under test closed the connection.
- **Fail** — The device under test completed the TLS handshake with AWS IoT.

**TLS Expired Server Certificate**

**Expired server certificate**

Validates that the device under test closes the connection if it's presented with an expired server certificate.

**Example API test case definition:**

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

```
"tests": [  
  {    
    "name":"my_tls_expired_cert_test",    
    "configuration": {      
      // optional:      
      "EXECUTION_TIMEOUT":"300",  // in seconds    
    },    
    "test":{      
      "id":"TLS_Expired_Server_Cert",      
      "version":"0.0.0"    
    }  
  }  
]
```
Example Test case outputs:

- **Pass** — The device under test refuses to complete the TLS handshake with AWS IoT. The device sends a TLS alert message before it closes the connection.
- **Pass with warnings** — The device under test refuses to complete the TLS handshake with AWS IoT. However, it doesn’t send a TLS alert message before it closes the connection.
- **Fail** — The device under test completes the TLS handshake with AWS IoT.

### MQTT CONNECT, DISCONNECT, and RECONNECT

"Device send CONNECT to AWS IoT Core (Happy case)"

Validates that the device under test sends a CONNECT request.

**API test case definition:**

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

```
"tests": [  
  {  
    "name": "my_mqtt_connect_test",  
    "configuration": {  
      // optional:  
      "EXECUTION_TIMEOUT": "300",  
      // in seconds  
    },  
    "test": {  
      "id": "MQTT_Connect",  
      "version": "0.0.0"  
    }  
  }  
]
```

"Device can return PUBACK to an arbitrary topic for QoS1"

This test case will check if device (client) can return a PUBACK message if it received a publish message from the broker after subscribing to a topic with QoS1.

The payload content and the payload size are configurable for this test case. If the payload size is configured, Device Advisor will overwrite the value for the payload content, and send a predefined payload to the device with the desired size. The payload size is a value between 0 to 128 and cannot exceed 128 KB. AWS IoT Core rejects publish and connect requests larger than 128 KB, as seen in the AWS IoT Core message broker and protocol limits and quotas page.

**API test case definition:**

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes. PAYLOAD_SIZE can be configured to a value between 0 and 128 kilobytes. Defining a payload size overrides the payload content as Device Advisor will be sending a pre-defined payload with the given size back to the device.

```
"tests": [  
{  
```
"Device connect retries with jitter backoff - No CONNACK response"

Validates that the device under test uses the proper jitter backoff when reconnecting with the broker for at least five times. The broker logs the timestamp of the device under test's CONNECT request, performs packet validation, pauses without sending a CONNACK to the device under test, and waits for the device under test to resend the request. The sixth connection attempt is allowed to pass through and CONNACK is allowed to flow back to the device under test.

The preceding process is performed again. In total, this test case requires the device to connect at least 12 times in total. The collected timestamps are used to validate that jitter backoff is used by the device under test. If the device under test has a strictly exponential backoff delay, this test case will pass with warnings.

We recommend implementation of the [Exponential Backoff And Jitter](#) mechanism on the device under test to pass this test case.

**API test case definition:**

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 4 minutes.

"tests": [

  "name": "my_mqtt_jitter_backoff_retries_test",
  "configuration": {
    "EXECUTION_TIMEOUT": "300",  // in seconds
  },
  "test": {
    "id": "MQTT_Connect_Jitter_Backoff_Retries",
    "version": "0.0.0"
  }
]

"Device connect retries with exponential backoff - No CONNACK response"

Validates that the device under test uses the proper exponential backoff when reconnecting with the broker for at least five times. The broker logs the timestamp of the device under test's CONNECT request, performs packet validation, pauses without sending a CONNACK to the client device, and waits for the device under test to resend the request. The collected timestamps are used to validate that an exponential backoff is used by the device under test.

We recommend implementation of the [Exponential Backoff And Jitter](#) mechanism on the device under test to pass this test case.

**API test case definition:**
**Note**
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 4 minutes.

```
"tests": [
    {
        "name": "my_mqtt_exponential_backoff_retries_test",
        "configuration": {
            // optional:
            "EXECUTION_TIMEOUT": "600", // in seconds
        },
        "test": {
            "id": "MQTT_Connect_Exponential_Backoff_Retries",
            "version": "0.0.0"
        }
    }
]
```

"Device re-connect with jitter backoff - After server disconnect"

Validates if a device under test uses necessary jitter and backoff while reconnecting after it's been disconnected from the server. Device Advisor disconnects the device from the server for at least five times and observes the device's behavior for MQTT reconnection. Device Advisor logs the timestamp of the CONNECT request for the device under test, performs packet validation, pauses without sending a CONNACK to the client device, and waits for the device under test to resend the request. The collected timestamps are used to validate that the device under test uses jitter and backoff while reconnecting. If the device under test has a strictly exponential backoff or doesn't implement a proper jitter backoff mechanism, this test case will pass with warnings. If the device under test has implemented either a linear backoff or a constant backoff mechanism, the test will fail.

To pass this test case, we recommend implementing the [Exponential Backoff And Jitter](https://docs.aws.amazon.com/iot/latest/developerguide/mqtt-configuration.html) mechanism on the device under test.

**API test case definition:**

**Note**
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 4 minutes.

The number of reconnection attempts to validate for backoff can be changed by specifying the RECONNECTION_ATTEMPTS. The number must be between 5 and 10. The default value is 5.

```
"tests": [
    {
        "name": "my_mqtt_reconnect_backoff_retries_on_server_disconnect",
        "configuration": {
            // optional:
            "EXECUTION_TIMEOUT": "300", // in seconds
            "RECONNECTION_ATTEMPTS": 5
        },
        "test": {
            "id": "MQTT_Reconnect_Backoff_Retries_On_Server_Disconnect",
            "version": "0.0.0"
        }
    }
]
```

"Device re-connect with jitter backoff - On unstable connection"

Validates if a device under test uses necessary jitter and backoff while reconnecting on an unstable connection. Device Advisor disconnects the device from the server after five successful connections,
and observes the device's behavior for MQTT reconnection. Device Advisor logs the timestamp of the CONNECT request for the device under test, performs packet validation, sends back CONNACK, disconnects, log the timestamp of the disconnection, and waits for the device under test to resend the request. The collected timestamps are used to validate that the device under test uses jitter and backoff while reconnecting after successful but unstable connections. If the device under test has a strictly exponential backoff or doesn't implement a proper jitter backoff mechanism, this test case will pass with warnings. If the device under test has implemented either a linear backoff or a constant backoff mechanism, the test will fail.

To pass this test case, we recommend implementing the Exponential Backoff And Jitter mechanism on the device under test.

**API test case definition:**

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 4 minutes.

The number of reconnection attempts to validate for backoff can be changed by specifying the RECONNECTION_ATTEMPTS. The number must be between 5 and 10. The default value is 5.

```
"tests": [
    {
        "name": "my_mqtt_reconnect_backoff_retries_on_unstable_connection",
        "configuration": {
            // optional:
            "EXECUTION_TIMEOUT": "300",  // in seconds
            "RECONNECTION_ATTEMPTS": 5
        },
        "test": {
            "id": "MQTT_Reconnect_Backoff_Retries_On_Unstable_Connection",
            "version": "0.0.0"
        }
    }
]
```

**Publish**

"QoS0 (Happy Case)"

Validates that the device under test publishes a message with QoS0 or QoS1. You can also validate the topic of the message and payload by specifying the topic value and payload in the test settings.

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

```
"tests": [
    {
        "name": "my_mqtt_publish_test",
        "configuration": {
            // optional:
            "EXECUTION_TIMEOUT": "300",  // in seconds
            "TOPIC_FOR_PUBLISH_VALIDATION": "my_TOPIC_FOR_PUBLISH_VALIDATION",
            "PAYLOAD_FOR_PUBLISH_VALIDATION": "my_PAYLOAD_FOR_PUBLISH_VALIDATION"
        },
        "test": {
            "id": "MQTT_Publish",
            "version": "0.0.0"
        }
    }
]
```
"QoS1 publish retry - No PUBACK"

Validates that the device under test republishes a message sent with QoS1, if the broker doesn't send PUBACK. You can also validate the topic of the message by specifying this topic in the test settings. The client device must not disconnect before republishing the message. This test also validates that the republished message has the same packet identifier as the original. During the test execution, if the device loses connection and reconnects, the test case will reset without failing and the device has to perform the test case steps again.

**API test case definition:**

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. It is recommended for at least 4 minutes.

```
"tests": [
  {
    "name":"my_mqtt_publish_retry_test",
    "configuration":{
      // optional:
      "EXECUTION_TIMEOUT":"300", // in seconds
      "TOPIC_FOR_PUBLISH_VALIDATION": "my_TOPIC_FOR_PUBLISH_VALIDATION",
      "PAYLOAD_FOR_PUBLISH_VALIDATION": "my_PAYLOAD_FOR_PUBLISH_VALIDATION",
    },
    "test":{
      "id":"MQTT_Publish_Retry_No_Puback",
      "version":"0.0.0"
    }
  }
]
```

"Publish Retained messages"

Validates that the device under test publishes a message with retainFlag set to true. You can validate the topic and payload of the message by setting the topic value and payload in the test settings. If the retainFlag sent within the PUBLISH packet is not set to true, the test case will fail.

**API test case definition:**

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes. To run this test case, add the iot:RetainPublish action in your device role.

```
"tests": [
  {
    "name":"my_mqtt_publish_retained_messages_test",
    "configuration":{
      // optional:
      "EXECUTION_TIMEOUT":"300", // in seconds
      "TOPIC_FOR_PUBLISH_RETAINED_VALIDATION": "my_TOPIC_FOR_PUBLISH_RETAINED_VALIDATION",
      "PAYLOAD_FOR_PUBLISH_RETAINED_VALIDATION": "my_PAYLOAD_FOR_PUBLISH_RETAINED_VALIDATION",
    },
    "test":{
      "id":"MQTT_Publish_Retained_Messages",
      "version":"0.0.0"
    }
  }
]
```
"Publish with User Property"

Validates that the device under test publishes a message with the correct user property. You can validate the user property by setting the name-value pair in the test settings. If the user property is not provided or doesn't match, the test case fails.

_API test case definition:

*Note*

This is a MQTT5 only test case.

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

"tests": [
    {
      "name": "my_mqtt_user_property_test",
      "test": {
        "USER_PROPERTIES": [
          {"name": "name1", "value": "value1"},
          {"name": "name2", "value": "value2"}
        ],
        "EXECUTION_TIMEOUT": "300", // in seconds
      },
      "test": {
        "id": "MQTT_Publish_User_Property",
        "version": "0.0.0"
      }
    }
]

Subscribe

"Can Subscribe (Happy Case)"

Validates that the device under test subscribes to MQTT topics. You can also validate the topic that the device under test subscribes to by specifying this topic in the test settings.

_API test case definition:

*Note*

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

"tests": [
    {
      "name": "my_mqtt_subscribe_test",
      "configuration": {
        // optional:
        "EXECUTION_TIMEOUT": "300", // in seconds
        "TOPIC_LIST_FOR_SUBSCRIPTION_VALIDATION": [
          "my_TOPIC_FOR_PUBLISH_VALIDATION_a",
          "my_TOPIC_FOR_PUBLISH_VALIDATION_b"
        ],
      },
      "test": {
        "id": "MQTT_Subscribe",
        "version": "0.0.0"
      }
    }
]

1148
"Subscribe Retry - No SUBACK"

Validates that the device under test retries a failed subscription to MQTT topics. The server then waits and doesn't send a SUBACK. If the client device doesn't retry the subscription, the test fails. The client device must retry the failed subscription with the same packet Id. You can also validate the topic that the device under test subscribes to by specifying this topic in the test settings. During the test execution, if the device loses connection and reconnects, the test case will reset without failing and the device has to perform the test case steps again.

*API test case definition:*

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 4 minutes.

```
"tests": [
  {
    "name": "my_mqtt_subscribe_retry_test",
    "configuration": {
      "EXECUTION_TIMEOUT": "300", // in seconds
      // optional:
      "TOPIC_LIST_FOR_SUBSCRIPTION_VALIDATION": [
        "myTOPIC_FOR_PUBLISH_VALIDATION_a",
        "my_TOPIC_FOR_PUBLISH_VALIDATION_b"
      ],
      "test": {
        "id": "MQTT_Subscribe_Retry_No_Suback",
        "version": "0.0.0"
      }
    }
  }
]
```

**Keep-Alive**

"Mqtt No Ack PingResp"

This test case validates if the device under test disconnects when it doesn't receive a ping response. As part of this test case, Device Advisor blocks responses sent from AWS IoT Core for publish, subscribe, and ping requests. It also validates if the device under test disconnects the MQTT connection.

*API test case definition:*

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout greater than 1.5 times the keepAliveTime value.

The maximum keepAliveTime must be no greater than 230 seconds for this test.

```
"tests": [
  {
    "name": "Mqtt No Ack PingResp",
    "configuration": {
      // optional:
      "EXECUTION_TIMEOUT": "306", // in seconds
    },
    "test": {
      "id": "MQTT_No_Ack_PingResp",
      "version": "0.0.0"
    }
  }
]
```
**Persistent Session**

"Persistent Session (Happy Case)"

This test case validates the device behavior when disconnected from a persistent session. The test case checks if the device can reconnect, resume the subscriptions to its trigger topics without explicitly re-subscribing, receive the stored messages in the topics, and work as expected during a persistent session. When this test case passes, it indicates that the client device is able to maintain a persistent session with the AWS IoT Core broker in an expected manner. For more information on AWS IoT Persistent Sessions, see [Using MQTT persistent sessions](#).

In this test case, the client device is expected to CONNECT with the AWS IoT Core with a clean session flag set to false, and then subscribe to a trigger topic. After a successful subscription, the device will be disconnected by AWS IoT Core Device Advisor. While the device is in a disconnected state, a QoS 1 message payload will be stored in that topic. Device Advisor will then allow the client device to re-connect with the test endpoint. At this point, since there is a persistent session, the client device is expected to resume its topic subscriptions without sending any additional SUBSCRIBE packets and receive the QoS 1 message from the broker. After re-connecting, if the client device re-subscribes to its trigger topic again by sending an additional SUBSCRIBE packet and/or if the client fails to receive the stored message from the trigger topic, the test case will fail.

**API test case definition:**

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of at least 4 minutes. In the first connection, client device needs to explicitly subscribe to a TRIGGER_TOPIC which was not subscribed before. To pass the test case, client device must successfully subscribe to TRIGGER_TOPIC with a QoS 1. After re-connecting, the client device is expected to understand that there is an active persistent session; so it should accept the stored message sent by the trigger topic and return PUBACK for that specific message.

```json
"tests": [
  {
    "name": "my_mqtt_persistent_session_happy_case",
    "configuration": {
      // required:
      "TRIGGER_TOPIC": "myTrigger/topic",
      // optional:
      // if Payload not provided, a string will be stored in the trigger topic to be sent back to the client device
      "PAYLOAD": "The message which should be received from AWS IoT Broker after re-connecting to a persistent session from the specified trigger topic.",
      "EXECUTION_TIMEOUT": "300" // in seconds
    },
    "test": {
      "id": "MQTT_Persistent_Session_Happy_Case",
      "version": "0.0.0"
    }
  }
]
```

"Persistent Session - Session Expiry"

This test case helps to validate device behavior when a disconnected device reconnects to an expired persistent session. After the session expires, we expect the device to resubscribe to the topics previously subscribed to by explicitly sending a new SUBSCRIBE packet.

During the first connection, we expect the test device to CONNECT with the AWS IoT broker, as its CleanSession flag is set to false to initiate a persistent session. The device should then subscribe to a trigger topic. Then the device is disconnected by AWS IoT Core Device Advisor, after a successful
subscription and initiation of a persistent session. After the disconnection, AWS IoT Core Device Advisor allows the test device to re-connect back with the test endpoint. At this point, when the test device sends another CONNECT packet, AWS IoT Core Device Advisor sends back a CONNACK packet that indicates that the persistent session is expired. The test device needs to interpret this packet properly, and it is expected to re-subscribe to the same trigger topic again as the persistent session is terminated. If the test device does not re-subscribe to its topic trigger again, the test case fails. For the test to pass, the device needs to understand that the persistent session is over, and send back a new SUBSCRIBE packet for the same trigger topic in the second connection.

If this test case passes for a test device, it indicates that the device is able to handle re-connection on expiry of persistent session in an expected way.

API test case definition:

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of at least 4 minutes. The test device needs to explicitly subscribe to a TRIGGER_TOPIC, to which it was not subscribed before. To pass the test case, the test device must send a CONNECT packet with CleanSession flag set to false, and successfully subscribe to a trigger topic with a QoS 1. After a successful connection, AWS IoT Core Device Advisor disconnects the device. After the disconnection, AWS IoT Core Device Advisor allows the device to re-connect back, and the device is expected to re-subscribe to the same TRIGGER_TOPIC since AWS IoT Core Device Advisor would have terminated the persistent session.

Shadow
Use these tests to verify your devices under test use AWS IoT Device Shadow service correctly. See AWS IoT Device Shadow service (p. 657) for more information. If these test cases are configured in your test suite, then providing a thing is required when starting the suite run.

MQTT over WebSocket is not supported at this time.

Publish

"Device publishes state after it connects (Happy case)"

Validates if a device can publish its state after it connects to AWS IoT Core

API test case definition:

Note
EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.
The REPORTED_STATE can be provided for additional validation on your device's exact shadow state, after it connects. By default, this test case validates your device publishing state.

If SHADOW_NAME is not provided, the test case looks for messages published to topic prefixes of the Unnamed (classic) shadow type by default. Provide a shadow name if your device uses the named shadow type. See Using shadows in devices for more information.

Update

"Device updates reported state to desired state (Happy case)"

Validates if your device reads all update messages received and synchronizes the device's state to match the desired state properties. Your device should publish its latest reported state after synchronizing. If your device already has an existing shadow before running the test, make sure the desired state configured for the test case and the existing reported state do not already match. You can identify Shadow update messages sent by Device Advisor by looking at the ClientToken field in the Shadow document as it will be DeviceAdvisorShadowTestCaseSetup.

**API test case definition:**

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 2 minutes.

The DESIRED_STATE should have at least one attribute and associated value.
If SHADOW_NAME is not provided, then the test case looks for messages published to topic prefixes of the Unnamed (classic) shadow type by default. Provide a shadow name if your device uses the named shadow type. See Using shadows in devices for more information.

Job Execution

"Device can complete a job execution"

This test case helps you validate if your device is able to receive updates using AWS IoT Jobs, and publish the status of successful updates. For more information on AWS IoT Jobs, see Jobs.

In order to successfully run this test case, there are two reserved AWS topics that you need to grant your Device Role. To subscribe to job activity related messages, use the notify and notify-next topics. Your device role must grant PUBLISH action for the following topics:

- $aws/things/thingName/jobs/jobId/get
- $aws/things/thingName/jobs/jobId/update

It is recommended to grant SUBSCRIBE and RECEIVE actions for the following topics:

- $aws/things/thingName/jobs/get/accepted
- $aws/things/thingName/jobs/jobId/get/rejected
- $aws/things/thingName/jobs/jobId/update/accepted
- $aws/things/thingName/jobs/jobId/update/rejected

It is recommended to grant SUBSCRIBE action for the following topic:

- $aws/things/thingName/jobs/notify-next

For more information about these reserved topics, see reserved topics for AWS IoT Jobs.

MQTT over WebSocket is not supported at this time.

API test case definition:

**Note**

EXECUTION_TIMEOUT has a default value of 5 minutes. We recommend a timeout value of 3 minutes. Depending on the AWS IoT Job document or source provided, adjust the timeout value (for example, if a job will take a long time to run, define a longer timeout value for the test case). To run the test, either a valid AWS IoT Job document or an already existing job ID is required. An AWS IoT Job document can be provided as a JSON document or an S3 link. If a job document is provided, a job ID is optional. If a job ID is provided, Device Advisor will use that ID while creating the AWS IoT Job on your behalf. If the job document is not provided, you can provide an existing ID that is in the same region as you are running the test case. In this case, Device Advisor will use that AWS IoT Job while running the test case.

```
"tests": [
    {
        "name": "my_job_execution",
        "configuration": {
            // optional:
            // Test case will create a job task by using either JOB_DOCUMENT or JOB_DOCUMENT_SOURCE.
            // If you manage the job task on your own, leave it empty and provide the JOB_JOBID (self-managed job task).
            // JOB_DOCUMENT is a JSON formatted string
            "JOB_DOCUMENT": "{"
            "operation": "reboot",
            "files": 
```
Permissions and policies

You can use the following tests to determine if the policies attached to your devices' certificates follow standard best practices.

**MQTT over WebSocket** is not supported at this time.

"Device certificate attached policies don't contain wildcards"

Validates if the permission policies associated with a device follow best practices and do not grant the device more permissions than needed.

**API test case definition:**

**Note**

EXECUTION_TIMEOUT has a default value of 1 minute. We recommend setting a timeout of at least 30 seconds.

"tests": [
    {
        "name": "my_security_device_policies",
        "configuration": {
            // optional:
            "EXECUTION_TIMEOUT": "60"  // in seconds
        },
        "test": {
            "id": "Security_Device_Policies",
            "version": "0.0.0"
        }
    }
]
Long duration tests

Long duration tests is a new test suite that monitors a device's behavior when it operates over longer periods of time. Compared to running individual tests that focus on specific behaviors of a device, the long duration test examines the device's behavior in a variety of real-world scenarios over the device's lifespan. Device Advisor orchestrates the tests in the most efficient possible order. The test generates results and logs, including a summary log with useful metrics about the device's performance while under test.

MQTT long duration test case

In the MQTT long duration test case, the device's behavior is initially observed in happy case scenarios such as MQTT Connect, Subscribe, Publish, and Reconnect. Then, the device is observed in multiple, complex failure scenarios such as MQTT Reconnect Backoff, Long Server Disconnect, and Intermittent Connectivity.

MQTT long duration test case execution flow

There are three phases in the execution of a MQTT long duration test case:
Basic tests execution

In this phase, the test case runs simple tests in parallel. The test validates if the device has the operations selected in the configuration.

The set of basic tests can include the following, based on the operations selected:

CONNECT

This scenario validates if the device is able to make a successful connection with the broker.
PUBLISH

This scenario validates if the device successfully publishes against the broker.

QoS 0

This test case validates if the device successfully sends a PUBLISH message to the broker during a publish with QoS 0. The test does not wait on the PUBACK message to be received by the device.

QoS 1

In this test case, the device is expected to send two PUBLISH messages to the broker with QoS 1. After the first PUBLISH message, the broker waits for up to 15 seconds before it responds. The device must retry the original PUBLISH message with the same packet identifier within the 15 second window. If it does, the broker responds with a PUBACK message and the test validates. If the device doesn't retry the PUBLISH, the original PUBACK is sent to the device and the test is marked as Pass with warnings, along with a system message. During the test execution, if the device loses connection and reconnects, the test scenario will reset without failing and the device has to perform the test scenario steps again.
This scenario validates if the device successfully subscribes against the broker.

**QoS 0**
This test case validates if the device successfully sends a SUBSCRIBE message to the broker during a subscribe with QoS 0. The test doesn't wait for the device to receive a SUBACK message.

**QoS 1**
In this test case, the device is expected to send two SUBSCRIBE messages to the broker with QoS 1. After the first SUBSCRIBE message, the broker waits for up to 15 seconds before it responds. The device
must retry the original SUBSCRIBE message with the same packet identifier within the 15 second window. If it does, the broker responds with a SUBACK message and the test validates. If the device doesn't retry the SUBSCRIBE, the original SUBACK is sent to the device and the test is marked as Pass with warnings, along with a system message. During the test execution, if the device loses connection and reconnects, the test scenario will reset without failing and the device has to perform the test scenario steps again.

**RECONNECT**

This scenario validates if the device successfully reconnects with the broker after the device is disconnected from a successful connection. Device Advisor won't disconnect the device if it connected more than once previously during the test suite. Instead, it will mark the test as Pass.
Advanced tests execution

In this phase, the test case runs more complex tests in serial to validate if the device follows best practices. These advanced tests are available for selection and can be opted out if not required. Each advanced test has its own timeout value based on what the scenario demands.

**RETURN PUBACK ON QoS 1 SUBSCRIPTION**

*Note*

Only select this scenario if your device is capable of performing QoS 1 subscriptions.

This scenario validates if, after the device subscribes to a topic and receives a PUBLISH message from the broker, it returns a PUBACK message.
RECEIVE LARGE PAYLOAD

**Note**
Select this scenario only if your device is capable of performing QoS 1 subscriptions.

This scenario validates if the device responds with a PUBACK message after receiving a PUBLISH message from the broker for a QoS 1 topic with a large payload. The format of the expected payload can be configured using the LONG_PAYLOAD_FORMAT option.

**PERSISTENT SESSION**

**Note**
Select this scenario only if your device is capable of performing QoS 1 subscriptions and can maintain a persistent session.

This scenario validates the device behavior in maintaining persistent sessions. The test validates when the following conditions are met:

- The device connects to the broker with an active QoS 1 subscription and persistent sessions enabled.
- The device successfully disconnects from the broker during the session.
- The device reconnects to the broker and resumes subscriptions to its trigger topics without explicitly resubscribing to those topics.
- The device successfully receives messages stored by the broker for its subscribed topics and runs as expected.

For more information on AWS IoT Persistent Sessions, see Using MQTT persistent sessions.
KEEP ALIVE

This scenario validates if the device successfully disconnects after it doesn't receive a ping response from the broker. The connection must have a valid keep-alive timer configured. As part of this test, the broker blocks all responses sent for PUBLISH, SUBSCRIBE, and PINGREQ messages. It also validates if the device under test disconnects the MQTT connection.
INTERMITTENT CONNECTIVITY

This scenario validates if the device can connect back to the broker after the broker disconnects the device at random intervals for a random period of time.
**RECONNECT BACKOFF**

This scenario validates if the device has a backoff mechanism implemented when the broker disconnects from it multiple times. Device Advisor reports the backoff type as exponential, jitter, linear or constant. The number of backoff attempts is configurable using the `BACKOFF_CONNECTION_ATTEMPTS` option. The default value is 5. The value is configurable between 5 and 10.

To pass this test, we recommend implementing the **Exponential Backoff And Jitter** mechanism on the device under test.

---

**LONG SERVER DISCONNECT**

This scenario validates if the device can successfully reconnect after the broker disconnects the device for a long period of time (up to 120 minutes). The time for server disconnection can be configured using the `LONG_SERVER_DISCONNECT_TIME` option. The default value is 120 minutes. This value is configurable from 30 to 120 minutes.
Additional execution time

The additional execution time is the time the test waits after completing all the above tests and before ending the test case. Customers use this additional time period to monitor and log all communications between the device and the broker. The additional execution time can be configured using the ADDITIONAL_EXECUTION_TIME option. By default, this option is set to 0 minutes and can be 0 to 120 minutes.

MQTT long duration test configuration options

All configuration options provided for the MQTT long duration test are optional. The following options are available:

OPERATIONS

The list of operations that the device performs, such as CONNECT, PUBLISH and SUBSCRIBE. The test case runs scenarios based on the specified operations. Operations that aren't specified are assumed valid.

```json
{
  "OPERATIONS": ["PUBLISH", "SUBSCRIBE"]
  //by default the test assumes device can CONNECT
}
```

SCENARIOS

Based on the operations selected, the test case runs scenarios to validate the device's behavior. There are two types of scenarios:
• **Basic Scenarios** are simple tests that validate if the device can perform the operations selected above as part of the configuration. These are pre-selected based on the operations specified in the configuration. No additional input is required in the configuration.

• **Advanced Scenarios** are more complex scenarios that are performed against the device to validate if the device follows best practices when met with real world conditions. These are optional and can be passed as an array of scenarios to the configuration input of the test suite.

```json
{
    "SCENARIOS": [
        "PUBACK_QOS_1",
        "RECEIVE_LARGE_PAYLOAD",
        "PERSISTENT_SESSION",
        "KEEP_ALIVE",
        "INTERMITTENT_CONNECTIVITY",
        "RECONNECT_BACK_OFF",
        "LONG_SERVER_DISCONNECT"
    ]
}
```

**BASIC_TESTS_EXECUTION_TIME_OUT:**

The maximum time the test case will wait for all the basic tests to complete. The default value is 60 minutes. This value is configurable from 30 to 120 minutes.

**LONG_SERVER_DISCONNECT_TIME:**

The time taken for the test case to disconnect and reconnect the device during the Long Server Disconnect test. The default value is 60 minutes. This value is configurable from 30 to 120 minutes.

**ADDITIONAL_EXECUTION_TIME:**

Configuring this option provides a time window after all the tests are completed, to monitor events between the device and broker. The default value is 0 minutes. This value is configurable from 0 to 120 minutes.

**BACKOFF_CONNECTION_ATTEMPTS:**

This option configures the number of times the device is disconnected by the test case. This is used by the Reconnect Backoff test. The default value is 5 attempts. This value is configurable from 5 to 10.

**LONG_PAYLOAD_FORMAT:**

The format of the message payload that the device expects when the test case publishes to a QoS 1 topic subscribed by the device.

**API test case definition:**

```json
{
    "tests": [
        {
            "name": "my_mqtt_long_duration_test",
            "configuration": {
                "OPERATIONS": ["PUBLISH", "SUBSCRIBE"],
                "SCENARIOS": [
                    "LONG_SERVER_DISCONNECT",
                    "RECONNECT_BACK_OFF",
                    "KEEP_ALIVE",
                    "RECEIVE_LARGE_PAYLOAD",
                    "INTERMITTENT_CONNECTIVITY",
                    "PERSISTENT_SESSION"],
                "BACKOFF_CONNECTION_ATTEMPTS": 5
            }
        }
    ]
}
```
MQTT long duration test case summary log

The MQTT long duration test case runs for longer duration than regular test cases. A separate summary log is provided, which lists important events such as device connections, publish, and subscribe during the run. Details include what was tested, what was not tested and what failed. At the end of the log, the test includes a summary of all the events that happened during the test case run. This includes:

- **Keep Alive timer configured on the device.**
- **Persistent session flag configured on the device.**
- **The number of device connections during the test run.**
- **The device reconnection backoff type, if validated for the reconnect backoff test.**
- **The topics the device published to, during the test case run.**
- **The topics the device subscribed to, during the test case run.**
AWS IoT Device Management
Software Package Catalog

With AWS IoT Device Management Software Package Catalog, you can maintain an inventory of software packages and their versions. You can associate package versions to individual things and AWS IoT dynamic thing groups, and deploy them through in-house processes or AWS IoT jobs.

A software package contains one or more package versions, which is a collection of files that can be deployed as a single unit. Package versions can contain firmware, operating system updates, device applications, configurations, and security patches. As the software evolves over time, you can create a new package version and deploy it to your fleet.

The AWS IoT software package hub is located within AWS IoT Core. You can use the hub to centrally register and maintain your software package inventory and metadata, which creates a catalog of software packages and their versions. You can choose to group devices based on software packages and package versions deployed on the device. This feature provides the opportunity to keep device-side package inventory as a named shadow, associate and group devices based on versions, and visualize package version distribution across the fleet by using fleet metrics.

If you have an in-house software deployment system established, you can continue to use that process to deploy your package versions. If you don't have a deployment process established or if you prefer, we recommend using AWS IoT jobs to use the features in the Software Package Catalog. For more information, see Preparing AWS IoT jobs.

This chapter contains the following sections:

- Preparing to use Software Package Catalog (p. 1168)
- Preparing security (p. 1172)
- Preparing fleet indexing (p. 1176)
- Preparing AWS IoT Jobs (p. 1179)
- Getting started with Software Package Catalog (p. 1182)

Preparing to use Software Package Catalog

The following section provides an overview of the package version lifecycle and information for using AWS IoT Device Management Software Package Catalog.

Package version lifecycle

A package version can evolve through the following lifecycle states: draft, published, and deprecated. It can also be deleted.
When a package version is created, it's in a draft state. This state indicates that the software package is being prepared, or is incomplete.

While the package version in this state, you can't set it as the default version, deploy it, or edit the package version's name.

You can edit the package version's description, attributes, and tags. You can also associate it to an AWS IoT thing.

You can transition a package version that's in the draft state to published or be deleted by using the console, or by issuing either the UpdatePackageVersion or DeletePackageVersion API operations.

When your package version is ready to be deployed, transition the package version to a published state. While in the published state, you can choose to identify the package version as the default version by editing the software package in the console or through the UpdatePackage API operation.

You can edit a published package version's data, including the description and tags. You can't edit the package version's name or attributes.

You can transition a package version that's in the published state to deprecated or be deleted by using the console, or issuing either the UpdatePackageVersion or DeletePackageVersion API operations.

If a new package version is available, you can transition earlier package versions to deprecated. You can still deploy jobs with a deprecated package version and identify it as the default version.

When a package version is deprecated, you can edit only some of its data, such as the description and tags. However, you can't edit the package version's name or attributes.

You can transition a package version that's in the deprecated state to published or be deleted by using the console, or issuing either the UpdatePackageVersion or DeletePackageVersion API operations.
• Deleted

When you no longer intend to use a package version, you can delete it by using the console or issuing the DeletePackageVersion API operation.

**Note**

If you delete a package version while there are pending jobs that reference it, you will receive an error message when the job successfully completes and attempts to update the reserved named shadow.

If the software package version you want to delete is named as the default package version, you must first update the package to name another version as default or leave the field unnamed. You can do this by using the console or the UpdatePackageVersion API operation. (To remove any named package version as default, set the unsetDefaultVersion parameter to true when you issue the UpdatePackage API operation).

If you delete a software package through the console, it deletes all of the package versions associated with that package, unless one is named as the default version.

### Package version naming conventions

When you name package versions, it's important to plan and apply a logical naming strategy so that you and others can easily identify the latest package version and the version progression. You must provide a version name when creating the package version, but the strategy and format is largely up to your business case.

As a best practice, we recommend using the Semantic Versioning **SemVer** format. For example, 1.2.3 where 1 is the major version for functionally incompatible changes, 2 the major version for functionally compatible changes, and 3 is the patch version (for bug fixes). For more information, see Semantic Versioning 2.0.0. For more information about the package version name requirements, see `versionName` in the AWS IoT API reference guide.

### Default version

Setting a version as default is optional. You can add or remove default package versions. You can also deploy a package version that is not named as the default version.

When you create a package version, it's placed in a draft state and can't be named as the default version until you transition the package version to published. Software Package Catalog doesn't automatically select a version as default or update a newer package version as the default. You must intentionally name the package version you choose through the console or by issuing the UpdatePackageVersion API operation.

### Version attributes

Version attributes and their values hold important information about your package versions. We recommend that you define general purpose attributes for a package or package version. For example, you might create a name-value pair for platform, architecture, operating system, release date, author, or Amazon S3 URL.

When you create an AWS IoT job with a job document, you can also choose to use a substitution variable ($parameter$) that refers to an attribute's value. For more information, see Preparing AWS IoT Jobs.

Version attributes that are used in package versions will not be automatically added to the reserved named shadow and can't be indexed or queried through Fleet Indexing directly. To index or query package version attributes through Fleet Indexing, you can populate the version attribute in the reserved named shadow.
We recommend that the version attribute parameter in the reserved named shadow capture device-reported properties, such as operation system and installation time. They can also be indexed and queried through Fleet Indexing.

Version attributes aren't required to follow a specific naming convention. You can create name-value pairs to meet your business needs. The combined size of all the attributes on a package version is limited to 3KB. For more information, see Software Package Catalog software package and package versions limits.

**Enabling AWS IoT fleet indexing**

You must activate fleet indexing for Software Package Catalog to create or update software packages and package versions. Fleet indexing provides support that enables AWS IoT things to be grouped through dynamic thing groups that are filtered by version. For example, fleet indexing can identify things that have or don't have a specific package version installed, don't have any package versions installed, or match specific name-value pairs. Finally, fleet indexing provides standard and custom metrics that you can use to gain insight about the state of your fleet. For more information, see [Preparing fleet indexing](p. 1176).

*Note*

Enabling fleet indexing for Software Package Catalog incurs standard service costs. For more information, see [AWS IoT Device Management, Pricing](#).

**Reserved named shadow**

The reserved named shadow, `$package`, reflects the state of the device's installed software packages and package versions. Fleet indexing uses the reserved named shadow as a data source to build standard and custom metrics so you can query the state of your fleet. For more information, see [Preparing fleet indexing](#).

A reserved named shadow is similar to a named shadow with the exception that its name is predefined and you can't change it. In addition, the reserved named shadow doesn't update with metadata, and uses only the version and attributes keywords.

Update requests that include other keywords, such as description, will receive an error response under the rejected topic. For more information, see [Device Shadow error messages](#).

It can be created when you create an AWS IoT thing through the console, when an AWS IoT job successfully completes and updates the shadow, and if you issue the `UpdateThingShadow` API operation. For more information, see [UpdateThingShadow](#) in the AWS IoT Core developer guide.

*Note*

Indexing the reserved named shadow doesn't count toward the number of named shadows that fleet indexing can index. For more information, see [AWS IoT Device Management fleet indexing limits and quotas](#). In addition, if you choose to have AWS IoT jobs update the reserved named shadow when a job successfully completes, the API call is counted toward your Device Shadow and registry operations and can incur a cost. For more information, see [AWS IoT Device Management jobs limits and quotas](#) and the [IndexingFilter](#) API data type.

**Structure of the $package shadow**

The reserved named shadow contains the following:

```json
{
    "state": {
        "reported": {
            "<packageName>": {
                "version": "",
```
The shadow properties are updated with the following information:

- `<packageName>`: The name of the installed software package, which is updated with the `packageName` parameter.
- `version`: The name of the installed package version, which is updated with the `versionName` parameter.
- `attributes`: Optional metadata stored by the device and indexed by Fleet indexing. This allows customers to query their indexes based on the data stored.
- `version`: The shadow's version number. It's automatically incremented each time the shadow is updated and begins at 1.
- `timestamp`: Indicates when the shadow was last updated and is recorded in Unix time.

For more information about the format and behavior of a named shadow, see AWS IoT Device Shadow service Message order.

Deleting a software package and its package versions

Before you delete a software package, do the following:

- Confirm that the package and its versions aren't actively being deployed.
- Delete all the associated versions first. If one of the versions is designated as the default version, you must remove the named default version from the package. Because designating a default version is optional, there is no conflict removing it. To remove the default version from the software package, edit the package through the console or use the `UpdatePackageVersion` API operation.

As long as there is no named default package version, you can use the console to delete a software package and all of its package versions will also be deleted. If you use an API call to delete software packages, you must delete the package versions first and then the software package.

Preparing security

This section discusses the main security requirements for AWS IoT Device Management Software Package Catalog.

Resource-based authentication

Software Package Catalog uses resource-based authorization to provide added security when updating software on your fleet. This means that you must create an AWS Identity and Access Management (IAM) policy that grants rights to perform create, read, update, delete, and list actions for software packages and package versions, and reference the specific software packages and package versions that you want to deploy in the Resources section. You also need these rights so that you can update the reserved named shadow. You reference the software packages and package versions by including an Amazon Resource Name (ARN) for each entity.
Note
If you intend the policy to grant rights for package version API calls (such as CreatePackageVersion, UpdatePackageVersion, DeletePackageVersion), then you need to include both the software package and the package version ARNs in the policy. If you intend the policy to grant rights for software package API calls (such as CreatePackage, UpdatePackage, and DeletePackage) then you must include only the software package ARN in the policy.

Structure the software package and package version ARNs as follows:

- Package version: arn:aws:iot:<region>:<accountID>:package/<packageName>/version/<versionName>

Note
There are other related rights that you might include in this policy. For example, you might include an ARN for the job, thinggroup, and jobtemplate. For more information and a complete listing of the policy options, see Securing users and devices with AWS IoT Jobs.

For example, if you have a software package and package version that's named as follows:

- AWS IoT thing: myThing
- Package name: samplePackage
- Version 1.0.0

The policy might look like the following example:

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": [
                "iot:createPackage",
                "iot:createPackageVersion",
                "iot:updatePackage",
                "iot:updatePackageVersion"
            ],
            "Resource": [
                "arn:aws:iot:us-east-1:111122223333:package/samplePackage/version/1.0.0"
            ]
        },
        {
            "Effect": "Allow",
            "Action": [
                "iot:GetThingShadow",
                "iot:UpdateThingShadow"
            ],
        }
    ]
}
```

AWS IoT Job rights to deploy package versions

For security purposes it's important for you to grant rights to deploy packages and package versions, and name the specific packages and package versions they're allowed to deploy. To do this, you create an IAM
role and policy that grants permission to deploy jobs with package versions. The policy must specify the destination package versions as a resource.

IAM policy

The IAM policy grants the right to create a job that includes the package and version that are named in the Resource section.

```json
{
  "Version": "2012-10-17",
  "Statement": [

    { "Effect": "Allow",
      "Action": [
        "iot:CreateJob",
        "iot:CreateJobTemplate"
      ],
      "Resource": [
        "arn:aws:iot:*:111122223333:job/<jobId>",
        "arn:aws:iot:*:111122223333:thing/<thingName>/$package",
        "arn:aws:iot:*:111122223333:thinggroup/<thingGroupName>",
        "arn:aws:iot:*:111122223333:jobtemplate/<jobTemplateName>",
        "arn:aws:iot:*:111122223333:package/<packageName>/version/<versionName>"
      ]
    }
  ]
}
```

Note

If you want to deploy a job that uninstalls a software package and package version, you must authorize an ARN where the package version is `$null`, such as in the following:

```
```

AWS IoT Job rights to update the reserved named shadow

To allow jobs to update the thing's reserved name shadow when the job successfully completes, you must create an IAM role and policy. There are two ways you can do this in the AWS IoT console. The first is when you create a software package in the console. If you see an Enable dependencies for package management dialog box, you can choose to use an existing role or create a new role. Or, in the AWS IoT console, choose Settings, choose Manage indexing, and then Manage indexing for device packages and versions.

Note

If you choose to have the AWS IoT Job service update the reserved named shadow when a job successfully completes, the API call is counted toward your Device Shadow and registry operations and can incur a cost. For more information, see AWS IoT Core pricing.

When you use the Create role option, the generated role's name begins with aws-iot-role-update-shadows and contains the following policies:

Setting up a role

Permissions

The permissions policy grants the rights to query and update the thing shadow. The $package parameter in the resource ARN targets the reserved named shadow.
Trust relationship

In addition to the permissions policy, the role requires a trust relationship with AWS IoT Core so that the entity can assume the role and update the reserved named shadow.

Setting up a user policy

iam:PassRole permission

Finally, you must have the permission to pass the role to AWS IoT Core when you call the UpdatePackageConfiguration API operation.
AWS IoT Jobs permissions to download from Amazon S3

The job document is saved in Amazon S3. You refer to this file when you dispatch through AWS IoT Jobs. You must provide AWS IoT Jobs with the rights to download the file (s3:GetObject). You must also set up a trust relationship between Amazon S3 and AWS IoT Jobs. For instructions to create these policies, see Presigned URLs in Managing Jobs.

Preparing fleet indexing

With AWS IoT fleet indexing, you can search and aggregate data by using the reserved named shadow ($package). You can also group AWS IoT things by querying the Reserved named shadow (p. 1171) and dynamic thing groups. For example, you can find information about which AWS IoT things use a specific package version, don’t have a specific package version installed, or don’t have any package version installed. You can gain further insight by combining attributes. For example, identifying things that have a specific version and are of a specific thing type (such as version 1.0.0 and thing type of pump_sensor). For more information, see Fleet indexing.

Setting the $package shadow as a data source

To use fleet indexing with Software Package Catalog, you must enable fleet indexing, set the named shadow as the data source, and define $package as the named shadow filter. If you haven't enabled fleet indexing, you can enable it within this process. From AWS IoT Core in the console, open Settings, choose Manage indexing, then Add named shadows, Add device software packages and versions, and Update. For more information, see Manage thing indexing.

Alternately, you can enable fleet indexing when you create your first package. When the Enable dependencies for package management dialog box appears, choose the option to add device software packages and versions as data sources to fleet indexing. By selecting this option, you also enable fleet indexing.

Note

Enabling fleet indexing for Software Package Catalog incurs standard service costs. For more information, see AWS IoT Device Management, Pricing.

Metrics displayed in the console

On the AWS IoT console software package details page, the Discovery panel displays standard metrics ingested through the $package shadow.
• The **Current version distribution** chart shows the number of devices and percentage for the 10 most recent package versions that are associated to an AWS IoT thing from all the devices associated to this software package. **Note:** If the software package has more package versions than those labeled in the chart, you can find them grouped within **Other**.

• The **Historical chart** shows the number of devices associated with selected package versions over a specified time period. The chart is initially empty until you select up to 5 package versions and define the date range and time interval. To select the chart's parameters, choose **Settings**. The data displayed in the **Historical chart** might be different than the **Current version distribution** chart because of the difference in number of package versions that they display and also because you can choose which package versions to analyze in the **Historical chart**. **Note:** When you select a package version to visualize, it counts toward the maximum number of fleet metrics limits. For more information, see **Fleet indexing limits and quotas**.

For another method to gain insight into collecting package version distribution, see [Collecting package version distribution through getBucketsAggregation](#).

### Query patterns

Fleet indexing with Software Package Catalog uses most of the supported features (for example, terms and phrases and search fields) that are standard for fleet indexing. The exception is that the comparison and range queries aren't available for the reserved named shadow ($package) version key. However, these queries are available for the attributes key. For more information, see [Query syntax](#).

### Example data

**Note:** for information about the reserved named shadow and its structure, see [Reserved named shadow](#).

In this example, a first device is named **AnyThing** and has the following packages installed:

- **Software package:** SamplePackage
  - Package version: **1.0.0**
  - Package ID: **1111**

The shadow looks as follows:

```json
{
   "state": {
      "reported": {
         "SamplePackage": {
            "version": "1.0.0",
            "attributes": {
               "s3UrlForSamplePackage": "https://EXAMPLEBUCKET.s3.us-west-2.amazonaws.com/exampleCodeFile1",
               "packageID": "1111"
            }
         }
      }
   }
}
```

A second device is named **AnotherThing** and has the following package installed:

- **Software package:** SamplePackage
The shadow looks as follows:

```json
{
    "state": {
        "reported": {
            "SamplePackage": {
                "version": "1.0.0",
                "attributes": {
                    "s3UrlForSamplePackage": "https://EXAMPIEBUCKET.s3.us-west-2.amazonaws.com/exampleCodeFile1",
                    "packageID": "1111"
                }
            },
            "OtherPackage": {
                "version": "1.2.5",
                "attributes": {
                    "s3UrlForOtherPackage": "https://EXAMPIEBUCKET.s3.us-west-2.amazonaws.com/exampleCodeFile2",
                    "packageID": "2222"
                }
            }
        }
    }
}
```

**Sample queries**

The following table lists sample queries based on the example device shadows for *AnyThing* and *AnotherThing*. For more information, see [Example thing queries](#).

**Latest version of AWS IoT Device Tester for FreeRTOS**

<table>
<thead>
<tr>
<th>Requested information</th>
<th>Query</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Things that have a specific package version installed</td>
<td>shadow.name.</td>
<td><em>AnyThing, OtherThing</em></td>
</tr>
<tr>
<td></td>
<td>$package.reported.SamplePackage.version:1.0.0</td>
<td></td>
</tr>
<tr>
<td>Things that don't have a specific package version installed</td>
<td>NOT shadow.name.</td>
<td><em>AnyThing</em></td>
</tr>
<tr>
<td></td>
<td>$package.reported.OtherPackage.version:1.2.5</td>
<td></td>
</tr>
<tr>
<td>Any device using a package version whose package ID is</td>
<td>shadow.name.</td>
<td><em>OtherThing</em></td>
</tr>
<tr>
<td>greater than 1500</td>
<td>$package.reported.*.attributes.packageID&gt;1500&quot;</td>
<td></td>
</tr>
<tr>
<td>Things that have a specific package installed and have</td>
<td>shadow.name.</td>
<td><em>OtherThing</em></td>
</tr>
<tr>
<td>more than one package installed</td>
<td>$package.reported.SamplePackage.version:1.0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AND shadow.name.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$package.reported.totalCount:2</td>
<td></td>
</tr>
</tbody>
</table>
Collecting package version distribution through getBucketsAggregation

In addition to the Discovery panel within the AWS IoT console, you can also get package version distribution information by using the `getBucketsAggregation` API operation. To get the package version distribution information, you must do the following:

- Define a custom field within fleet indexing for each software package. **Note:** Creating custom fields count toward [AWS IoT fleet indexing service quotas](https://aws.amazon.com/iot/fleet-indexing/).
- Format the custom field as follows:

  ```
  shadow.name.$package.reported.<packageName>.version
  ```

For more information, see the [Custom fields](https://docs.aws.amazon.com/iot/latest/developerguide/fleet-indexing-custom-fields.html) section in AWS IoT fleet indexing.

Preparing AWS IoT Jobs

AWS IoT Device Management Software Package Catalog extends AWS IoT Jobs through substitution parameters, and integration with AWS IoT fleet indexing, dynamic thing groups, and the AWS IoT thing’s reserved named shadow.

**Note**

To use all the functionality that Software Package Catalog offers, you must create these AWS Identity and Access Management (IAM) roles and policies: [AWS IoT Jobs rights to deploy package versions](https://docs.aws.amazon.com/iot/latest/developerguide/iot-jobs-package-version-update.html) and [AWS IoT Jobs rights to update the reserved named shadow](https://docs.aws.amazon.com/iot/latest/developerguide/iot-jobs-package-version-update.html). For more information, see [Preparing security](https://docs.aws.amazon.com/iot/latest/developerguide/iot-jobs-package-version-update.html).

Substitution parameters for AWS IoT jobs

You can use substitution parameters as a placeholder within your AWS IoT job document. When the job service encounters a substitution parameter, it points the job to a named software version’s attribute for the parameter value. You can use this process to create a single job document and pass the metadata into the job through general-purpose attributes. For example, you might pass an Amazon Simple Storage Service (Amazon S3) URL, a software package Amazon Resource Name (ARN), or a signature into the job document through package version attributes.

The substitution parameter should be formatted in the job document as follows:

```
${aws:iot:package:<packageName>:version:<versionName>:attributes:<anyAttributeName>}
```

In this example, there is a software package named, `samplePackage`, and it has a package version named 2.1.5 that has the following attributes:

- **name:** s3URL, value: `https://EXAMPIEBUCKET.s3.us-west-2.amazonaws.com/exampleCodeFile`
  - This attribute identifies the location of the code file that's stored within Amazon S3.
- **name:** signature, value: `aaaaabbbbbccccddddddeeeeffffgghhhhhiiiiijjjjj`
  - This attribute provides a code signature value that the device requires as a security measure. For more information, see [Code Signing for jobs](https://docs.aws.amazon.com/iot/latest/developerguide/iot-jobs-package-version-update.html). **Note:** This attribute is an example and not required as part of Software Package Catalog or jobs.

For downloads, the job document parameter is written as follows:

```
Preparing the job document and package version for deployment

When a package version is created, it's in a draft state indicating that it's being prepared for deployment. To complete this process, you must create a job document, save the document in a location that the job can access (such as Amazon S3), confirm that the package version has the attribute values that you want the job document to use, and publish the package version.
Transitioning the package version to published

When you have the job document complete and you’re ready to deploy, review your package version and its attributes to ensure that any information you pass to the job is included and accurate. You can update attributes for a package version while it’s in the draft state.

When you have reviewed the package version and are satisfied with its configuration, transition it to published either through the software package details page in the AWS IoT console, or by issuing the UpdatePackageVersion API operation.

Naming the packages and versions when deploying

When you deploy an AWS IoT job, you must name the same software packages and package versions that are named in the job document in the job deployment (destinationPackageVersions). If you don’t, you'll receive an error message stating the missing package versions.

You can include additional software packages and package versions that aren’t included within the job document. If you do this, the job doesn’t provide instructions to the device about what to do with those files and the device is expected to know what to do. For example, you might send additional files to the device if they contain data that the device might reference.

Targeting jobs through AWS IoT dynamic thing groups

Software Package Catalog works with fleet indexing, AWS IoT jobs, and AWS IoT dynamic thing groups to filter and target devices within your fleet to select which package version to deploy to your devices. You can run a fleet indexing query based on your device's current package information and target those things for an AWS IoT job. You can also release software updates, but only to eligible target devices. For example, you can specify that you want to deploy a configuration only to those devices that currently run the iot-device-client 1.5.09. For more information, see Create a dynamic thing group.

Reserved named shadow and package versions

If configured, AWS IoT Jobs can update a thing's reserved named shadow ($package) when the job successfully completes. If you do so, you don’t need to manually associate a package version to a thing's reserved named shadow.

You might choose to manually associate or update a package version to the thing's reserved named shadow in the following situations:

- You register a thing to AWS IoT Core without associating the installed package version.
- AWS IoT Jobs isn’t configured to update the thing’s reserved named shadow.
- You use an in-house process to dispatch package versions to your fleet and that process doesn’t update AWS IoT Core when it completes.

Note

We recommend you use AWS IoT Jobs to update the package version in the reserved named shadow ($package). Updating the version parameter in the $package shadow through other processes (such as, manual or programmatic API calls) when AWS IoT Jobs is also configured to update the shadow, can cause inconsistencies between the actual version on device and version reported to the reserved named shadow.
Uninstalling a software package

$null is a reserved placeholder that prompts the AWS IoT Jobs service to remove the existing software package and package version from the device's reserved named shadow $package. For more information, see Reserved named shadow.

To use this feature, replace the version name at the end of the destinationPackageVersion Amazon Resource Name (ARN) with $null. Afterward, you must instruct your service to remove the software from the device.

The authorized ARN uses the following format:

```
```

For example,

```
$ aws iot create-job \
  ... \
```

Getting started with Software Package Catalog

You can build and maintain the AWS IoT Device Management Software Package Catalog through the AWS Management Console, AWS IoT Core API operations, and AWS Command Line Interface (AWS CLI).

Using the console

To use the AWS Management Console, sign into your AWS account and navigate to AWS IoT Core. In the navigation pane, choose Software packages. You can then create and manage packages and their versions from this section.

Using API or CLI operations

You can use the AWS IoT Core API operations to create and manage Software Package Catalog features. For more information, see AWS IoT API Reference and AWS SDKs and Toolkits. The AWS CLI commands also manage your catalog. For more information, see the AWS IoT CLI Command Reference.

This chapter contains the following sections:

- Creating a software package and package version (p. 1183)
- Deploying a package version through AWS IoT jobs (p. 1184)
- Associating a package version to an AWS IoT thing (p. 1185)
Creating a software package and package version

You can use the following steps to create a package and an initial version thing through the AWS Management Console.

To create a software package

1. Sign into your AWS account and navigate to the AWS IoT console.
2. On the navigation pane, choose Software packages.
3. On the AWS IoT software package page, choose Create package. The Enable dependencies for package management dialog box appears.
4. Under Fleet indexing, select Add device software packages and version. This is required for Software Package Catalog and provides fleet indexing and metrics about your fleet.
5. [Optional] If you want AWS IoT jobs to update the reserved named shadow when jobs successfully complete, select Auto update shadows from jobs. If you do not want AWS IoT jobs to make this update, leave this check-box unselected.
6. [Optional] To grant AWS IoT jobs the rights to update the reserved named shadow, under Select role, choose Create role. If you don’t want AWS IoT jobs to make this update, this role is not required.
7. Create or select a role.
   a. If you don’t have a role for this purpose: When the Create role dialog box appears, enter a Role name, and then choose Create.
   b. If you do have a role for this purpose: For Select role, choose your role and then make sure the Attach policy to IAM role check box is selected.
9. Under Package detail, enter a Package name.
10. Under Package description, enter information to help you identify and manage this package.
11. [Optional] You can use tags to help you categorize and manage this package. To add tags, expand Tags, choose Add tag, and enter a key-value pair. You can enter up to 50 tags. For more information, see Tagging your AWS IoT resources.

To add a package version while creating a new package

1. Under First version, enter a Version name.
   We recommend using the SemVer format (for example, 1.0.0.0) to uniquely identify your package version. You are also able to use a different formatting strategy that better suits your use case. For more information, see Package version lifecycle (p. 1168).
2. Under Version description, enter information that will help you identify and manage this package version.
   Note
   The Default version check box is deactivated because package versions are created in a draft state. You can name the default version after the package version is created and when you change the state to published. For more information, see Package version lifecycle (p. 1168).
3. [Optional] To help you manage this version or to communicate information to your devices, enter one or more name-value pairs for Version attributes. Choose Add attribute for each name-value pair you enter. For more information, see Version attributes (p. 1170).
4. [Optional] You can use tags to help you categorize and manage this package. To add tags, expand Tags, choose Add tag, and enter a key-value pair. You can enter up to 50 tags. For more information, see Tagging your AWS IoT resources.
5. Choose **Create package**. The **AWS IoT software package** page appears and your package is listed in the table of packages.

6. [Optional] To review information about the software package and package version you created, choose your package name. The package details page appears.

### Deploying a package version through AWS IoT jobs

You can use the following steps to deploy a package version through the AWS Management Console.

**Prerequisites:**

Before you begin, do the following:

- Register AWS IoT things with AWS IoT Core. For directions to add your devices to AWS IoT Core, see [Create a thing object](#).
- [Optional] Create an AWS IoT thing group or dynamic thing group to target the devices that you will deploy the package version. For directions to create a thing group, see [Create a static thing group](#). For directions to create a dynamic thing group, see [Create a dynamic thing group](#).
- Create a software package and a package version. For more information, see [Creating a software package and package version](#).
- Create a job document. For more information, see [Preparing the job document and package version for deployment](#).

**To deploy an AWS IoT job**

1. On the **AWS IoT console**, choose **Software packages**.
2. Choose the software package that you want to deploy. The **software package details** page appears.
3. Choose the package version that you want to deploy, under **Versions**, and choose **Deploy job version**.
4. If this is your first time deploying a job through this portal, a dialog box describing the requirements appears. Review the information and choose **Acknowledge**.
5. Enter a name for the deployment or leave the autogenerated name in the **Name** field.
6. [Optional] In the **Description** field, enter a description that identifies the purpose or contents of the deployment, or leave the autogenerated information.

   **Note:** We recommend that you don’t use personally identifiable information in the Job name and description fields.

7. [Optional] Add any tags to associate with this job.
8. Choose **Next**.
9. Under **Job targets**, choose the things or thing groups that should receive the job.
10. In the **Job file** field, specify the job document JSON file.
11. Open **Jobs integration with the Package Catalog service**.
12. Select the packages and versions that are specified within your job document.

   **Note**

   You are required to choose the same packages and package versions that are specified within the job document. You can include more, but the job will issue instructions only for the packages and versions included in the job document. For more information, see [Naming the packages and versions when deploying](#).

13. Choose **Next**.
14. On the Job configuration page, select one of the following job types in the Job configuration dialog box:
- **Snapshot job**: A snapshot job is complete when it's finished its run on the target devices and groups.
- **Continuous job**: A continuous job applies to thing groups and runs on any device that you later add to a specified target group.

15. In the **Additional configurations - optional** dialog box, review the following optional job configurations and make your selections accordingly. For more information, see Job rollout, scheduling, and abort configurations and Job execution timeout and retry configurations.

- Rollout configuration
- Scheduling configuration
- Job executions timeout configuration
- Job executions retry configuration
- Abort configuration

16. Review the job selections and then choose **Submit**.

After you create the job, the console generates a JSON signature and places it in your job document. You can use the AWS IoT console to view the status of a job, or cancel or delete a job. To manage jobs, go to the Job hub of the console.

**Associating a package version to an AWS IoT thing**

After you install software on your device, you can associate a package version to an AWS IoT thing’s reserved named shadow. If AWS IoT jobs has been configured to update the thing’s reserved named shadow after the job deploys and successfully completes, you don’t need to complete this procedure. For more information, see Reserved named shadow (p. 1171).

**Prerequisites:**

Before you begin, do the following:

- Create an AWS IoT thing, or things, and establish telemetry through AWS IoT Core. For more information, see Getting started with AWS IoT Core.
- Create a software package and package version. For more information, see Creating a software package and package version (p. 1183).
- Install the package version software on the device.

**Note**

Associating a package version to an AWS IoT thing doesn’t update or install software on the physical device. The package version must be deployed to the device.

**To associate a package version to an AWS IoT thing**

1. On the **AWS IoT console** navigation pane, expand the All devices menu and choose Things.
2. Identify the AWS IoT thing that you want to update from the list and choose the thing name to display its details page.
3. In the **Details** section, choose Packages and versions.
4. Choose Add to package and version.
5. For Choose a device package, choose the software package you want.
6. For Choose a version, choose the software version you want.
7. Choose Add device package.

The package and version appear on the **Selected packages and versions** list.
8. Repeat these steps for each package and version that you want to associate to this thing.

9. When you're finished, choose **Add package and version details**. The **Thing details** page opens and you can see the new package and version in the list.
AWS IoT Core Device Location

Before using the AWS IoT Core Device Location feature, review the Terms and Conditions for this feature. Note that AWS may transmit your geolocation search request parameters, such as the location data used to run searches, and other information to your chosen third party data provider, which may be outside of the AWS Region that you are currently using. For more information, see AWS Service Terms.

Use AWS IoT Core Device Location to test the location of your IoT devices using third-party solvers. Solvers are algorithms provided by third-party vendors that resolve measurement data and estimate the location of your device. By identifying the location of your devices, you can track and debug them in the field to troubleshoot any issues.

The measurement data collected from various sources is resolved, and the geolocation information is reported as a GeoJSON payload. The GeoJSON format is a format that's used to encode geographic data structures. The payload contains the latitude and longitude coordinates of your device location, which are based on the World Geodetic System coordinate system (WGS84).

Topics
- Measurement types and solvers (p. 1187)
- How AWS IoT Core Device Location works (p. 1188)
- How to use AWS IoT Core Device Location (p. 1189)
- Resolving location of IoT devices (p. 1189)
- Resolving device location using AWS IoT Core Device Location MQTT topics (p. 1194)
- Location solvers and device payload (p. 1199)

Measurement types and solvers

AWS IoT Core Device Location partners with third-party vendors to resolve the measurement data and to provide an estimated device location. The following table shows the measurement types and the third-party location solvers, and information about supported devices. For information about LoRaWAN devices and configuring device location for them, see Configure position of wireless resources with AWS IoT Core for LoRaWAN (p. 1249).

<table>
<thead>
<tr>
<th>Measurement type</th>
<th>Third-party solvers</th>
<th>Supported devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wi-Fi access points</td>
<td>Wi-Fi based solver</td>
<td>General IoT devices and LoRaWAN devices</td>
</tr>
<tr>
<td>Cellular radio towers: GSM, LTE, CDMA, SCDMA, WCDMA, and TD-SCDMA data</td>
<td>Cellular based solver</td>
<td>General IoT devices and LoRaWAN devices</td>
</tr>
<tr>
<td>IP address</td>
<td>IP reverse lookup solver</td>
<td>General IoT devices</td>
</tr>
</tbody>
</table>
How AWS IoT Core Device Location works

The following diagram shows how AWS IoT Core Device Location collects measurement data and resolves the location information of your devices.

The following steps show how AWS IoT Core Device Location works.

1. **Receive measurement data**

   The raw measurement data related to your device location is first sent from the device. The measurement data is specified as a JSON payload.

2. **Process measurement data**

   The measurement data is processed, and AWS IoT Core Device Location chooses the measurement data to be used, which can be Wi-Fi, cellular, GNSS scan, or IP address information.

3. **Choose solver**

   The third-party solver is chosen based on the measurement data. For example, if the measurement data contains Wi-Fi and IP address information, it chooses the Wi-Fi solver and the IP reverse lookup solver.

For more information about the location solvers and examples that show the device payload for the various measurement types, see [Location solvers and device payload](p. 1199).
4. **Obtain resolved location**
   An API request is sent to the solver providers requesting to resolve the location. AWS IoT Core Device Location then gets the estimated geolocation information from the solvers.

5. **Choose resolved location**
   The resolved location information and its accuracy is compared, and AWS IoT Core Device Location chooses the geolocation results with the highest accuracy.

6. **Output location information**
   The geolocation information is sent to you as a GeoJSON payload. The payload contains the WGS84 geo coordinates, the accuracy information, confidence levels, and the timestamp at which the resolved location was obtained.

---

**How to use AWS IoT Core Device Location**

The following steps show how to use AWS IoT Core Device Location.

1. **Provide measurement data**
   Specify the raw measurement data related to the location of your device as a JSON payload. To retrieve the payload measurement data, go to your device logs, or use CloudWatch Logs, and copy the payload data information. The JSON payload must contain one or more types of data measurement. For examples that show the payload format for various solvers, see [Location solvers and device payload](p. 1199).

2. **Resolve location information**
   Using the Device Location page in the AWS IoT console or the GetPositionEstimate API operation, pass the payload measurement data and resolve the device location. AWS IoT Core Device Location then chooses the solver with the highest accuracy and reports the device location. For more information, see [Resolving location of IoT devices](p. 1189).

3. **Copy location information**
   Verify the geolocation information that was resolved by AWS IoT Core Device Location and reported as a GeoJSON payload. You can copy the payload for use with your applications and other AWS services. For example, you can send your geographical location data to Amazon Location Service using the [Location](p. 560) AWS IoT rule action.

The following topics show how to use AWS IoT Core Device Location and examples of device location payload.

- [Resolving location of IoT devices](p. 1189)
- [Location solvers and device payload](p. 1199)

---

**Resolving location of IoT devices**

Use AWS IoT Core Device Location to decode the measurement data from your devices, and resolve the device location using third-party solvers. The resolved location is generated as a GeoJSON payload with the geo coordinates and accuracy information. You can resolve the location of your device from the AWS IoT console, the AWS IoT Wireless API, or AWS CLI.

**Topics**

- [Resolving device location (console)](p. 1190)
Resolving device location (console)

To resolve the device location (console)

1. Go to the Device Location page in the AWS IoT console.
2. Obtain the payload measurement data from your device logs or from CloudWatch Logs, and enter it in the Resolve position via payload section.

The following code shows a sample JSON payload. The payload contains cellular and Wi-Fi measurement data. If your payload contains additional types of measurement data, the solver with the best accuracy will be used. For more information and payload examples, see the section called "Location solvers and device payload" (p. 1199).

**Note**
The JSON payload must contain at least one type of measurement data.

```json
{
   "timestamp": 1664313161,
   "ip": {
      "ip-address": "54.240.198.35"
   },
   "wifi-access-points": [
      {
         "mac-address": "A0:EC:F9:1E:32:C1",
         "rss": -77
      }
   ],
   "cell-towers": {
      "gsm": {
         "mcc": 262,
         "mnc": 1,
         "lac": 5126,
         "geran-cid": 16504,
         "gsm-local-id": {
            "bsic": 6,
            "bcch": 82
         },
         "gsm-timing-advance": 1,
         "rx-level": -110,
         "gsm-nmr": {
            "bsic": 7,
            "bcch": 85,
            "rx-level": -100,
            "global-identity": {
               "lac": 1,
               "geran-cid": 1
            }
         }
      },
      "wcdma": {
         "mcc": 262,
         "mnc": 7,
         "lac": 65535,
         "utran-cid": 14674663,
         "wcdma-nmr": {
            "uarfcndl": 10786,
            "utran-cid": 14674663,
            "psc": 149
         }
      }
   }
}
```
3. To resolve the location information, choose Resolve.

The location information is of type blob and returned as a payload that uses the GeoJSON format, which is a format used for encoding geographical data structures. The payload contains:

- The WGS84 geo coordinates, which include the latitude and longitude information. It might also include an altitude information.
- The type of location information reported, such as Point. A point location type represents the location as a WGS84 latitude and longitude, encoded as a GeoJSON point.
- The horizontal and vertical accuracy information, which indicates the difference, in meters, between the location information estimated by the solvers and the actual device location.
- The confidence level, which indicates the uncertainty in the location estimate response. The default value is 0.68, which indicates a 68% probability that the actual device location is within the uncertainty radius of the estimated location.
- The city, state, country, and postal code where the device is located. This information will be reported only when the IP reverse lookup solver is used.
- The timestamp information, which corresponds to the date and time at which the location was resolved. It uses the Unix timestamp format.

The following code shows a sample GeoJSON payload returned by resolving the location.

```
{
  "coordinates": 
  [13.376076698303223,
   ...
  ]
}
```

Note
If AWS IoT Core Device Location reports errors when attempting to resolve the location, you can troubleshoot the errors and resolve the location. For more information, see Troubleshooting errors when resolving the location (p. 1193).
Go to the Resource location section and verify the geolocation information reported by AWS IoT Core Device Location. You can copy the payload for use with other applications and AWS services. For example, you can use the Location (p. 560) to send your geographical location data to Amazon Location Service.

Resolving device location (API)

To resolve the device location using the AWS IoT Wireless API, use the GetPositionEstimate API operation or the get-position-estimate CLI command. Specify the payload measurement data as input, and run the API operation to resolve the device location.

Note
The GetPositionEstimate API operation doesn't store any device or state information and can't be used to retrieve historical location data. It performs a one-time operation that resolves the measurement data and produces the estimated location. To retrieve the location information, you must specify the payload information every time you perform this API operation.

The following command shows an example of how to resolve the location using this API operation.

Note
When running the get-position-estimate CLI command, you must specify the output JSON file as the first input. This JSON file will store the estimated location information obtained as response from the CLI in GeoJSON format. For example, the following command stores the location information in the locationout.json file.

```
aws iotwireless get-position-estimate locationout.json 
--ip IpAddress="54.240.198.35" 
--wi-fi-access-points 
  MacAddress="A0:EC:F9:1E:32:C1",Rss=-75 
```

This example includes both Wi-Fi access points and IP address as the measurement types. AWS IoT Core Device Location chooses between the Wi-Fi solver and the IP reverse lookup solver, and it selects the solver with the higher accuracy.

The resolved location is returned as a payload that uses the GeoJSON format, which is a format used for encoding geographical data structures. It is then stored in the locationout.json file. The payload contains the WGS84 latitude and longitude coordinates, accuracy and confidence level information, the location data type, and the timestamp at which the location was resolved.

```
{ 
  "coordinates": [
```
13.37704086303711, 52.51865005493164
], "type": "Point", "properties": {
  "verticalAccuracy": 707,
  "verticalConfidenceLevel": 0.68,
  "horizontalAccuracy": 389,
  "horizontalConfidenceLevel": 0.68,
  "country": "USA",
  "state": "CA",
  "city": "Sunnyvalue",
  "postalCode": "91234",
  "timestamp": "2022-11-18T14:03:57.391Z"
}
}

Troubleshooting errors when resolving the location

When you attempt to resolve the location, you might see any of the following error codes. AWS IoT Core Device Location might generate an error when using the GetPositionEstimate API operation, or else refer to the line number corresponding to the error in the AWS IoT console.

• **400 error**

  This error indicates that the format of the device payload JSON can't be validated by AWS IoT Core Device Location. The error might occur because:
  
  • The JSON measurement data is formatted incorrectly.
  • The payload contains only the timestamp information.
  • The measurement data parameters, such as the IP address, are not valid.

  To resolve this error, check whether your JSON is formatted correctly and contains data from one or more measurement types as input. If the IP address is invalid, for information about how you can provide a valid IP address to resolve the error, see [IP reverse lookup solver](p. 1203).

• **403 error**

  This error indicates that you don't have the permissions to perform the API operation or to use the AWS IoT console to retrieve the device location. To resolve this error, verify that you have the required permissions to perform this action. This error might occur if your AWS Management Console session or your AWS CLI session token have expired. To resolve this error, refresh the session token to use the AWS CLI, or log out of the AWS Management Console and then log in using your credentials.

• **404 error**

  This error indicates that no location information was found or solved by AWS IoT Core Device Location. The error might occur due to cases such as insufficient data in the measurement data input. For example:
  
  • The MAC address or cellular tower information is not sufficient.
  • The IP address is not available to look up and retrieve the location.
  • The GNSS payload is not sufficient.

  To resolve the error in such cases, check whether your measurement data contains sufficient information required to resolve the device location.

• **500 error**

  This error indicates that an internal server exception occurred when AWS IoT Core Device Location attempted to resolve the location. To attempt to fix this error, refresh the session and retry sending the measurement data to be resolved.
Resolving device location using AWS IoT Core Device Location MQTT topics

You can use reserved MQTT topics to get the latest location information for your devices with the AWS IoT Core Device Location feature.

Format of device location MQTT topics

Reserved topics for AWS IoT Core Device Location use the following prefix:

$aws/device_location/{customer_device_id}/

To create a complete topic, first replace customer_device_id with your unique ID that you use for identifying your device. We recommend that you specify the WirelessDeviceId, such as for LoRaWAN and Sidewalk devices, and thingName, if your device is registered as an AWS IoT thing. You then append the topic with the topic stub, such as get_position_estimate or get_position_estimate/accepted as shown in the following section.

Note
The {customer_device_id} can only contain letters, numbers, and dashes. When subscribing to device location topics, you can only use the plus sign (+) as a wildcard character. For example, you can use the + wildcard for the {customer_device_id} to obtain the location information for your devices. When you subscribe to the topic $aws/device_location/+/
get_position_estimate/accepted, a message will be published with the location information for devices that match any device ID if it was successfully resolved.

The following are the reserved topics used to interact with AWS IoT Core Device Location.

### Device location MQTT topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Allowed operations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aws/device_location/customer_device_id/get_position_estimate</td>
<td>Publish</td>
<td>A device publishes to this topic to get the scanned raw measurement data to be resolved by AWS IoT Core Device Location.</td>
</tr>
<tr>
<td>$aws/device_location/customer_device_id/get_position_estimate/accepted</td>
<td>Subscribe</td>
<td>AWS IoT Core Device Location publishes the location information to this topic when it successfully resolves the device location.</td>
</tr>
<tr>
<td>$aws/device_location/customer_device_id/get_position_estimate/rejected</td>
<td>Subscribe</td>
<td>AWS IoT Core Device Location publishes the error information to this topic when it fails to resolve the device location.</td>
</tr>
</tbody>
</table>

### Policy for device location MQTT topics

To receive messages from device location topics, your device must use a policy that allows it to connect to the AWS IoT device gateway and subscribe to the MQTT topics.
Device location topics and payload

The following shows the AWS IoT Core Device Location topics, the format of their message payload, and an example policy for each topic.

Topics

- `/get_position_estimate` (p. 1195)
- `/get_position_estimate/accepted` (p. 1197)
- `/get_position_estimate/rejected` (p. 1198)

`/get_position_estimate`

Publish a message to this topic to get the raw measurement data from the device to be resolved by AWS IoT Core Device Location.

$aws/device_location/customer_device_id/get_position_estimate
AWS IoT Core Device Location responds by publishing to either `/get_position_estimate/accepted` (p. 1197) or `/get_position_estimate/rejected` (p. 1198).

**Note**

The message published to this topic must be a valid JSON payload. If the input message is not in valid JSON format, you won't get any response. For more information, see [Message payload](p. 1196).

**Message payload**

The message payload format follows a similar structure as the AWS IoT Wireless API operation request body, `GetPositionEstimate`. It contains:

- An optional `Timestamp` string, which corresponds to the date and time the location was resolved. The `Timestamp` string can have a minimum length of 1 and maximum length of 10.
- An optional `MessageId` string, which can be used to map the request to the response. If you specify this string, the message published to the `get_position_estimate/accepted` or `get_position_estimate/rejected` topics will contain this `MessageId`. The `MessageId` string can have a minimum length of 1 and maximum length of 256.
- The measurement data from the device that contains one or more of the following measurement types:
  - `WiFiAccessPoint`
  - `CellTowers`
  - `IpAddress`
  - `Gnss`

The following shows a sample message payload.

```json
{
  "Timestamp": "1664313161",
  "MessageId": "ABCD1",
  "WiFiAccessPoints": [
    {
      "MacAddress": "A0:EC:F9:1E:32:C1",
      "Rss": -66
    }
  ],
  "Ip": {
    "IpAddress": "54.192.168.0"
  },
  "Gnss": {
    "Payload": "8295A614A2829517F4F77C0A7823B161A6FC57E25183D9653SE3689783F6CA48",
    "CaptureTime": 1354393948
  }
}
```

**Example policy**

The following is an example of the required policy:

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Publish"],
      "Resource": "arn:aws:iot:*:*:*"
    }
  ]
}
```
Device location topics and payload

AWS IoT Core Device Location publishes a response to this topic when returning the resolved location information for your device. The location information is returned in GeoJSON format.

$aws/device_location/customer_device_id/get_position_estimate/accepted

The following shows the message payload and an example policy.

Message payload

The following is an example of the message payload in GeoJSON format. If you specified a MessageId in your raw measurement data and AWS IoT Core Device Location resolved the location information successfully, then the message payload returns the same MessageId information.

```
{
    "coordinates": [
        13.37704086303711,
        52.51865005493164
    ],
    "type": "Point",
    "properties": {
        "verticalAccuracy": 707,
        "verticalConfidenceLevel": 0.68,
        "horizontalAccuracy": 389,
        "horizontalConfidenceLevel": 0.68,
        "country": "USA",
        "state": "CA",
        "city": "Sunnyvalue",
        "postalCode": "91234",
        "timestamp": "2022-11-18T14:03:57.391Z",
        "messageId": "ABCD1"
    }
}
```

Example policy

The following is an example of the required policy:

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iot:Subscribe"],
            "Resource": [
                "arn:aws:iot:region:account:topicfilter/$aws/device_location/customer_device_id/get_position_estimate/accepted"
            ]
        }
    ]
}
```
Device location topics and payload

```
{
  "Effect": "Allow",
  "Action": ["iot:Receive"],
  "Resource": [
    "arn:aws:iot:region:account:topic/$aws/device_location/customer_device_id/get_position_estimate/accepted"
  ]
}
```

/aws/device_location/customer_device_id/get_position_estimate/rejected

AWS IoT Core Device Location publishes an error response to this topic when it fails to resolve the device location.

The following shows the message payload and example policy. For information about the errors, see Troubleshooting errors when resolving the location (p. 1193).

**Message payload**

The following is an example of the message payload that provides the error code and message, which indicates why AWS IoT Core Device Location failed to resolve the location information. If you specified a MessageId when providing your raw measurement data and AWS IoT Core Device Location failed to resolve the location information, then the same MessageId information will be returned in the message payload.

```
{
  "errorCode": 500,
  "errorMessage": "Internal server error",
  "messageId": "ABCD1"
}
```

**Example policy**

The following is an example of the required policy:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": ["iot:Subscribe"],
      "Resource": [
        "arn:aws:iot:region:account:topicfilter/$aws/device_location/customer_device_id/get_position_estimate/rejected"
      ]
    },
    {
      "Action": ["iot:Receive"],
      "Resource": [
```
Location solvers and device payload

Location solvers are algorithms that can be used to resolve the location of your IoT devices. AWS IoT Core Device Location supports the following location solvers. You'll see examples of the JSON payload format for these measurement types, the devices supported by the solver, and how the location is resolved.

To resolve the device location, specify one or more of these measurement data types. A single, resolved location will be returned for all measurement data combined.

**Topics**
- [Wi-Fi based solver (p. 1199)](#)
- [Cellular based solver (p. 1200)](#)
- [IP reverse lookup solver (p. 1203)](#)
- [GNSS solver (p. 1203)](#)

**Wi-Fi based solver**

Use the Wi-Fi based solver to resolve the location using the scan information from Wi-Fi access points. The solver supports the WLAN technology, and it can be used to compute the device location for general IoT devices and LoRaWAN wireless devices.

The LoRaWAN devices must have the LoRa Edge chipset, which can decode the incoming Wi-Fi scan information. LoRa Edge is an ultra-low power platform that integrates a long-range LoRa transceiver, multi-constellation GNSS scanner, and passive Wi-Fi MAC scanner targeting geolocation applications. When an uplink message is received from the device, the Wi-Fi scan data is sent to AWS IoT Core Device Location, and the location is estimated based on the Wi-Fi scan results. The decoded information is then passed to the Wi-Fi based solver to retrieve the location information.

**Wi-Fi based solver payload example**

The following code shows an example of the JSON payload from the device that contains the measurement data. When AWS IoT Core Device Location receives this data as input, it sends an HTTP request to the solver provider to resolve the location information. To retrieve the information, specify values for the MAC Address and RSS (received signal strength). To do this, either provide the JSON payload using this format, or use the WiFiAccessPoints object parameter of the GetPositionEstimate API operation.

```json
{
  "Timestamp": 1664313161, // optional
  "WiFiAccessPoints": [
    {
      "MacAddress": "A0:EC:F9:1E:32:C1", // required
      "Rss": -75 // required
    }
  ]
}
```
Cellular based solver

You can use the cellular based solver to resolve the location using measurement data obtained from cellular radio towers. The solver supports the following technologies. A single resolved location information is obtained, even if you include measurement data from any or all of these technologies.

- GSM
- CDMA
- WCDMA
- TD-SCDMA
- LTE

Cellular based solver payload examples

The following code shows examples of the JSON payload from the device that contains cellular measurement data. When AWS IoT Core Device Location receives this data as input, it sends an HTTP request to the solver provider to resolve the location information. To retrieve the information, you either provide the JSON payload using this format in the console, or specify values for the `CellTowers` parameter of the `GetPositionEstimate` API operation. You can provide the measurement data by specifying values for parameters using any or all of these cellular technologies.

**LTE (Long-term evolution)**

When you use this measurement data, you must specify information such as the network and country code of the mobile network, and optional additional parameters including information about the local ID. The following code shows an example of the payload format. For more information about these parameters, see [LTE object](#).

```json
{
  "Timestamp": 1664313161,       // optional
  "CellTowers": {
    "Lte": [
      {
        "Mcc": int,               // required
        "Mnc": int,               // required
        "EutranCid": int,         // required
        "Tac": int,               // optional
        "LteLocalId": {           // optional
          "Pci": int,             // required
          "Earfcn": int,          // required
        },
        "LteTimingAdvance": int,  // optional
        "Rsrp": int,              // optional
        "Rsrq": float,            // optional
        "NrCapable": boolean,     // optional
        "LteNmr": [               // optional
          {
            "Pci": int,          // required
            "Earfcn": int,       // required
            "EutranCid": int,    // required
            "Rsrp": int,         // optional
            "Rsrq": float        // optional
          }
        ]
      }
    ]
  }
}
```
GSM (Global System for Mobile Communications)

When you use this measurement data, you must specify information such as the network and country code of the mobile network, the base station information, and optional additional parameters. The following code shows an example of the payload format. For more information about these parameters, see GSM object.

```json
{
  "Timestamp": 1664313161, // optional
  "CellTowers": {
    "Gsm": [
      {
        "Mcc": int, // required
        "Mnc": int, // required
        "Lac": int, // required
        "GeranCid": int, // required
        "GsmLocalId": {
          "Bsic": int, // required
          "Bcch": int, // required
        },
        "GsmTimingAdvance": int, // optional
        "RxLevel": int, // optional
        "GsmNmr": [
          {
            "Bsic": int, // required
            "Bcch": int, // required
            "RxLevel": int, // optional
            "GlobalIdentity": {
              "Lac": int, // required
              "GeranCid": int // required
            }
          }
        ]
      }
    ]
  }
}
```

CDMA (Code-division multiple access)

When you use this measurement data, you must specify information such as the signal power and identification information, the base station information, and optional additional parameters. The following code shows an example of the payload format. For more information about these parameters, see CDMA object.

```json
{
  "Timestamp": 1664313161, // optional
  "CellTowers": {
    "Cdma": [
      {
        "SystemId": int, // required
        "NetworkId": int, // required
        "BaseStationId": int, // required
        "RegistrationZone": int, // optional
        "CdmaLocalId": {
          "PnOffset": int, // required
          "CdmaChannel": int, // required
        },
        "PilotPower": int, // optional
        "BaseLat": float, // optional
        "BaseLng": float, // optional
        "CdmaNmr": [
          {
            "PnOffset": int, // required
            "CdmaChannel": int, // required
          }
        ]
      }
    ]
  }
}
```
WCDMA (Wideband code-division multiple access)

When you use this measurement data, you must specify information such as the network and country code, signal power and identification information, the base station information, and optional additional parameters. The following code shows an example of the payload format. For more information about these parameters, see [CDMA object](#).

```json
{
  "Timestamp": 1664313161,       // optional
  "CellTowers": {
    "Wcdma": [
      {
        "Mcc": int,                  // required
        "Mnc": int,                  // required
        "UtranCid": int,             // required
        "Lac": int,                  // optional
        "WcdmaLocalId": {
          "Uarfcndl": int,          // required
          "Psc": int,               // required
        },
        "Rscp": int,                // optional
        "Pathloss": int,            // optional
        "WcdmaNmr": [                // optional
          {
            "Uarfcndl": int,      // required
            "Psc": int,           // required
            "UtranCid": int,      // required
            "Rscp": int,          // optional
            "Pathloss": int,      // optional
          }
        ]
      }
    ]
  }
}
```

TD-SCDMA (Time division synchronous code-division multiple access)

When you use this measurement data, you must specify information such as the network and country code, signal power and identification information, the base station information, and optional additional parameters. The following code shows an example of the payload format. For more information about these parameters, see [CDMA object](#).

```json
{
  "Timestamp": 1664313161,       // optional
  "CellTowers": {
    "Tdscdma": [
      {
        "Mcc": int,                  // required
        "Mnc": int,                  // required
        "UtranCid": int,             // required
        "Lac": int,                  // optional
        "Pathloss": int,             // optional
      }
    ]
  }
}
```
IP reverse lookup solver

You can use the IP reverse lookup solver to resolve the location using the IP address as input. The solver can obtain the location information from devices that have been provisioned with AWS IoT. Specify the IP address information using a format that's either the IPv4 or IPv6 standard pattern, or the IPv6 hex compressed pattern. You then obtain the resolved location estimate, including additional information such as city and country where the device is located.

**Note**

By using the IP reverse lookup, you agree not to use it for the purpose of identifying or locating a specific household or street address.

### IP reverse lookup solver payload example

The following code shows an example of the JSON payload from the device that contains the measurement data. When AWS IoT Core Device Location receives the IP address information in the measurement data, it looks up this information in the solver provider's database, which is then used to resolve the location information. To retrieve the information, either provide the JSON payload using this format, or specify values for the `Ip` parameter of the `GetPositionEstimate` API operation.

**Note**

When this solver is used, the city, state, country, and postal code where the device is located is also reported in addition to the coordinates. For an example, see Resolving device location (console) (p. 1190).

```json
{
  "Timestamp": 1664313161,
  "Ip": {
    "IpAddress": "54.240.198.35"
  }
}
```

### GNSS solver

Use the GNSS (Global Navigation Satellite System) solver to retrieve the device location using the information contained in the GNSS scan result messages or NAV messages. You can optionally provide additional GNSS assistance information, which reduces the number of variables that the solver must use to search for signals. By providing this assistance information, which includes the position, altitude,
and the capture time and accuracy information, the solver can easily identify the satellites in view and
compute the device location.

This solver can be used with LoRaWAN devices, and other devices that have been provisioned with AWS
IoT. For general IoT devices, if the devices support location estimation using GNSS, when the GNSS scan
information is received from the device, the transceivers resolve the location information. For LoRaWAN
devices, the devices must have the LoRa Edge chipset. When an uplink message is received from the
device, the GNSS scan data is sent to AWS IoT Core for LoRaWAN, and the location is estimated based on
the scan results from the transceivers.

**GNSS solver payload example**

The following code shows an example of the JSON payload from the device that contains the
measurement data. When AWS IoT Core Device Location receives the GNSS scan information containing
the payload in the measurement data, it uses the transceivers and any additional assistance information
included to search for signals and resolve the location information. To retrieve the information,
either provide the JSON payload using this format, or specify values for the `Gnss` parameter of the
`GetPositionEstimate` API operation.

**Note**

Before AWS IoT Core Device Location can resolve the device location, you must remove the
destination byte from the payload.

```json
{
  "Timestamp": 1664313161, // optional
  "Gnss": {
    "AssistAltitude": number, // optional
    "AssistPosition": [ number ], // optional
    "CaptureTime": number, // optional
    "CaptureTimeAccuracy": number, // optional
    "Payload": "string", // required
    "Use2DSolver": boolean // optional
  }
}
```
Event messages

This section contains information about messages published by AWS IoT when things or jobs are updated or changed. For information about the AWS IoT Events service that allows you to create detectors to monitor your devices for failures or changes in operation, and to trigger actions when they occur, see AWS IoT Events.

How event messages are generated

AWS IoT publishes event messages when certain events occur. For example, events are generated by the registry when things are added, updated, or deleted. Each event causes a single event message to be sent. Event messages are published over MQTT with a JSON payload. The content of the payload depends on the type of event.

**Note**

Event messages are guaranteed to be published once. It is possible for them to be published more than once. The ordering of event messages is not guaranteed.

Policy for receiving event messages

To receive event messages, your device must use an appropriate policy that allows it to connect to the AWS IoT device gateway and subscribe to MQTT event topics. You must also subscribe to the appropriate topic filters.

The following is an example of the policy required for receiving lifecycle events:

```
{
    "Version":"2012-10-17",
    "Statement":[
        {
            "Effect":"Allow",
            "Action":[
                "iot:Subscribe",
                "iot:Receive"
            ],
            "Resource":[
                "arn:aws:iot:region:account:$aws/events/*"
            ]
        }
    ]
}
```

Enable events for AWS IoT

Before subscribers to the reserved topics can receive messages, you must enable event messages from the AWS Management Console or by using the API or CLI. For information about the event messages that the different options manage, see the Table of AWS IoT event configuration settings (p. 1206).

- To enable event messages, go to the Settings tab of the AWS IoT console and then, in the Event-based messages section, choose Manage events. You can specify the events that you want to manage.
- To control which event types are published by using the API or CLI, call the UpdateEventConfigurations API or use the update-event-configurations CLI command. For example:

  ```
  aws iot update-event-configurations --event-configurations "{"THING":{"Enabled":true}}"
  ```
You can get the current event configuration by calling the `DescribeEventConfigurations` API or by using the `describe-event-configurations` CLI command. For example:

```shell
aws iot describe-event-configurations
```

### Table of AWS IoT event configuration settings

<table>
<thead>
<tr>
<th>Event category (AWS IoT Console: Settings: Event-based messages)</th>
<th>eventConfigurations key value (AWS CLI/API)</th>
<th>Event message topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Can only be configured by using the AWS CLI/API)</td>
<td>CA_CERTIFICATE</td>
<td>$aws/events/certificates/registered/caCertificateId</td>
</tr>
<tr>
<td>(Can only be configured by using the AWS CLI/API)</td>
<td>CERTIFICATE</td>
<td>$aws/events/presence/connected/clientId</td>
</tr>
<tr>
<td>(Can only be configured by using the AWS CLI/API)</td>
<td>CERTIFICATE</td>
<td>$aws/events/presence/disconnected/clientId</td>
</tr>
<tr>
<td>(Can only be configured by using the AWS CLI/API)</td>
<td>CERTIFICATE</td>
<td>$aws/events/subscriptions/subscribed/clientId</td>
</tr>
<tr>
<td>(Can only be configured by using the AWS CLI/API)</td>
<td>CERTIFICATE</td>
<td>$aws/events/subscriptions/unsubscribed/clientId</td>
</tr>
<tr>
<td>Job completed, canceled</td>
<td>JOB</td>
<td>$aws/events/job/jobID/canceled</td>
</tr>
<tr>
<td>Job completed, canceled</td>
<td>JOB</td>
<td>$aws/events/job/jobID/cancellation_in_progress</td>
</tr>
<tr>
<td>Job completed, canceled</td>
<td>JOB</td>
<td>$aws/events/job/jobID/completed</td>
</tr>
<tr>
<td>Job completed, canceled</td>
<td>JOB</td>
<td>$aws/events/job/jobID/deleted</td>
</tr>
<tr>
<td>Job completed, canceled</td>
<td>JOB</td>
<td>$aws/events/job/jobID/deletion_in_progress</td>
</tr>
<tr>
<td>Job execution: success, failed, rejected, canceled, removed</td>
<td>JOB_EXECUTION</td>
<td>$aws/events/jobExecution/jobID/canceled</td>
</tr>
<tr>
<td>Job execution: success, failed, rejected, canceled, removed</td>
<td>JOB_EXECUTION</td>
<td>$aws/events/jobExecution/jobID/deleted</td>
</tr>
<tr>
<td>Event category (AWS IoT Console: Settings: Event-based messages)</td>
<td>eventConfigurations key value (AWS CLI/API)</td>
<td>Event message topic</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Job execution: success, failed, rejected, canceled, removed</td>
<td>JOB_EXECUTION</td>
<td>$aws/events/jobExecution/jobID/failed</td>
</tr>
<tr>
<td>Job execution: success, failed, rejected, canceled, removed</td>
<td>JOB_EXECUTION</td>
<td>$aws/events/jobExecution/jobID/rejected</td>
</tr>
<tr>
<td>Job execution: success, failed, rejected, canceled, removed</td>
<td>JOB_EXECUTION</td>
<td>$aws/events/jobExecution/jobID/removed</td>
</tr>
<tr>
<td>Job execution: success, failed, rejected, canceled, removed</td>
<td>JOB_EXECUTION</td>
<td>$aws/events/jobExecution/jobID/succeeded</td>
</tr>
<tr>
<td>Job execution: success, failed, rejected, canceled, removed</td>
<td>JOB_EXECUTION</td>
<td>$aws/events/jobExecution/jobID/timed_out</td>
</tr>
<tr>
<td>Thing: created, updated, deleted</td>
<td>THING</td>
<td>$aws/events/thing/thingName/created</td>
</tr>
<tr>
<td>Thing: created, updated, deleted</td>
<td>THING</td>
<td>$aws/events/thing/thingName/updated</td>
</tr>
<tr>
<td>Thing: created, updated, deleted</td>
<td>THING</td>
<td>$aws/events/thing/thingName/deleted</td>
</tr>
<tr>
<td>Thing group: added, removed</td>
<td>THING_GROUP</td>
<td>$aws/events/thingGroup/thingGroupName/created</td>
</tr>
<tr>
<td>Thing group: added, removed</td>
<td>THING_GROUP</td>
<td>$aws/events/thingGroup/thingGroupName/updated</td>
</tr>
<tr>
<td>Thing group: added, removed</td>
<td>THING_GROUP</td>
<td>$aws/events/thingGroup/thingGroupName/deleted</td>
</tr>
<tr>
<td>Thing group hierarchy: added, removed</td>
<td>THING_GROUP_HIERARCHY</td>
<td>$aws/events/thingGroupHierarchy/thingGroup/parentThingGroupName/childThingGroupName/childThingGroupName/added</td>
</tr>
</tbody>
</table>
## Registry events

The registry can publish event messages when things, thing types, and thing groups are created, updated, or deleted. These events, however, are not available by default. For information about how to turn on these events, see [Enable events for AWS IoT](p. 1205).

The registry can provide the following event types:

<table>
<thead>
<tr>
<th>Event category</th>
<th>eventConfigurations key value</th>
<th>Event message topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(AWS IoT Console: Settings: Event-based messages)</td>
<td>(AWS CLI/API)</td>
<td></td>
</tr>
<tr>
<td>Thing group hierarchy: added, removed</td>
<td>THING_GROUP_HIERARCHY</td>
<td>$aws/events/thingGroupHierarchy/thingGroup/parentThingGroupName/childThingGroup/childThingGroupName/removed</td>
</tr>
<tr>
<td>Thing group membership: added, removed</td>
<td>THING_GROUP_MEMBERSHIP</td>
<td>$aws/events/thingGroupMembership/thingGroup/thingGroupName/thing/thingName/added</td>
</tr>
<tr>
<td>Thing group membership: added, removed</td>
<td>THING_GROUP_MEMBERSHIP</td>
<td>$aws/events/thingGroupMembership/thingGroup/thingGroupName/thing/thingName/removed</td>
</tr>
<tr>
<td>Thing type: created, updated, deleted</td>
<td>THING_TYPE</td>
<td>$aws/events/thingType/thingTypeName/created</td>
</tr>
<tr>
<td>Thing type: created, updated, deleted</td>
<td>THING_TYPE</td>
<td>$aws/events/thingType/thingTypeName/updated</td>
</tr>
<tr>
<td>Thing type: created, updated, deleted</td>
<td>THING_TYPE</td>
<td>$aws/events/thingType/thingTypeName/deleted</td>
</tr>
<tr>
<td>Thing type association: added, removed</td>
<td>THING_TYPE_ASSOCIATION</td>
<td>$aws/events/thingTypeAssociation/thing/thingName/thingType/thingTypeName/added</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$aws/events/thingTypeAssociation/thing/thingName/thingType/thingTypeName/removed</td>
</tr>
</tbody>
</table>
Thing events

Thing Created/Updated/Deleted

The registry publishes the following event messages when things are created, updated, or deleted:

- $aws/events/thing/thiname/created
- $aws/events/thing/thiname/updated
- $aws/events/thing/thiname/deleted

The messages contain the following example payload:

```json
{
    "eventType": "THING_EVENT",
    "eventId": "f5ae9b94-8b8e-4d8e-8c8f-b3266dd89853",
    "timestamp": 1234567890123,
    "operation": "CREATED|UPDATED|DELETED",
    "accountId": "123456789012",
    "thingId": "b604f69c-aa9a-4d4a-829e-c480e958a0b5",
    "thingName": "MyThing",
    "versionNumber": 1,
    "thingTypeName": null,
    "attributes": {
        "attribute3": "value3",
        "attribute1": "value1",
        "attribute2": "value2"
    }
}
```

The payloads contain the following attributes:

- **eventType**: Set to "THING_EVENT".
- **eventId**: A unique event ID (string).
- **timestamp**: The UNIX timestamp of when the event occurred.
- **operation**: The operation that triggered the event. Valid values are:
  - CREATED
  - UPDATED
  - DELETED
- **accountId**: Your AWS account ID.
thingId
   The ID of the thing being created, updated, or deleted.

thingName
   The name of the thing being created, updated, or deleted.

versionNumber
   The version of the thing being created, updated, or deleted. This value is set to 1 when a thing is created. It is incremented by 1 each time the thing is updated.

thingTypeName
   The thing type associated with the thing, if one exists. Otherwise, null.

attributes
   A collection of name-value pairs associated with the thing.

## Thing type events

### Thing type related events:
- [Thing Type Created/Deprecated/Undeprecated/Deleted](p. 1210)
- [Thing Type Associated or Disassociated with a Thing](p. 1211)

### Thing Type Created/Deprecated/Undeprecated/Deleted

The registry publishes the following event messages when thing types are created, deprecated, undeprecated, or deleted:

- $aws/events/thingType/thingTypeName/created
- $aws/events/thingType/thingTypeName/updated
- $aws/events/thingType/thingTypeName/deleted

The message contains the following example payload:

```json
{
   "eventType" : "THING_TYPE_EVENT",
   "eventId" : "8827376c-4b05-49a3-9b3b-733729df7ed5",
   "timestamp" : 1234567890123,
   "operation" : "CREATED|UPDATED|DELETED",
   "accountId" : "123456789012",
   "thingTypeId" : "c530ae83-32aa-4592-94d3-da29879d1aac",
   "thingTypeName" : "MyThingType",
   "isDeprecated" : false|true,
   "deprecationDate" : null,
   "searchableAttributes" : [ "attribute1", "attribute2", "attribute3" ],
   "description" : "My thing type"
}
```

The payloads contain the following attributes:

**eventType**

Set to "THING_TYPE_EVENT".
eventId

A unique event ID (string).

timestamp

The UNIX timestamp of when the event occurred.

operation

The operation that triggered the event. Valid values are:
- CREATED
- UPDATED
- DELETED

accountId

Your AWS account ID.

thingTypeId

The ID of the thing type being created, deprecated, or deleted.

thingTypeName

The name of the thing type being created, deprecated, or deleted.

isDeprecated

true if the thing type is deprecated. Otherwise, false.

deprecationDate

The UNIX timestamp for when the thing type was deprecated.

searchableAttributes

A collection of name-value pairs associated with the thing type that can be used for searching.

description

A description of the thing type.

Thing Type Associated or Disassociated with a Thing

The registry publishes the following event messages when a thing type is associated or disassociated with a thing.

- `$aws/events/thingTypeAssociation/thing/thingName/thingType/typeName/added`
- `$aws/events/thingTypeAssociation/thing/thingName/thingType/typeName/removed`

The following is an example of an added payload. Payloads for removed messages are similar.

```json
{
  "eventId" : "87f8e095-531c-47b3-aab5-5171364d138d",
  "eventType" : "THING_TYPE_ASSOCIATION_EVENT",
  "operation" : "ADDED",
  "thingId" : "b604f69c-aa9a-4d4a-829e-c480e958a0b5",
  "thingName" : "myThing",
  "thingTypeName" : "MyThingType",
  "timestamp" : 1234567890123,
}
```
The payloads contain the following attributes:

**eventId**
A unique event ID (string).

**eventType**
Set to "THING_TYPE_ASSOCIATION_EVENT".

**operation**
The operation that triggered the event. Valid values are:
- ADDED
- REMOVED

**thingId**
The ID of the thing whose type association was changed.

**thingName**
The name of the thing whose type association was changed.

**thingTypeName**
The thing type associated with, or no longer associated with, the thing.

**timestamp**
The UNIX timestamp of when the event occurred.

### Thing group events

#### Thing group related events:
- Thing Group Created/Updated/Deleted (p. 1212)
- Thing Added to or Removed from a Thing Group (p. 1214)
- Thing Group Added to or Deleted from a Thing Group (p. 1215)

#### Thing Group Created/Updated/Deleted

The registry publishes the following event messages when a thing group is created, updated, or deleted.

- `$aws/events/thingGroup/groupName/created`
- `$aws/events/thingGroup/groupName/updated`
- `$aws/events/thingGroup/groupName/deleted`

The following is an example of an updated payload. Payloads for created and deleted messages are similar.

```json
{
  "eventType": "THING_GROUP_EVENT",
  "eventId": "8b9ea8626aee81e42100f3f32b975899",
  "timestamp": 1603995417409,
  "operation": "UPDATED"
}
```
The payloads contain the following attributes:

**eventType**

Set to "THING_GROUP_EVENT".

**eventId**

A unique event ID (string).

**timestamp**

The UNIX timestamp of when the event occurred.

**operation**

The operation that triggered the event. Valid values are:

- CREATED
- UPDATED
- DELETED

**accountId**

Your AWS account ID.

**thingGroupId**

The ID of the thing group being created, updated, or deleted.
thingGroupName

The name of the thing group being created, updated, or deleted.

versionNumber

The version of the thing group. This value is set to 1 when a thing group is created. It is incremented by 1 each time the thing group is updated.

parentGroupName

The name of the parent thing group, if one exists.

parentGroupId

The ID of the parent thing group, if one exists.

description

A description of the thing group.

rootToParentThingGroups

An array of information about the parent thing group. There is one element for each parent thing group, starting from the root thing group and continuing to the thing group's parent. Each entry contains the thing group's groupArn and groupId.

attributes

A collection of name-value pairs associated with the thing group.

## Thing Added to or Removed from a Thing Group

The registry publishes the following event messages when a thing is added to or removed from a thing group.

- `$aws/events/thingGroupMembership/thingGroup/thingGroupName/thing/thingName/added`
- `$aws/events/thingGroupMembership/thingGroup/thingGroupName/thing/thingName/removed`

The messages contain the following example payload:

```json
{
    "eventType" : "THING_GROUP_MEMBERSHIP_EVENT",
    "eventId" : "d684bd5f-6f6e-48e1-950c-766ac7f02fd1",
    "timestamp" : 1234567890123,
    "operation" : "ADDED|REMOVED",
    "accountId" : "123456789012",
    "groupId" : "06838589-373f-4312-b1f2-53f2192291c4",
    "thingId" : "b604f0c0-99a-4d4a-829e-c480e958a0b5",
    "membershipId" : "8505ebf8-4d32-4286-80e9-c23a4a16bbd8"
}
```

The payloads contain the following attributes:

- **eventType**
  
  Set to "THING_GROUP_MEMBERSHIP_EVENT".
thingId
The event ID.
timestamp
The UNIX timestamp for when the event occurred.
operation
ADDED when a thing is added to a thing group. REMOVED when a thing is removed from a thing group.
accountId
Your AWS account ID.
groupArn
The ARN of the thing group.
groupId
The ID of the group.
thingArn
The ARN of the thing that was added or removed from the thing group.
thingId
The ID of the thing that was added or removed from the thing group.
membershipId
An ID that represents the relationship between the thing and the thing group. This value is generated when you add a thing to a thing group.

Thing Group Added to or Deleted from a Thing Group

The registry publishes the following event messages when a thing group is added to or removed from another thing group.

• $aws/events/thingGroupHierarchy/thingGroup/{parentThingGroupName}/childThingGroup/{childThingGroupName}/added
• $aws/events/thingGroupHierarchy/thingGroup/{parentThingGroupName}/childThingGroup/{childThingGroupName}/removed

The message contains the following example payload:

```
{
    "eventType" : "THING_GROUP_HIERARCHY_EVENT",
    "eventId" : "264192c7-b573-46ef-ab7b-489fcd47da41",
    "timestamp" : 1234567890123,
    "operation" : "ADDED|REMOVED",
    "accountId" : "123456789012",
    "thingGroupId" : "8f82a106-6b1d-4331-8984-a84db5f6f8cb",
    "thingGroupName" : "MyRootThingGroup",
    "childGroupId" : "06838589-373f-4312-b1f2-53f2192291c4",
    "childGroupName" : "MyChildThingGroup"
}
```

The payloads contain the following attributes:
eventType
Set to "THING_GROUP_HIERARCHY_EVENT".

eventId
The event ID.

timestamp
The UNIX timestamp for when the event occurred.

operation
ADDED when a thing is added to a thing group. REMOVED when a thing is removed from a thing group.

accountId
Your AWS account ID.

thingGroupId
The ID of the parent thing group.

thingGroupName
The name of the parent thing group.

childGroupId
The ID of the child thing group.

childGroupName
The name of the child thing group.

---

Jobs events

The AWS IoT Jobs service publishes to reserved topics on the MQTT protocol when jobs are pending, completed, or canceled, and when a device reports success or failure when running a job. Devices or management and monitoring applications can track the status of jobs by subscribing to these topics.

How to enable jobs events

Response messages from the AWS IoT Jobs service don't pass through the message broker and they can't be subscribed to by other clients or rules. To subscribe to job activity-related messages, use the notify and notify-next topics. For information about jobs topics, see Job topics (p. 117).

To be notified of jobs updates, enable these jobs events by using the AWS Management Console, or by using the API or CLI. For more information, see Enable events for AWS IoT (p. 1205).

How jobs events work

Because it can take some time to cancel or delete a job, two messages are sent to indicate the start and end of a request. For example, when a cancellation request starts, a message is sent to the $aws/events/job/jobID/cancellation_in_progress topic. When the cancellation request is complete, a message is sent to the $aws/events/job/jobID/canceled topic.

A similar process occurs for a job deletion request. Management and monitoring applications can subscribe to these topics to keep track of the status of jobs. For more information about publishing and subscribing to MQTT topics, see the section called “Device communication protocols” (p. 85).

Job event types
The following shows the different types of jobs events:

**Job Completed/Canceled/Deleted**

The AWS IoT Jobs service publishes a message on an MQTT topic when a job is completed, canceled, deleted, or when cancellation or deletion are in progress:

- $aws/events/job/jobID/completed
- $aws/events/job/jobID/canceled
- $aws/events/job/jobID/deleted
- $aws/events/job/jobID/cancellation_in_progress
- $aws/events/job/jobID/deletion_in_progress

The completed message contains the following example payload:

```json
{
    "eventType": "JOB",
    "eventId": "7364fffd-18b65-4824-85d5-6c14686c97c6",
    "timestamp": 1234567890,
    "operation": "completed",
    "jobId": "27450507-bf6f-4012-92af-bb8a1c8c4484",
    "status": "COMPLETED",
    "targetSelection": "SNAPSHOT|CONTINUOUS",
    "targets": [],
    "arn:aws:iot:us-east-1:123456789012:thing/a396f91-70cf-4bd2-a381-9c66df1a80d0",
    "arn:aws:iot:us-east-1:123456789012:thinggroup/2fc4c0a4-6e45-4525-a238-0fe8d3dd21bb"
}
```

The canceled message contains the following example payload:

```json
{
    "eventType": "JOB",
    "eventId": "568d2ade-2e9c-46e6-a115-18afa1286b06",
    "timestamp": 1234567890,
    "operation": "canceled",
    "jobId": "4d2a531a-da2e-47bb-8b9e-ff5adcd53e0",
    "status": "CANCELED",
    "targetSelection": "SNAPSHOT|CONTINUOUS",
    "targets": [],
    "arn:aws:iot:us-east-1:123456789012:thinggroup/2fc4c0a4-6e45-4525-a238-0fe8d3dd21bb"
}
```
The deleted message contains the following example payload:

```json
{
    "eventType": "JOB",
    "eventId": "568d2ade-2e9c-46e6-a115-18afa1286b06",
    "timestamp": 1234567890,
    "operation": "deleted",
    "jobId": "4d2a531a-da2e-47bb-8b9e-ff5adcd53ef0",
    "status": "DELETED",
    "targetSelection": "SNAPSHOT|CONTINUOUS",
    "targets": [
        "arn:aws:iot:us-east-1:123456789012:thing/Thing0-947b9c0c-ff10-4a80-b4b3-
        cd33d0145a0f",
        "arn:aws:iot:us-east-1:123456789012:thinggroup/ThingGroup1-95c644d5-1621-41a6-9aa5-ad2de581d18f"
    ],
    "description": "My job description",
    "createdAt": 1234567890123,
    "lastUpdatedAt": 1234567890123,
    "comment": "Comment for this operation"
}
```

The cancellation_in_progress message contains the following example payload:

```json
{
    "eventType": "JOB",
    "eventId": "568d2ade-2e9c-46e6-a115-18afa1286b06",
    "timestamp": 1234567890,
    "operation": "cancellation_in_progress",
    "jobId": "4d2a531a-da2e-47bb-8b9e-ff5adcd53ef0",
    "status": "CANCELLATION_IN_PROGRESS",
    "targetSelection": "SNAPSHOT|CONTINUOUS",
    "targets": [
        "arn:aws:iot:us-east-1:123456789012:thing/Thing0-947b9c0c-ff10-4a80-b4b3-
        cd33d0145a0f",
        "arn:aws:iot:us-east-1:123456789012:thinggroup/ThingGroup1-95c644d5-1621-41a6-9aa5-ad2de581d18f"
    ],
    "description": "My job description",
    "createdAt": 1234567890123,
    "lastUpdatedAt": 1234567890123,
    "comment": "Comment for this operation"
}
```

The deletion_in_progress message contains the following example payload:

```json
{
    "eventType": "JOB",
    "eventId": "568d2ade-2e9c-46e6-a115-18afa1286b06",
    "timestamp": 1234567890,
    "operation": "deletion_in_progress",
    "jobId": "4d2a531a-da2e-47bb-8b9e-ff5adcd53ef0",
    "status": "DELETION_IN_PROGRESS",
    "targetSelection": "SNAPSHOT|CONTINUOUS",
    "targets": [
        "arn:aws:iot:us-east-1:123456789012:thing/Thing0-947b9c0c-ff10-4a80-b4b3-
        cd33d0145a0f",
        "arn:aws:iot:us-east-1:123456789012:thinggroup/ThingGroup1-95c644d5-1621-41a6-9aa5-ad2de581d18f"
    ],
    "description": "My job description",
    "createdAt": 1234567890123,
    "lastUpdatedAt": 1234567890123,
    "comment": "Comment for this operation"
}
```
Job Execution Terminal Status

The AWS IoT Jobs service publishes a message when a device updates a job execution to terminal status:

- $aws/events/jobExecution/jobID/succeeded
- $aws/events/jobExecution/jobID/failed
- $aws/events/jobExecution/jobID/rejected
- $aws/events/jobExecution/jobID/canceled
- $aws/events/jobExecution/jobID/timed_out
- $aws/events/jobExecution/jobID/removed
- $aws/events/jobExecution/jobID/deleted

The message contains the following example payload:

```json
{
  "eventType": "JOB_EXECUTION",
  "eventId": "cca89fa5-8a7f-4ced-8c20-5e653af3572",
  "timestamp": 1234567890,
  "operation": "succeeded|failed|rejected|canceled|removed|timed_out",
  "jobId": "154b39e5-60b0-48a4-9b73-f6f8dd032d27",
  "thingArn": "arn:aws:iot:us-east-1:123456789012:myThing/6d639fbc-8f85-4a90-924d-a2867f8366a7",
  "status": "SUCCEEDED|FAILED|REJECTED|CANCELED|MOVED|TIMED_OUT",
  "statusDetails": {
    "key": "value"
  }
}
```

Lifecycle events

AWS IoT can publish lifecycle events on the MQTT topics. These events are available by default and they can't be disabled.

**Note**

Lifecycle messages might be sent out of order. You might receive duplicate messages.

In this topic:

- Connect/Disconnect events (p. 1219)
- Subscribe/Unsubscribe events (p. 1222)

Connect/Disconnect events

**Note**

With AWS IoT Device Management fleet indexing, you can search for things, run aggregate queries, and create dynamic groups based on thing Connect/Disconnect events. For more information, see Fleet indexing.

AWS IoT publishes a message to the following MQTT topics when a client connects or disconnects:

- $aws/events/presence/connected/clientId – A client connected to the message broker.
• $aws/events/presence/disconnected/<clientId> – A client disconnected from the message broker.

The following is a list of JSON elements that are contained in the connection/disconnection messages published to the $aws/events/presence/connected/<clientId> topic.

**clientId**

  The client ID of the connecting or disconnecting client.

  **Note**
  
  Client IDs that contain # or + do not receive lifecycle events.

**clientInitiatedDisconnect**

  True if the client initiated the disconnect. Otherwise, false. Found in disconnect messages only.

**disconnectReason**

  The reason why the client is disconnecting. Found in disconnect messages only. The following table contains valid values and whether the broker will send Last Will and Testament (LWT) messages (p. 97) when the disconnection occurs.

<table>
<thead>
<tr>
<th>Disconnect reason</th>
<th>Description</th>
<th>The broker will send the LWT messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTH_ERROR</td>
<td>The client failed to authenticate or authorization failed.</td>
<td>Yes. If the device has an active connection before receiving this error.</td>
</tr>
<tr>
<td>CLIENT_INITIATED_DISCONNECT</td>
<td>Indicates that it will disconnect. The client can do this by sending either a MQTT DISCONNECT control packet or a Close frame if the client is using a WebSocket connection.</td>
<td>No.</td>
</tr>
<tr>
<td>CLIENT_ERROR</td>
<td>The client did something wrong that causes it to disconnect. For example, a client will be disconnected for sending more than 1 MQTT CONNECT packet on the same connection or if the client attempts to publish with a payload that exceeds the payload limit.</td>
<td>Yes.</td>
</tr>
<tr>
<td>CONNECTION_LOST</td>
<td>The client-server connection is cut off. This can happen during a period of high network latency or when the internet connection is lost.</td>
<td>Yes.</td>
</tr>
<tr>
<td>DUPLICATE_CLIENTID</td>
<td>The client is using a client ID that is already in use. In this case, the client that is already connected will be disconnected with this disconnect reason.</td>
<td>Yes.</td>
</tr>
<tr>
<td>FORBIDDEN_ACCESS</td>
<td>The client is not allowed to be connected. For example, a client with a denied IP address will fail to connect.</td>
<td>Yes. If the device has an active connection before receiving this error.</td>
</tr>
<tr>
<td>MQTT_KEEP_ALIVE_TIMEOUT</td>
<td>If there is no client-server communication for 1.5x of the client's keep-alive time, the client is disconnected.</td>
<td>Yes.</td>
</tr>
</tbody>
</table>
Connect/Disconnect events

<table>
<thead>
<tr>
<th>Disconnect reason</th>
<th>Description</th>
<th>The broker will send the LWT messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>SERVER_ERROR</td>
<td>Disconnected due to unexpected server issues.</td>
<td>Yes.</td>
</tr>
<tr>
<td>SERVER_INITIATED_DISCONNECT</td>
<td>Server intentionally disconnects a client for operational reasons.</td>
<td>Yes.</td>
</tr>
<tr>
<td>THROTTLED</td>
<td>The client is disconnected for exceeding a throttling limit.</td>
<td>Yes.</td>
</tr>
<tr>
<td>WEBSOCKET_TTL_EXPIRATION</td>
<td>The client is disconnected because a WebSocket has been connected longer than its time-to-live value.</td>
<td>Yes.</td>
</tr>
</tbody>
</table>

**eventType**

The type of event. Valid values are connected or disconnected.

**ipAddress**

The IP address of the connecting client. This can be in IPv4 or IPv6 format. Found in connection messages only.

**principalIdentifier**

The credential used to authenticate. For TLS mutual authentication certificates, this is the certificate ID. For other connections, this is IAM credentials.

**sessionIdentifier**

A globally unique identifier in AWS IoT that exists for the life of the session.

**timestamp**

An approximation of when the event occurred.

**versionNumber**

The version number for the lifecycle event. This is a monotonically increasing long integer value for each client ID connection. The version number can be used by a subscriber to infer the order of lifecycle events.

**Note**

The connect and disconnect messages for a client connection have the same version number.

- The version number might skip values and is not guaranteed to be consistently increasing by 1 for each event.
- If a client is not connected for approximately one hour, the version number is reset to 0. For persistent sessions, the version number is reset to 0 after a client has been disconnected longer than the configured time-to-live (TTL) for the persistent session.

A connect message has the following structure.

```json
{
    "clientId": "186b5",
    "timestamp": 1573002230757,
    "eventType": "connected",
    "sessionIdentifier": "a4666d2a7d844ae4ac5d7b38c9cb7967",
    "principalIdentifier": "12345678901234567890123456789012",
    "ipAddress": "192.0.2.0",
    "versionNumber": 0
}```
A disconnect message has the following structure.

```json
{
    "clientId": "186b5",
    "timestamp": 1573002340451,
    "eventType": "disconnected",
    "sessionIdentifier": "a466d2a7d844ae4ac5d7b38c9cb7967",
    "principalIdentifier": "12345678901234567890123456789012",
    "clientInitiatedDisconnect": true,
    "disconnectReason": "CLIENT_INITIATED_DISCONNECT",
    "versionNumber": 0
}
```

### Handling client disconnections

The best practice is to always have a wait state implemented for lifecycle events, including Last Will and Testament (LWT) messages (p. 88). When a disconnect message is received, your code should wait a period of time and verify a device is still offline before taking action. One way to do this is by using SQS Delay Queues. When a client receives a LWT or a lifecycle event, you can enqueue a message (for example, for 5 seconds). When that message becomes available and is processed (by Lambda or another service), you can first check if the device is still offline before taking further action.

### Subscribe/Unsubscribe events

AWS IoT publishes a message to the following MQTT topic when a client subscribes or unsubscribes to an MQTT topic:

- `$aws/events/subscriptions/subscribed/clientId`
- `$aws/events/subscriptions/unsubscribed/clientId`

Where `clientId` is the MQTT client ID that connects to the AWS IoT message broker.

The message published to this topic has the following structure:

```json
{
    "clientId": "186b5",
    "timestamp": 1460065214626,
    "eventType": "subscribed" | "unsubscribed",
    "sessionIdentifier": "00000000-0000-0000-0000-000000000000",
    "principalIdentifier": "000000000000/ABCDEFGHIJKLMNOPQRSTU:some-user/ABCDEFGHIJKLMNOPQRSTU:some-user",
    "topics" : ["foo/bar","device/data","dog/cat"]
}
```

The following is a list of JSON elements that are contained in the subscribed and unsubscribed messages published to the `$aws/events/subscriptions/subscribed/clientId` and `$aws/events/subscriptions/unsubscribed/clientId` topics.

- `clientId`  
  The client ID of the subscribing or unsubscribing client.
**Note**  
Client IDs that contain # or + do not receive lifecycle events.

**eventType**  
The type of event. Valid values are subscribed or unsubscribed.

**principalIdentifier**  
The credential used to authenticate. For TLS mutual authentication certificates, this is the certificate ID. For other connections, this is IAM credentials.

**sessionIdentifier**  
A globally unique identifier in AWS IoT that exists for the life of the session.

**timestamp**  
An approximation of when the event occurred.

**topics**  
An array of the MQTT topics to which the client has subscribed.

**Note**  
Lifecycle messages might be sent out of order. You might receive duplicate messages.
AWS IoT Core for LoRaWAN

AWS IoT Core for LoRaWAN is a fully managed LoRaWAN network server (LNS) that provides gateway management using the Configuration and Update Server (CUPS) and Firmware Updates Over-The-Air (FUOTA) capabilities. You can replace your private LNS with AWS IoT Core for LoRaWAN and connect your Long Range Wide Area Network (LoRaWAN) devices and gateways to AWS IoT Core. By doing so, you’ll reduce the maintenance, operational costs, setup time, and overhead costs.

**Note**

AWS IoT Core for LoRaWAN supports only the IPv4 address format. It doesn't support the IPv6 or the dual stack configuration (IPv4 and IPv6). For more information, see [AWS services that support IPv6](https://aws.amazon.com/ipv6/).

**Introduction**

LoRaWAN devices are long-range, low-power, battery-operated devices that use the LoRaWAN protocol to operate in a license-free radio spectrum. LoRaWAN is a Low Power Wide Area Network (LPWAN) communication protocol that is built on LoRa. LoRa is the physical layer protocol that enables low power, wide-area communication between devices.

You can onboard your LoRaWAN devices the same way you would onboard other IoT devices to AWS IoT. To connect your LoRaWAN devices to AWS IoT, you must use a LoRaWAN gateway. The gateway acts as a bridge to connect your device to AWS IoT Core for LoRaWAN and to exchange messages. AWS IoT Core for LoRaWAN uses the AWS IoT rules engine to route the messages from your LoRaWAN devices to other AWS IoT services.

To reduce development effort and quickly onboard your devices to AWS IoT Core for LoRaWAN, we recommend that you use LoRaWAN-certified end devices. For more information, see the [AWS IoT Core for LoRaWAN product overview](https://aws.amazon.com/iot-core-lorawan/) page. For information about getting your devices LoRaWAN certified, see [Certifying LoRaWAN products](https://aws.amazon.com/iot-core-lorawan-certification/).

**How to use AWS IoT Core for LoRaWAN**

You can quickly onboard your LoRaWAN devices and gateways to AWS IoT Core for LoRaWAN by using the console or the AWS IoT Wireless API.

**Using the console**

To onboard your LoRaWAN devices and gateways by using the AWS Management Console, sign in to the AWS Management Console and navigate to the [AWS IoT Core for LoRaWAN](https://aws.amazon.com/iot-core-lorawan/) page in the AWS IoT console. You can then use the **Intro** section to add your gateways and devices to AWS IoT Core for LoRaWAN. For more information, see [Using the console to onboard your device and gateway to AWS IoT Core for LoRaWAN](p. 1228).

**Using the API or CLI**

You can onboard both LoRaWAN and Sidewalk devices by using the [AWS IoT Wireless](https://aws.amazon.com/iot-wireless/) API. The AWS IoT Wireless API that AWS IoT Core for LoRaWAN is built on is supported by the AWS SDK. For more information, see [AWS SDKs and Toolkits](https://aws.amazon.com/iot-wireless-sdk/).

You can use the AWS CLI to run commands for onboarding and managing your LoRaWAN gateways and devices. For more information, see [AWS IoT Wireless CLI reference](https://aws.amazon.com/iot-wireless-cli/).
AWS IoT Core for LoRaWAN Regions and endpoints

AWS IoT Core for LoRaWAN provides support for control plane and data plane API endpoints that are specific to your AWS Region. The data plane API endpoints are specific to your AWS account and AWS Region. For more information about the AWS IoT Core for LoRaWAN endpoints, see AWS IoT Core for LoRaWAN Endpoints in the AWS General Reference.

For more secure communication between your devices and AWS IoT, you can connect your devices to AWS IoT Core for LoRaWAN through AWS PrivateLink in your virtual private cloud (VPC), instead of connecting over the public internet. For more information, see Connecting to AWS IoT Core for LoRaWAN through a VPC interface endpoint (p. 1257).

AWS IoT Core for LoRaWAN has quotas that apply to device data that is transmitted between the devices and the maximum TPS for the AWS IoT Wireless API operations. For more information, see AWS IoT Core for LoRaWAN quotas in the AWS General Reference.

AWS IoT Core for LoRaWAN pricing

When you sign up for AWS, you can get started with AWS IoT Core for LoRaWAN for no charge by using the AWS Free Tier.

For more information about general product overview and pricing, see AWS IoT Core pricing.

What is AWS IoT Core for LoRaWAN?

AWS IoT Core for LoRaWAN replaces a private LoRaWAN network server (LNS) by connecting your LoRaWAN devices and gateways to AWS. Using the AWS IoT rules engine, you can route messages received from LoRaWAN devices, where they can be formatted and sent to other AWS IoT services. To secure device communications with AWS IoT, AWS IoT Core for LoRaWAN uses X.509 certificates.

AWS IoT Core for LoRaWAN manages the service and device policies that AWS IoT Core requires to communicate with the LoRaWAN gateways and devices. AWS IoT Core for LoRaWAN also manages the destinations that describe the AWS IoT rules that send device data to other services.

With AWS IoT Core for LoRaWAN, you can:

- Onboard and connect LoRaWAN devices and gateways to AWS IoT without the need to set up and manage a private LNS.
- Connect LoRaWAN devices that comply to 1.0.x or 1.1 LoRaWAN specifications standardized by LoRa Alliance. These devices can operate in class A, class B, or class C mode.
- Use LoRaWAN gateways that support LoRa Basics Station version 2.0.4 or later. All gateways that are qualified for AWS IoT Core for LoRaWAN run a compatible version of LoRa Basics Station.
- Monitor signal strength, bandwidth, and spreading factor by using AWS IoT Core for LoRaWAN's adaptive data rate, and optimize the data rate if needed.
- Update LoRaWAN gateways' firmware using the CUPS service and the firmware of LoRaWAN devices using Firmware Updates Over-The-Air (FUOTA).

Topics

- What is LoRaWAN? (p. 1226)
- How AWS IoT Core for LoRaWAN works (p. 1226)
What is LoRaWAN?

The LoRa Alliance describes LoRaWAN as, "a Low Power, Wide Area (LPWA) networking protocol designed to wirelessly connect battery operated ‘things’ to the internet in regional, national or global networks, and targets key Internet of Things (IoT) requirements such as bi-directional communication, end-to-end security, mobility and localization services."

LoRa and LoRaWAN

The LoRaWAN protocol is a Low Power Wide Area Networking (LPWAN) communication protocol that functions on LoRa. The LoRaWAN specification is open so anyone can set up and operate a LoRa network.

LoRa is a wireless radio frequency technology that operates in a license-free radio frequency spectrum. LoRa is a physical layer protocol that uses spread spectrum modulation and supports long-range communication at the cost of a narrow bandwidth. It uses a narrow band waveform with a central frequency to send data, which makes it robust to interference.

Characteristics of LoRaWAN technology

- Long range communication up to 10 miles in line of sight.
- Long battery duration of up to 10 years. For enhanced battery life, you can operate your devices in class A or class B mode, which requires increased downlink latency.
- Low cost for devices and maintenance.
- License-free radio spectrum but region-specific regulations apply.
- Low power but has a limited payload size of 51 bytes to 241 bytes depending on the data rate. The data rate can be 0.3 Kbit/s – 27 Kbit/s data rate with a 222 maximal payload size.

Learn more about LoRaWAN

The following links contain helpful information about the LoRaWAN technology and about LoRa Basics Station, which is the software that runs on your LoRaWAN gateways for connecting end devices to AWS IoT Core for LoRaWAN.

- The Things Fundamentals on LoRaWAN
  
  The Things Fundamentals on LoRaWAN contains an introductory video that covers the fundamentals of LoRaWAN and a series of chapters that'll help you learn about LoRa and LoRaWAN.

- What is LoRaWAN
  
  LoRa Alliance provides a technical overview of LoRa and LoRaWAN, including a summary of the LoRaWAN specifications in different Regions.

- LoRa Basics Station
  
  Semtech Corporation provides helpful concepts about LoRa basics for gateways and end nodes. LoRa Basics Station, an open source software that runs on your LoRaWAN gateway, is maintained and distributed through Semtech Corporation's GitHub repository. You can also learn about the LNS and CUPS protocols that describe how to exchange LoRaWAN data and perform configuration updates.

How AWS IoT Core for LoRaWAN works

The LoRaWAN network architecture is deployed in a star of stars topology in which gateways relay information between end devices and the LoRaWAN network server (LNS).
AWS IoT Core for LoRaWAN helps you connect and manage wireless LoRaWAN (low-power long-range Wide Area Network) devices and replaces the need for you to develop and operate an LNS. Long range WAN (LoRaWAN) devices and gateways can connect to AWS IoT Core by using AWS IoT Core for LoRaWAN.

The following shows how a LoRaWAN device interacts with AWS IoT Core for LoRaWAN. It also shows how AWS IoT Core for LoRaWAN replaces an LNS and communicates with other AWS services in the AWS Cloud.

LoRaWAN devices communicate with AWS IoT Core through LoRaWAN gateways. AWS IoT Core for LoRaWAN manages the service and device policies that AWS IoT Core requires to manage and communicate with the LoRaWAN gateways and devices. AWS IoT Core for LoRaWAN also manages the destinations that describe the AWS IoT rules that send device data to other services.

Get started using AWS IoT Core for LoRaWAN

1. Select the wireless devices and LoRaWAN gateways that you’ll need.

   The AWS Partner Device Catalog contains gateways and developer kits that are qualified for use with AWS IoT Core for LoRaWAN. For more information, see Using qualified gateways from the AWS Partner Device Catalog (p. 1267).

2. Add your wireless devices and LoRaWAN gateways to AWS IoT Core for LoRaWAN.

   Connecting gateways and devices to AWS IoT Core for LoRaWAN (p. 1228) gives you information about how to describe your resources and add your wireless devices and LoRaWAN gateways to AWS IoT Core for LoRaWAN. You’ll also learn how to configure the other AWS IoT Core for LoRaWAN resources that you’ll need to manage these devices and send their data to AWS services.

3. Complete your AWS IoT Core for LoRaWAN solution.

   Start with our sample AWS IoT Core for LoRaWAN solution and make it yours.

AWS IoT Core for LoRaWAN resources

The following resources will help you get familiar with the LoRaWAN technology and AWS IoT Core for LoRaWAN.

- Getting Started with AWS IoT Core for LoRaWAN

   The following video describes how AWS IoT Core for LoRaWAN works and walks you through the process of adding LoRaWAN gateways from the AWS Management Console.

- AWS IoT Core for LoRaWAN workshop
Connecting gateways and devices to AWS IoT Core for LoRaWAN

AWS IoT Core for LoRaWAN helps you connect and manage wireless LoRaWAN (low-power long-range Wide Area Network) devices and replaces the need for you to develop and operate a LNS. Long range WAN (LoRaWAN) devices and gateways can connect to AWS IoT Core by using AWS IoT Core for LoRaWAN.

Naming conventions for your devices, gateways, profiles, and destinations

Before you get started with AWS IoT Core for LoRaWAN and creating the resources, consider the naming convention of your devices, gateways, and destination.

AWS IoT Core for LoRaWAN assigns unique IDs to the resources you create for wireless devices, gateways, and profiles; however, you can also give your resources more descriptive names to make it easier to identify them. Before you add devices, gateways, profiles, and destinations to AWS IoT Core for LoRaWAN, consider how you'll name them to make them easier to manage.

You can also add tags to the resources you create. Before you add your LoRaWAN devices, consider how you might use tags to identify and manage your AWS IoT Core for LoRaWAN resources. Tags can be modified after you add them.

For more information about naming and tagging, see Describe your AWS IoT Core for LoRaWAN resources (p. 1229).

Mapping of device data to service data

The data from LoRaWAN wireless devices is often encoded to optimize bandwidth. These encoded messages arrive at AWS IoT Core for LoRaWAN in a format that might not be easily used by other AWS services. AWS IoT Core for LoRaWAN uses AWS IoT rules that can use AWS Lambda functions to process and decode the device messages to a format that other AWS services can use.

To transform device data and send it to other AWS services, you need to know:

- The format and contents of the data that the wireless devices send.
- The service to which you want to send the data.
- The format that service requires.

Using that information, you can create the AWS IoT rule that performs the conversion and sends the converted data to the AWS services that will use it.

Using the console to onboard your device and gateway to AWS IoT Core for LoRaWAN

You can use the console interface or the API to add your LoRaWAN gateway and devices. If you're using AWS IoT Core for LoRaWAN for the first time, we recommend that you use the console. The console
interface is most practical when managing a few AWS IoT Core for LoRaWAN resources at a time. When managing large numbers of AWS IoT Core for LoRaWAN resources, consider creating more automated solutions by using the AWS IoT Wireless API.

Much of the data that you enter when configuring AWS IoT Core for LoRaWAN resources is provided by the devices' vendors and is specific to the LoRaWAN specifications they support. The following topics describe how you can describe your AWS IoT Core for LoRaWAN resources and use the console or the API to add your gateways and devices.

**Topics**
- Describe your AWS IoT Core for LoRaWAN resources (p. 1229)
- Onboard your gateways to AWS IoT Core for LoRaWAN (p. 1230)
- Onboard your devices to AWS IoT Core for LoRaWAN (p. 1238)

### Describe your AWS IoT Core for LoRaWAN resources

If you're using AWS IoT Core for LoRaWAN for the first time, you can add your first LoRaWAN gateway and device by using the [AWS IoT Core for LoRaWAN](https://aws.amazon.com/iot/core/) intro page of the AWS IoT console.

Before you get started with creating the resources, consider the naming convention of your devices, gateways, and destination. AWS IoT Core for LoRaWAN provides several options to identify the resources you create. While AWS IoT Core for LoRaWAN resources are given a unique ID when they're created, this ID is not descriptive nor can it be changed after the resource is created. You can also assign a name, add a description, and attach tags and tag values to most AWS IoT Core for LoRaWAN resources to make it more convenient to select, identify, and manage your AWS IoT Core for LoRaWAN resources.

- **Resource names (p. 1229)**

  For gateways, devices, and profiles, the resource name is an optional field that you can change after the resource is created. The name appears in the lists displayed on the resource hub pages.

  For destinations, you provide a name that is unique in your AWS account and AWS Region. You can't change the destination name after you create the destination resource.

  While a name can have up to 256 characters, the display space in the resource hub is limited. Make sure that the distinguishing part of the name appears in the first 20 to 30 characters, if possible.

- **Resource tags (p. 1230)**

  Tags are key-value pairs of metadata that can be attached to AWS resources. You choose both tag keys and their corresponding values.

  Gateways, destinations, and profiles can have up to 50 tags attached to them. Devices don't support tags.

### Resource names

**AWS IoT Core for LoRaWAN resource support for name**

<table>
<thead>
<tr>
<th>Resource</th>
<th>Name field support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Name is unique ID of resource and can't be changed.</td>
</tr>
<tr>
<td>Device</td>
<td>Name is optional descriptor of resource and can be changed.</td>
</tr>
</tbody>
</table>
### Resource tags

**AWS IoT Core for LoRaWAN resource support for AWS tags**

<table>
<thead>
<tr>
<th>Resource</th>
<th>AWS tag support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Up to 50 AWS tags can be added to the resource.</td>
</tr>
<tr>
<td>Device</td>
<td>This resource doesn't support AWS tags.</td>
</tr>
<tr>
<td>Gateway</td>
<td>Up to 50 AWS tags can be added to the resource.</td>
</tr>
<tr>
<td>Profile</td>
<td>Up to 50 AWS tags can be added to the resource.</td>
</tr>
</tbody>
</table>

Tags are words or phrases that act as metadata that you can use to identify and organize your AWS resources. You can think of the tag key as a category of information and the tag value as a specific value in that category.

For example, you might have a tag value of *color* and then give some resources a value of *blue* for that tag and others a value of *red*. With that, you could use the Tag editor in the AWS console to find the resources with a *color* tag value of *blue*.

For more information about tagging and tagging strategies, see Tag editor.

### Onboard your gateways to AWS IoT Core for LoRaWAN

If you're using AWS IoT Core for LoRaWAN for the first time, you can add your first LoRaWAN gateway and device by using the console.

#### Before onboarding your gateway
Before you onboard your gateway to AWS IoT Core for LoRaWAN, we recommend that you:

- Use gateways that are qualified for use with AWS IoT Core for LoRaWAN. These gateways connect to AWS IoT Core without any additional configuration settings and have a compatible version of the LoRa Basics Station software running on them. For more information, see Managing gateways with AWS IoT Core for LoRaWAN (p. 1267).
- Consider the naming convention of the resources that you create so that you can more easily manage them. For more information, see Describe your AWS IoT Core for LoRaWAN resources (p. 1229).
- Have the configuration parameters that are unique to each gateway ready to enter in advance, which makes entering the data into the console go more smoothly. The wireless gateway configuration parameters that AWS IoT requires to communicate with and manage the gateway include the gateway's EUI and its LoRa frequency band.

For onboarding your gateways to AWS IoT Core for LoRaWAN:

- Consider frequency band selection and add necessary IAM role (p. 1231)
- Add a gateway to AWS IoT Core for LoRaWAN (p. 1232)
- Connect your LoRaWAN gateway and verify its connection status (p. 1237)

Consider frequency band selection and add necessary IAM role

Before you add your gateway to AWS IoT Core for LoRaWAN, we recommend that you consider the frequency band in which your gateway will be operating and add the necessary IAM role for connecting your gateway to AWS IoT Core for LoRaWAN.

**Note**

If you're adding your gateway using the console, click **Create role** in the console to create the necessary IAM role so you can then skip these steps. You need to perform these steps only if you're using the CLI to create the gateway.

Consider selection of LoRa frequency bands for your gateways and device connection

AWS IoT Core for LoRaWAN supports EU863-870, US902-928, AU915, and AS923-1 frequency bands, which you can use to connect your gateways and devices that are physically present in countries that support the frequency ranges and characteristics of these bands. The EU863-870 and US902-928 bands are commonly used in Europe and North America, respectively. The AS923-1 band is commonly used in Australia, New Zealand, Japan, and Singapore among other countries. The AU915 is used in Australia and Argentina among other countries. For more information about which frequency band to use in your region or country, see LoRaWAN® Regional Parameters.

LoRa Alliance publishes LoRaWAN specifications and regional parameter documents that are available for download from the LoRa Alliance website. The LoRa Alliance regional parameters help companies decide which frequency band to use in their region or country. AWS IoT Core for LoRaWAN's frequency band implementation follows the recommendation in the regional parameters specification document. These regional parameters are grouped into a set of radio parameters, along with a frequency allocation that is adapted to the Industrial, Scientific, and Medical (ISM) band. We recommend that you work with the compliance teams to ensure that you meet any applicable regulatory requirements.

Add an IAM role to allow the Configuration and Update Server (CUPS) to manage gateway credentials

This procedure describes how to add an IAM role that will allow the Configuration and Update Server (CUPS) to manage gateway credentials. Make sure you perform this procedure before a LoRaWAN gateway tries to connect with AWS IoT Core for LoRaWAN; however, you need to do this only once.
Add the IAM role to allow the Configuration and Update Server (CUPS) to manage gateway credentials

1. Open the Roles hub of the IAM console and choose Create role.
2. If you think that you might have already added the IoTWirelessGatewayCertManagerRole role, in the search bar, enter IoTWirelessGatewayCertManagerRole.
   If you see an IoTWirelessGatewayCertManagerRole role in the search results, you have the necessary IAM role. You can leave the procedure now.
   If the search results are empty, you don't have the necessary IAM role. Continue the procedure to add it.
3. In Select type of trusted entity, choose Another AWS account.
4. In Account ID, enter your AWS account ID, and then choose Next: Permissions.
5. In the search box, enter AWSIoTWirelessGatewayCertManager.
6. In the list of search results, select the policy named AWSIoTWirelessGatewayCertManager.
7. Choose Next: Tags, and then choose Next: Review.
8. In Role name, enter IoTWirelessGatewayCertManagerRole, and then choose Create role.
9. To edit the new role, in the confirmation message, choose IoTWirelessGatewayCertManagerRole.
10. In Summary, choose the Trust relationships tab, and then choose Edit trust relationship.
11. In Policy Document, change the Principal property to look like this example.

   ```json
   "Principal": {  
       "Service": "iotwireless.amazonaws.com"
   },
   ```

   After you change the Principal property, the complete policy document should look like this example.

   ```json
   {  
       "Version": "2012-10-17",  
       "Statement": [  
           {  
               "Effect": "Allow",  
               "Principal": {  
                   "Service": "iotwireless.amazonaws.com"
               },  
               "Action": "sts:AssumeRole",  
               "Condition": {}
           }
       ]
   }
   ```

   12. To save your changes and exit, choose Update Trust Policy.

You've now created the IoTWirelessGatewayCertManagerRole. You won’t need to do this again.

If you performed this procedure while you were adding a gateway, you can close this window and the IAM console and return to the AWS IoT console to finish adding the gateway.

**Add a gateway to AWS IoT Core for LoRaWAN**

You can add your gateway to AWS IoT Core for LoRaWAN by using the console or the CLI.

Before adding your gateway, we recommend that you consider the factors mentioned in the Before onboarding your gateway section of Onboard your gateways to AWS IoT Core for LoRaWAN (p. 1230).
If you're adding your gateway for the first time, we recommend that you use the console. If you want to add your gateway by using the CLI instead, you must have already created the necessary IAM role so that the gateway can connect with AWS IoT Core for LoRaWAN. For information about how to create the role, see Add an IAM role to allow the Configuration and Update Server (CUPS) to manage gateway credentials (p. 1231).

### Add a gateway using the console

Navigate to the AWS IoT Core for LoRaWAN Intro page of the AWS IoT console and choose Get started, and then choose Add gateway. If you've already added a gateway, choose View gateway to view the gateway that you added. If you would like to add more gateways, choose Add gateway.

#### 1. Provide gateway details and frequency band information

Use the Gateway details section to provide information about the device configuration data such as the Gateway's EUI and the frequency band configuration.

- **Gateway's EUI**

  The EUI (Extended Unique Identifier) of the individual gateway device. The EUI is a 16-digit alphanumeric code, such as `c0ee40fff29df10`, that uniquely identifies a gateway in your LoRaWAN network. This information is specific to your gateway model and you can find it on your gateway device or in its user manual.

  **Note**

  The Gateway's EUI is different from the Wi-Fi MAC address that you may see printed on your gateway device. The EUI follows a EUI-64 standard that uniquely identifies your gateway and therefore cannot be reused in other AWS accounts and regions.

- **Frequency band (RFRegion)**

  The gateway's frequency band. You can choose from US915, EU868, AU915, or AS923-1, depending on what your gateway supports and which country or region the gateway is physically connecting from. For more information about the bands, see Consider selection of LoRa frequency bands for your gateways and device connection (p. 1231).

#### 2. Specify your wireless gateway configuration data (optional)

These fields are optional and you can use them to provide additional information about the gateway and it's configuration.

- **Name, Description, and Tags for your gateway**

  The information in these optional fields comes from how you organize and describe the elements in your wireless system. You can assign a Name to the gateway, use the Description field to provide information about the gateway, and use Tags to add key-value pairs of metadata about the gateway. For more information on naming and describing your resources, see Describe your AWS IoT Core for LoRaWAN resources (p. 1229).

- **LoRaWAN configuration using subbands and filters**

  Optionally, you can also specify LoRaWAN configuration data such as the subbands that you want to use and filters that can control the flow of traffic. For this tutorial, you can skip these fields. For more information, see Configure position of wireless resources with AWS IoT Core for LoRaWAN (p. 1249).

- **Position information and destination**

  Optionally, you can also specify the position information and a destination that describes the AWS IoT rule which processes the device's position data for use by AWS IoT Core for LoRaWAN. For more information, see Configure position of wireless resources with AWS IoT Core for LoRaWAN (p. 1249).
3. **Associate an AWS IoT thing with the gateway**

Specify whether to create an AWS IoT thing and associate it with the gateway. Things in AWS IoT can make it easier to search and manage your devices. Associating a thing with your gateway lets the gateway access other AWS IoT Core features.

4. **Create and download the gateway certificate**

To authenticate your gateway so that it can securely communicate with AWS IoT, your LoRaWAN gateway must present a private key and certificate to AWS IoT Core for LoRaWAN. Create a **Gateway certificate** so that AWS IoT can verify your gateway's identity by using the X.509 Standard.

Click the **Create certificate** button and download the certificate files. You'll use them later to configure your gateway.

5. **Copy the CUPS and LNS endpoints and download certificates**

Your LoRaWAN gateway must connect to a CUPS or LNS endpoint when establishing a connection to AWS IoT Core for LoRaWAN. We recommend that you use the CUPS endpoint as it also provides configuration management. To verify the authenticity of AWS IoT Core for LoRaWAN endpoints, your gateway will use a trust certificate for each of the CUPS and LNS endpoints.

Click the **Copy** button to copy the CUPS and LNS endpoints. You'll need this information later to configure your gateway. Then click the **Download server trust certificates** button to download the trust certificates for the CUPS and LNS endpoints.

6. **Create the IAM role for the gateway permissions**

You need to add an IAM role that allows the Configuration and Update Server (CUPS) to manage gateway credentials. You must do this before a LoRaWAN gateway tries to connect with AWS IoT Core for LoRaWAN; however, you need to do it only once.

To create the **IoTWirelessGatewayCertManager** IAM role for your account, click the **Create role** button. If the role already exists, select it from the dropdown list.

Click **Submit** to complete the gateway creation.

**Add a gateway by using the API**

**Note**

If you're adding a gateway for the first time by using the API or CLI, you must add the **IoTWirelessGatewayCertManager** IAM role so that the gateway can connect with AWS IoT Core for LoRaWAN. For information about how to create the role, see the following section **Add an IAM role to allow the Configuration and Update Server (CUPS) to manage gateway credentials** (p. 1231).

The following sections show how to add a gateway using the AWS IoT Wireless API operations or the AWS CLI. You first add your gateway and then associate a certificate a certificate with the gateway. You can also use the additional API operations, such as to update an existing gateway.

**Topics**

- [How to add your gateway (p. 1235)]
- [Associate a certificate with your gateway (p. 1235)]
- [Additional API operations (p. 1237)]
How to add your gateway

You can use the AWS CLI to create a wireless gateway by using the `CreateWirelessGateway` API operation or the `create-wireless-gateway` CLI command to add your wireless gateway.

**Note**
If your gateway is communicating with class B LoRaWAN devices, you can also specify certain beaconing parameters when adding the gateway using the `CreateWirelessGateway` API or the `create-wireless-gateway` CLI command. For more information, see [Configuring your gateways to send beacons to class B devices](p. 1268).

The following example creates a wireless LoRaWAN device gateway. You can also provide an `input.json` file that will contain additional details such as the gateway certificate and provisioning credentials.

**Note**
You can also perform this procedure with the API by using the methods in the AWS API that correspond to the CLI commands shown here.

```bash
aws iotwireless create-wireless-gateway \
  --lorawan GatewayEui="a1b2c3d4567890ab",RfRegion="US915" \
  --name "myFirstLoRaWANGateway" \
  --description "Using my first LoRaWAN gateway" \
  --cli-input-json file://input.json
```

**Associate a certificate with your gateway**

After you add your gateway to AWS IoT Wireless, it must be associated with a certificate to connect to the CUPS endpoint. To connect to the endpoint, your gateway running LoRa Basics Station requires the following files:

- `cups.crt` - The gateway's CUPS certificate that it uses to connect to the CUPS endpoint.
- `cups.key` - Private key corresponding to the certificate.
- `cups.trust` - The trust certificate of the CUPS endpoint.
- `cups.uri` - The CUPS endpoint URI.

The following steps show you how to generate a certificate and associate it with your gateway.

**Topics**
- **Step 1: Generating a gateway certificate** (p. 1235)
- **Step 2: Obtaining server trust certificate and CUPS endpoint** (p. 1236)
- **Step 3: Associate the certificate with your gateway** (p. 1236)

**Step 1: Generating a gateway certificate**

To generate a certificate for your gateway, use the AWS IoT API Reference API action, `CreateKeysAndCertificate`, or the AWS CLI command, `create-keys-and-certificate` CLI command.

The following command shows an example of generating the certificate, `cups.crt`, and the private key, `cups.key`.

```bash
aws iot create-keys-and-certificate \
  --set-as-active --certificate-pem-outfile "cups.crt" \
  --private-key-outfile "cups.key"
```

Running this command generates the certificate and private key, and a certificate ID. The following example shows an output of running this command.
Store the certificate ID temporarily, as it will be used in the subsequent step to associate your certificate with the gateway.

**Note**
You must securely store the private key, `cups.key`. If you misplace the private key, rerun the `create-keys-and-certificate` command to generate another certificate.

**Step 2: Obtaining server trust certificate and CUPS endpoint**

Now that you've generated the certificate and private key, use the `GetServiceEndpoint` API action or the `get-service-endpoint` CLI command to obtain the server trust certificate, `cups.trust` and the endpoint URI, `cups.uri`.

The following command shows an example of obtaining the server trust certificate and the endpoint URI. When running the command, set the `service-type` parameter to `CUPS`.

```
aws iotwireless get-service-endpoint --service-type CUPS
```

The following shows an output of running the command.

```
{
    "ServiceType": "CUPS",
    "ServiceEndpoint": "https://ABCDEFGHIJKLMNOPQRSTUVWXYZ.cups.lorawan.us-east-1.amazonaws.com:443",
    "ServerTrust": "-----BEGIN CERTIFICATE-----\n...\n-----END CERTIFICATE-----\n"
}
```

The `ServiceEndpoint` obtained from the response corresponds to the CUPS endpoint, `cups.uri`.

**Note**
Store the `ServerTrust` certificate in a `.pem` file with the `\n` replaced by new lines.

**Step 3: Associate the certificate with your gateway**

You must associate the gateway's certificate that you generated with the gateway that you added. AWS IoT Core for LoRaWAN will use this information to identify the certificate that the gateway will use to connect to the CUPS endpoint.

To associate the certificate with your gateway, use the `AssociateWirelessGatewaywithCertificate` API action or the `associate-wireless-gateway-with-certificate` CLI command.

The following command shows an example of associating a certificate with your gateway.

```
aws iotwireless associate-wireless-gateway-with-certificate
    --id <WirelessGatewayId>
    --iot-certificate-id <CertificateId>
```

Running this command returns the `IotCertificateId`, which is the ID of the certificate that you associated with the gateway. The following shows an output of running...
the command, where the IotCertificateId is the ID of the certificate, such as abc1234d55ef32101a34434bb123cba2a011b2cdefa6bb5cee1a221b4567ab12.

```
{
   "IotCertificateId": "<CertificateId>"
}
```

Additional API operations

You can use the following API actions to perform the tasks associated with adding, updating, or deleting a LoRaWAN gateway.

**AWS IoT Wireless API actions for AWS IoT Core for LoRaWAN gateways**

- GetWirelessGateway
- ListWirelessGateways
- UpdateWirelessGateway
- DeleteWirelessGateway

For the complete list of the actions and data types available to create and manage AWS IoT Core for LoRaWAN resources, see the [AWS IoT Wireless API reference](#).

For information about the CLIs that you can use, see [AWS CLI reference](#).

**Connect your LoRaWAN gateway and verify its connection status**

Before you can check the gateway connection status, you must have already added your gateway and connected it to AWS IoT Core for LoRaWAN. For information about how to add your gateway, see [Add a gateway to AWS IoT Core for LoRaWAN](#).

**Connect your gateway to AWS IoT Core for LoRaWAN**

After you've added your gateway, connect to the configuration interface of your gateway to enter the configuration information and trust certificates.

After adding the gateway's information to AWS IoT Core for LoRaWAN, add some AWS IoT Core for LoRaWAN information to the gateway device. The documentation provided by the gateway's vendor should describe the process for uploading the certificate files to the gateway and configuring the gateway device to communicate with AWS IoT Core for LoRaWAN.

**Gateways qualified for use with AWS IoT Core for LoRaWAN**

For instructions on how to configure your LoRaWAN gateway, refer to the [configure gateway device](#) section of the AWS IoT Core for LoRaWAN workshop. Here, you'll find information about instructions for connecting gateways that are qualified for use with AWS IoT Core for LoRaWAN.

**Gateways that support CUPS protocol**

The following instructions show how you can connect your gateways that support the CUPS protocol.

1. Upload the following files that you obtained when adding your gateway.
   - Gateway device certificate and private key files.
   - Trust certificate file for CUPS endpoint, cups.trust.
2. Specify the CUPS endpoint URL that you obtained previously. The endpoint will be of the format `prefix.cups.lorawan.region.amazonaws.com:443`.

1237
Gateways that support LNS protocol

The following instructions show how you can connect your gateways that support the LNS protocol.

1. Upload the following files that you obtained when adding your gateway.
   - Gateway device certificate and private key files.
   - Trust certificate file for LNS endpoint, `lns.trust`.
2. Specify the LNS endpoint URL that you obtained previously. The endpoint will be of the format `prefix.lns.lorawan.region.amazonaws.com:443`.

For details about how to obtain this information, see Add a gateway to AWS IoT Core for LoRaWAN (p. 1232).

After that you've connected your gateway to AWS IoT Core for LoRaWAN, you can check the status of your connection and get information about when the last uplink was received by using the console or the API.

Check gateway connection status using the console

To check the connection status using the console, navigate to the Gateways page of the AWS IoT console and choose the gateway you've added. In the LoRaWAN specific details section of the Gateway details page, you'll see the connection status and the date and time the last uplink was received.

Check gateway connection status using the API

To check the connection status using the API, use the GetWirelessGatewayStatistics API. This API doesn't have a request body and only contains a response body that shows whether the gateway is connected and when the last uplink was received.

```
HTTP/1.1 200
Content-type: application/json

{
    "ConnectionStatus": "Connected",
    "LastUplinkReceivedAt": "2021-03-24T23:13:08.476015749Z",
    "WirelessGatewayId": "30cbdcf3-86de-4291-bfab-5bfa2b12bad5"
}
```

Onboard your devices to AWS IoT Core for LoRaWAN

After you have onboarded your gateway to AWS IoT Core for LoRaWAN and verified its connection status, you can onboard your wireless devices. For information about how to onboard your gateways, see Onboard your gateways to AWS IoT Core for LoRaWAN (p. 1230).

LoRaWAN devices use a LoRaWAN protocol to exchange data with cloud-hosted applications. AWS IoT Core for LoRaWAN supports devices that comply to 1.0.x or 1.1 LoRaWAN specifications standardized by LoRa Alliance.

A LoRaWAN device typically contains one or more sensors and actors. The devices send uplink telemetry data through LoRaWAN gateways to AWS IoT Core for LoRaWAN. Cloud-hosted applications can control the sensors by sending downlink commands to LoRaWAN devices through LoRaWAN gateways.
Before onboarding your wireless device

Before you onboard your wireless device to AWS IoT Core for LoRaWAN, you need to have the following information ready in advance:

**Note**
Optionally, if you have the position information of your device available, you can specify this information when onboarding your device. For more information, see [Configure position of wireless resources with AWS IoT Core for LoRaWAN](p. 1249).

- **LoRaWAN specification and wireless device configuration**

  Having the configuration parameters that are unique to each device ready to enter in advance makes entering the data into the console go more smoothly. The specific parameters that you need to enter depend on the LoRaWAN specification that the device uses. For the complete listing of its specifications and configuration parameters, see each device's documentation.

- **Device name and description (optional)**

  The information in these optional fields comes from how you organize and describe the elements in your wireless system. For more information about naming and describing your resources, see [Describe your AWS IoT Core for LoRaWAN resources](p. 1229).

- **Device and service profiles**

  Have some wireless device configuration parameters ready that are shared by many devices and can be stored in AWS IoT Core for LoRaWAN as device and service profiles. The configuration parameters are found in the device's documentation or on the device itself. You'll want to identify a device profile that matches the configuration parameters of the device, or create one if necessary, before you add the device. For more information, see [Add profiles to AWS IoT Core for LoRaWAN](p. 1241).

- **AWS IoT Core for LoRaWAN destination**

  Each device must be assigned to a destination that will process its messages to send to AWS IoT and other services. The AWS IoT rules that process and send the device messages are specific to the device's message format. To process the messages from the device and send them to the correct service, identify the destination you'll create to use with the device's messages and assign it to the device.

To onboard your wireless device to AWS IoT Core for LoRaWAN

- [Add your wireless device to AWS IoT Core for LoRaWAN](p. 1239)
- [Add profiles to AWS IoT Core for LoRaWAN](p. 1241)
- [Add destinations to AWS IoT Core for LoRaWAN](p. 1243)
- [Create rules to process LoRaWAN device messages](p. 1246)
- [Connect your LoRaWAN device and verify its connection status](p. 1248)

Add your wireless device to AWS IoT Core for LoRaWAN

If you're adding your wireless device for the first time, we recommend that you use the console. Navigate to the [AWS IoT Core for LoRaWAN Intro](p. 1239) page of the AWS IoT console, choose **Get started**, and then choose **Add device**. If you've already added a device, choose **View device** to view the gateway that you added. If you would like to add more devices, choose **Add device**.

Alternatively, you can also add wireless devices from the **Devices** page of the AWS IoT console.

**Note**
If you add your devices from the **Devices** page, you can also specify optional position information for your device. This information consists of the static position coordinates, any geolocation solvers that you want to use for computing the device position, and a destination.
that describes the AWS IoT rule which processes the device's position data for use by AWS IoT Core for LoRaWAN. For more information, see Configure position of wireless resources with AWS IoT Core for LoRaWAN (p. 1249).

Add your wireless device specification to AWS IoT Core for LoRaWAN using the console

Choose a Wireless device specification based on your activation method and the LoRaWAN version. Once selected, your data is encrypted with a session key that AWS owns and manages for you.

OTAA and ABP activation modes

Before your LoRaWAN device can send uplink data, you must complete a process called activation or join procedure. To activate your device, you can either use OTAA (Over the air activation) or ABP (Activation by personalization).

ABP doesn't require a join procedure and uses static keys. When you use OTAA, your LoRaWAN device sends a join request and the Network Server can allow the request. We recommend that you use OTAA to activate your device because new session keys are generated for each activation, which makes it more secure.

LoRaWAN version

When you use OTAA, your LoRaWAN device and cloud-hosted applications share the root keys. These root keys depend on whether you're using version v1.0.x or v1.1. v1.0.x has only one root key, **AppKey** (Application Key) whereas v1.1 has two root keys, **AppKey** (Application Key) and **NwkKey** (Network Key). The session keys are derived based on the root keys for each activation. Both the **NwkKey** and **AppKey** are 32-digit hexadecimal values that your wireless vendor provided.

Wireless Device EUIs

After you select the Wireless device specification, you see the EUI (Extended Unique Identifier) parameters for the wireless device displayed on the console. You can find this information from the documentation for the device or the wireless vendor.

- **DevEUI**: 16-digit hexadecimal value that is unique to your device and found on the device label or its documentation.
- **AppEUI**: 16-digit hexadecimal value that is unique to the join server and found in the device documentation. In LoRaWAN versions v1.0.4 and v1.1, the **AppEUI** is called as **JoinEUI**.

For more information about the unique identifiers, session keys, root keys, and end-to-end security, refer to the LoRa Alliance documentation.

Add your wireless device specification to AWS IoT Core for LoRaWAN by using the API

If you're adding a wireless device using the API, you must create your device profile and service profile first before creating the wireless device. You'll use the device profile and service profile ID when creating the wireless device. For information about how to create these profiles using the API, see Add a device profile by using the API (p. 1242).

The following lists describe the API actions that perform the tasks associated with adding, updating, or deleting a service profile.

**AWS IoT Wireless API actions for service profiles**

- CreateWirelessDevice
- GetWirelessDevice
• **ListWirelessDevices**
• **UpdateWirelessDevice**
• **DeleteWirelessDevice**

For the complete list of the actions and data types available to create and manage AWS IoT Core for LoRaWAN resources, see the [AWS IoT Wireless API reference](https://docs.aws.amazon.com/iotwireless/latest/APIReference/).  

**How to use the AWS CLI to create a wireless device**

You can use the AWS CLI to create a wireless device by using the `create-wireless-device` command. The following example creates a wireless device by using an `input.json` file to input the parameters.

**Note**
You can also perform this procedure with the API by using the methods in the AWS API that correspond to the CLI commands shown here.

**Contents of input.json**

```json
{
  "Description": "My LoRaWAN wireless device",
  "DestinationName": "IoTWirelessDestination",
  "LoRaWAN": {
    "DeviceProfileId": "ab0c23d3-b001-45ef-6a01-2bc3de4f5333",
    "ServiceProfileId": "fe98dc76-cd12-001e-2d34-5550432da100",
    "OtaaV1_1": {
      "AppKey": "3f4ca100e2fc675ea123f4eb12c4a012",
      "JoinEui": "b4c231a359bc2e3d",
      "NwkKey": "01c3f004a2d6efffe32c4eda14bdc2b4"
    },
    "DevEui": "ac12efc654d23fc2"
  },
  "Name": "SampleIoTWirelessThing",
  "Type": "LoRaWAN"
}
```

You can provide this file as input to the `create-wireless-device` command.

```bash
aws iotwireless create-wireless-device \
  --cli-input-json file://input.json
```

For information about the CLIs that you can use, see [AWS CLI reference](https://docs.aws.amazon.com/cli/latest/reference/)

**Add profiles to AWS IoT Core for LoRaWAN**

Device and service profiles can be defined to describe common device configurations. These profiles describe configuration parameters that are shared by devices to make it easier to add those devices. AWS IoT Core for LoRaWAN supports device profiles and service profiles.

The configuration parameters and the values to enter into these profiles are provided by the device's manufacturer.

**Add device profiles**

Device profiles define the device capabilities and boot parameters that the network server uses to set the LoRaWAN radio access service. It includes selection of parameters such as LoRa frequency band, LoRa regional parameters version, and MAC version of the device. To learn about the different frequency bands, see [Consider selection of LoRa frequency bands for your gateways and device connection](https://docs.aws.amazon.com/iotwireless/latest/guides/).
Add a device profile by using the console

If you’re adding a wireless device by using the console as described in Add your wireless device specification to AWS IoT Core for LoRaWAN using the console (p. 1240), after you’ve added the wireless device specification, you can add your device profile. Alternatively, you can also add wireless devices from the Profiles page of the AWS IoT console on the LoRaWAN tab.

You can choose from default device profiles or create a new device profile. We recommend that you use the default device profiles. If your application requires you to create a device profile, provide a Device profile name, select the Frequency band (RfRegion) that you’re using for the device and gateway, and keep the other settings to the default values, unless specified otherwise in the device documentation.

Add a device profile by using the API

If you’re adding a wireless device by using the API, you must create your device profile before creating the wireless device.

The following lists describe the API actions that perform the tasks associated with adding, updating, or deleting a service profile.

AWS IoT Wireless API actions for service profiles

- CreateDeviceProfile
- GetDeviceProfile
- ListDeviceProfiles
- UpdateDeviceProfile
- DeleteDeviceProfile

For the complete list of the actions and data types available to create and manage AWS IoT Core for LoRaWAN resources, see the AWS IoT Wireless API reference.

How to use the AWS CLI to create a device profile

You can use the AWS CLI to create a device profile by using the create-device-profile command. The following example creates a device profile.

```
aws iotwireless create-device-profile
```

Running this command automatically creates a device profile with an ID that you can use when creating the wireless device. You can now create the service profile using the following API and then create the wireless device by using the device and service profiles.

```
{
   "Arn": "arn:aws:iotwireless:us-east-1:123456789012:DeviceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
   "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
}
```

For information about the CLIs that you can use, see AWS CLI reference

Add service profiles

Service profiles describe the communication parameters the device needs to communicate with the application server.

Add a service profile using the console

If you’re adding a wireless device using the console as described in Add your wireless device specification to AWS IoT Core for LoRaWAN using the console (p. 1240), after you’ve added the device profile, you can
add your service profile. Alternatively, you can also add wireless devices from the Profiles page of the AWS IoT console on the LoRaWAN tab.

We recommend that you leave the setting AddGWMetaData enabled so that you'll receive additional gateway metadata for each payload, such as RSSI and SNR for the data transmission.

Add a service profile using the API

If you're adding a wireless device using the API, you must first create your service profile before creating the wireless device.

The following lists describe the API actions that perform the tasks associated with adding, updating, or deleting a service profile.

**AWS IoT Wireless API actions for service profiles**

- `CreateServiceProfile`
- `GetServiceProfile`
- `ListServiceProfiles`
- `DeleteServiceProfile`

For the complete list of the actions and data types available to create and manage AWS IoT Core for LoRaWAN resources, see the [AWS IoT Wireless API reference](https://docs.aws.amazon.com/iotwireless/latest/developerguide/).  

How to use the AWS CLI to create a service profile

You can use the AWS CLI to create a service by using the `create-service-profile` command. The following example creates a service profile.

```
aws iotwireless create-service-profile
```

Running this command automatically creates a service profile with an ID that you can use when creating the wireless device. You can now create the wireless device by using the device and service profiles.

```
{
    "Arn": "arn:aws:iotwireless:us-east-1:123456789012:ServiceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
    "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
}
```

Add destinations to AWS IoT Core for LoRaWAN

AWS IoT Core for LoRaWAN destinations describe the AWS IoT rule that processes a device's data for use by AWS services.

Because most LoRaWAN devices don't send data to AWS IoT Core for LoRaWAN in a format that can be used by AWS services, an AWS IoT rule must process it first. The AWS IoT rule contains the SQL statement that interprets the device's data and the topic rule actions that send the result of the SQL statement to the services that will use it.

If you're adding your destination for the first time, we recommend that you use the console.

Add a destination using the console

If you're adding a wireless device using the console as described in Add your wireless device specification to AWS IoT Core for LoRaWAN using the console (p. 1240), after you've already added the wireless
device specification and profiles to AWS IoT Core for LoRaWAN as described previously, you can go ahead and add a destination.

Alternatively, you can also add an AWS IoT Core for LoRaWAN destination from the Destinations page of the AWS IoT console.

To process a device’s data, specify the following fields when creating an AWS IoT Core for LoRaWAN destination, and then choose Add destination.

- **Destination details**
  Enter a Destination name and an optional description for your destination.

- **Rule name**
  The AWS IoT rule that is configured to evaluate messages sent by your device and process the device's data. The rule name will be mapped to your destination. The destination requires the rule to process the messages that it receives. You can choose for the messages to be processed by either invoking an AWS IoT rule or by publishing to the AWS IoT message broker.

  - If you choose Enter a rule name, enter a name, and then choose Copy to copy the rule name that you’ll enter when creating the AWS IoT rule. You can either choose Create rule to create the rule now or navigate to the Rules Hub of the AWS IoT console and create a rule with that name.

    You can also enter a rule and use the Advanced setting to specify a topic name. The topic name is provided during rule invocation and is accessed by using the topic expression inside the rule. For more information about AWS IoT rules, see Rules for AWS IoT (p. 494).

  - If you choose Publish to AWS IoT message broker, enter a topic name. You can then copy the MQTT topic name and multiple subscribers can subscribe to this topic to receive messages published to that topic. For more information, see MQTT topics (p. 109).

For more information about AWS IoT rules for destinations, see Create rules to process LoRaWAN device messages (p. 1246).

- **Role name**
  The IAM role that grants the device's data permission to access the rule named in Rule name. In the console, you can create a new service role or select an existing service role. If you're creating a new service role, you can either enter a role name (for example, IoTWirelessDestinationRole), or leave it blank for AWS IoT Core for LoRaWAN to generate a new role name. AWS IoT Core for LoRaWAN will then automatically create the IAM role with the appropriate permissions on your behalf.

For more information about IAM roles, see Using IAM roles.

**Add a destination by using the API**

If you want to add a destination using the CLI instead, you must have already created the rule and IAM role for your destination. For more information about the details that a destination requires in the role, see Create an IAM role for your destinations (p. 1245).

The following list contains the API actions that perform the tasks associated with adding, updating, or deleting a destination.

**AWS IoT Wireless API actions for destinations**

- CreateDestination
- GetDestination
- ListDestinations
- UpdateDestination
DeleteDestination

For the complete list of the actions and data types available to create and manage AWS IoT Core for LoRaWAN resources, see the AWS IoT Wireless API reference.

How to use the AWS CLI to add a destination

You can use the AWS CLI to add a destination by using the create-destination command. The following example shows how to create a destination by entering a rule name by using RuleName as the value for the expression-type parameter. If you want to specify a topic name for publishing or subscribing to the message broker, change the expression-type parameter's value to MqttTopicId.

```
aws iotwireless create-destination \
  --name IoTWirelessDestination \
  --expression-type RuleName \
  --expression IoTWirelessRule \
  --role-arn arn:aws:iam::123456789012:role/IoTWirelessDestinationRole
```

Running this command creates a destination with the specified destination name, rule name, and role name. For information about rule and role names for destinations, see Create rules to process LoRaWAN device messages (p. 1246) and Create an IAM role for your destinations (p. 1245).

For information about the CLIs that you can use, see AWS CLI reference.

Create an IAM role for your destinations

AWS IoT Core for LoRaWAN destinations require IAM roles that give AWS IoT Core for LoRaWAN the permissions necessary to send data to the AWS IoT rule. If such a role is not already defined, you must define it so that it will appear in the list of roles.

When you use the console to add a destination, AWS IoT Core for LoRaWAN automatically creates an IAM role for you, as described previously in this topic. When you add a destination using the API or CLI, you must create the IAM role for your destination.

To create an IAM policy for your AWS IoT Core for LoRaWAN destination role

1. Open the Policies hub of the IAM console.
2. Choose Create policy, and choose the JSON tab.
3. In the editor, delete any content from the editor and paste this policy document.

   ```
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Action": [
           "iot:DescribeEndpoint",
           "iot:Publish"
         ],
         "Resource": "**"
       }
     ]
   }
   ```
4. Choose Review policy, and in Name, enter a name for this policy. You'll need this name to use in the next procedure.

   You can also describe this policy in Description, if you want.
5. Choose Create policy.
To create an IAM role for an AWS IoT Core for LoRaWAN destination

1. Open the [Roles hub of the IAM console](https://aws.amazon.com) and choose **Create role**.

2. In **Select type of trusted entity**, choose **Another AWS account**.

3. In **Account ID**, enter your AWS account ID, and then choose **Next: Permissions**.

4. In the search box, enter the name of the IAM policy that you created in the previous procedure.

5. In the search results, check the IAM policy that you created in the previous procedure.

6. Choose **Next: Tags**, and then choose **Next: Review**.

7. In **Role name**, enter the name of this role, and then choose **Create role**.

8. In the confirmation message, choose the name of the role you created to edit the new role.

9. In **Summary**, choose the **Trust relationships** tab, and then choose **Edit trust relationship**.

10. In **Policy Document**, change the Principal property to look like this example.

```
"Principal": {
    "Service": "iotwireless.amazonaws.com"
},
```

After you change the Principal property, the complete policy document should look like this example.

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "iotwireless.amazonaws.com"
            },
            "Action": "sts:AssumeRole",
            "Condition": {}
        }
    ]
}
```

11. To save your changes and exit, choose **Update Trust Policy**.

With this role defined, you can find it in the list of roles when you configure your AWS IoT Core for LoRaWAN destinations.

Create rules to process LoRaWAN device messages

AWS IoT rules send device messages to other services. AWS IoT rules can also process the binary messages received from a LoRaWAN device to convert the messages to other formats that can make them easier for other services to use.

AWS IoT Core for LoRaWAN destinations (p. 1243), associate a wireless device with the rule that processes the device’s message data to send to other services. The rule acts on the device’s data as soon as AWS IoT Core for LoRaWAN receives it. AWS IoT Core for LoRaWAN destinations (p. 1243) can be shared by all devices whose messages have the same data format and that send their data to the same service.

How AWS IoT rules process device messages

How an AWS IoT rule processes a device’s message data depends on the service that will receive the data, the format of the device’s message data, and the data format that the service requires. Typically, the rule
calls an AWS Lambda function to convert the device's message data to the format a service requires, and then sends the result to the service.

The following illustration shows how message data is secured and processed as it moves from the wireless device to an AWS service.

1. The LoRaWAN wireless device encrypts its binary messages using AES128 CTR mode before it transmits them.
2. AWS IoT Core for LoRaWAN decrypts the binary message and encodes the decrypted binary message payload as a base64 string.
3. The resulting base64-encoded message is sent as a binary message payload (a message payload that is not formatted as a JSON document) to the AWS IoT rule described in the destination assigned to the device.
4. The AWS IoT rule directs the message data to the service described in the rule's configuration.

The encrypted binary payload received from the wireless device is not altered or interpreted by AWS IoT Core for LoRaWAN. The decrypted binary message payload is encoded only as a base64 string. For services to access the data elements in the binary message payload, the data elements must be parsed out of the payload by a function called by the rule. The base64-encoded message payload is an ASCII string, so it could be stored as such to be parsed later.

Create rules for LoRaWAN

AWS IoT Core for LoRaWAN uses AWS IoT rules to securely send device messages directly to other AWS services without the need to use the message broker. By removing the message broker from the ingestion path, it reduces costs and optimizes the data flow.

For an AWS IoT Core for LoRaWAN rule to send device messages to other AWS services, it requires an AWS IoT Core for LoRaWAN destination and an AWS IoT rule assigned to that destination. The AWS IoT rule must contain a SQL query statement and at least one rule action.

Typically, the AWS IoT rule query statement consists of:

- A SQL SELECT clause that selects and formats the data from the message payload
- A topic filter (the FROM object in the rule query statement) that identifies the messages to use
- An optional conditional statement (a SQL WHERE clause) that specifies conditions on which to act

Here is an example of a rule query statement:
When building AWS IoT rules to process payloads from LoRaWAN devices, you do not have to specify the FROM clause as part of the rule query object. The rule query statement must have the SQL SELECT clause and can optionally have the WHERE clause. If the query statement uses the FROM clause, it is ignored.

Here is an example of a rule query statement that can process payloads from LoRaWAN devices:

```
SELECT WirelessDeviceId, WirelessMetadata.LoRaWAN.FPort as FPort,
       WirelessMetadata.LoRaWAN.DevEui as DevEui,
       PayloadData
```

In this example, the `PayloadData` is a base64-encoded binary payload sent by your LoRaWAN device.

Here is an example rule query statement that can perform a binary decoding of the incoming payload and transform it into a different format such as JSON:

```
SELECT WirelessDeviceId, WirelessMetadata.LoRaWAN.FPort as FPort,
       WirelessMetadata.LoRaWAN.DevEui as DevEui,
       aws_lambda("arn:aws:lambda:<region>:<account>:function:<name>",
                   {
                     "PayloadData":PayloadData,
                     "Fport": WirelessMetadata.LoRaWAN.FPort
                   }) as decodingoutput
```

For more information on using the SELECT AND WHERE clauses, see [AWS IoT SQL reference](https://docs.aws.amazon.com/iot/latest/developerguide/aws-iot-sql-reference.html) (p. 586).

For information about AWS IoT rules and how to create and use them, see [Rules for AWS IoT](https://docs.aws.amazon.com/iot/latest/developerguide/aws-iot-rules.html) (p. 494) and [Creating AWS IoT rules to route device data to other services](https://docs.aws.amazon.com/iot/latest/developerguide/aws-iot-rules-routing.html) (p. 199).

For information about creating and using AWS IoT Core for LoRaWAN destinations, see [Add destinations to AWS IoT Core for LoRaWAN](https://docs.aws.amazon.com/iot-lorawan/latest/developerguide/add-destinations-to-aws-iot-core-for-lorawan.html) (p. 1243).

For information about using binary message payloads in a rule, see [Working with binary payloads](https://docs.aws.amazon.com/iot/latest/developerguide/aws-iot-rules-binary.html) (p. 650).

For more information about the data security and encryption used to protect the message payload on its journey, see [Data protection in AWS IoT Core](https://docs.aws.amazon.com/iot/latest/developerguide/aws-iot-data-protection.html) (p. 385).

For a reference architecture that shows a binary decoding and implementation example for IoT rules, see [AWS IoT Core for LoRaWAN Solution Samples on GitHub](https://github.com/aws-iot-architecture/aws-iot-core-lorawan-samples).

**Connect your LoRaWAN device and verify its connection status**

Before you can check the device connection status, you must have already added your device and connected it to AWS IoT Core for LoRaWAN. For information about how to add your device, see [Add your wireless device to AWS IoT Core for LoRaWAN](https://docs.aws.amazon.com/iot-lorawan/latest/developerguide/add-device-to-aws-iot-core-for-lorawan.html) (p. 1239).

After you've added your device, refer to your device's user manual to learn how to initiate sending an uplink message from your LoRaWAN device.

**Check device connection status using the console**

To check the connection status using the console, navigate to the [Devices](https://console.aws.amazon.com/iot/) page of the AWS IoT console and choose the device you've added. In the [Details](https://console.aws.amazon.com/iot/) section of the [Wireless devices details page](https://console.aws.amazon.com/iot/iotdevicecontrol/home), you'll see the date and time the last uplink was received.
Check device connection status using the API

To check the connection status using the API, use the GetWirelessDeviceStatistics API. This API doesn't have a request body and only contains a response body that shows when the last uplink was received.

**Note**
The time when the last uplink was received, or the LastUplinkReceivedAt value, is only valid for 3 months.

```
HTTP/1.1 200
Content-type: application/json

{
    "LastUplinkReceivedAt": "2021-03-24T23:13:08.476015749Z",
    "LoRaWAN": {
        "DataRate": 5,
        "DevEui": "647fda0000006420",
        "Frequency": 868100000,
        "Gateways": [
            {
                "GatewayEui": "c0ee40ffff29df10",
                "Rssi": -67,
                "Snr": 9.75
            }
        ],
        "WirelessDeviceId": "30cbdcf3-86de-4291-bfab-5bfa2b12bad5"
    }
}
```

Next steps

Now that you have connected your device and verified the connection status, you can observe the format of the uplink metadata received from the device by using the MQTT test client on the Test page of the AWS IoT console. For more information, see View format of uplink messages sent from LoRaWAN devices (p. 1285).

Configure position of wireless resources with AWS IoT Core for LoRaWAN

Before using this feature, note that the chosen third party provider for resolving position information for LoRaWAN devices relies on data feeds and data sets provided or maintained by the International GNSS Service (IGS), EarthData via NASA, or other third-parties. These data feeds and data sets are Third-Party Content (as defined in the Customer Agreement) and provided on an as-is basis. For more information, see AWS Service Terms.

You can use AWS IoT Core for LoRaWAN to specify your static position data, or activate positioning to identify the position of your device in real time using third-party solvers. You can add or update the position information for either LoRaWAN devices or gateways, or both.

You specify the position information either when adding your device or gateway to AWS IoT Core for LoRaWAN, or when editing the configuration details of your device or gateway. The position information is specified as a GeoJSON payload. The GeoJSON format is a format that's used to encode geographic data structures. The payload contains the latitude and longitude co-ordinates of your device location, that are based on the World Geodetic System coordinate system (WGS84).
After the solvers compute the position of your resource, if you have Amazon Location Service, you can activate an Amazon Location map where the position of your resource will be displayed. Using the position data, you can:

- Activate positioning to identify and obtain the position of your LoRaWAN devices.
- Track and monitor the position of your gateways and devices.
- Define AWS IoT rules that process any updates to the position data and routes it to other AWS services. For a list of rule actions, see AWS IoT rule actions (p. 502).
- Create alerts and receive notifications to devices in case of any unusual activity by using the position data and Amazon SNS.

How positioning works for LoRaWAN devices

You can activate positioning to identify the position of your devices using third-party Wi-Fi and GNSS solvers. This information can be used to track and monitor your device. The following steps show you how to activate positioning and view the position information for LoRaWAN devices.

Note
The third-party solvers can only be used with LoRaWAN devices that have the LoRa Edge chip. Devices with LoRa Basics Modem are also supported. It can't be used with LoRaWAN gateways. For gateways, you can still specify the static position information and identify the location on an Amazon Location map.

1. Add your device

Before you activate positioning, first add your device to AWS IoT Core for LoRaWAN. The LoRaWAN device must have the LoRa Edge chipset, which is an ultra-low power platform that integrates a long range LoRa transceiver, multi-constellation GNSS scanner, and passive Wi-Fi MAC scanner targeting geolocation applications.

2. Activate positioning

To obtain the real-time position of your devices, activate positioning. When your LoRaWAN device sends an uplink message, the Wi-Fi and GNSS scan data contained in the message is sent to AWS IoT Core for LoRaWAN using the geolocation frame port.

3. Retrieve position information

Retrieve the estimated device position from the solvers computed based on the scan results from the transceivers. If the position information was computed using both Wi-Fi and GNSS scan results, AWS IoT Core for LoRaWAN selects the estimated position that has the higher accuracy.

4. View position information

After the solver computes the position information, it will also provide the accuracy information which indicates the difference between the position computed by the solvers and the static position information that you entered. You can also view the device location on an Amazon Location map.

Note
As solvers can't be used for LoRaWAN gateways, the accuracy information will be reported as 0.0.

For more information about the uplink message format and the frequency ports that are used for the positioning solver, see Uplink message from AWS IoT Core for LoRaWAN to rules engine (p. 1254).
Overview of positioning workflow

The following diagram shows how AWS IoT Core for LoRaWAN stores and updates the position information of your devices and gateways.

1. **Specify static position of your resource**
   
   Specify the static position information of your device or gateway as a GeoJSON payload, using the latitude and longitude coordinates. You can also specify an optional altitude coordinate. These coordinates are based on the WGS84 coordinate system. For more information, see World Geodetic System (WGS84).

2. **Activate positioning for devices**

   If you’re using LoRaWAN devices that have the LoRa Edge chip, you can optionally activate positioning to track your device position in real time. When your device sends an uplink message, the GNSS and Wi-Fi scan data is sent to AWS IoT Core for LoRaWAN using the geolocation frame port. The solvers then use this information to resolve the device position.

3. **Add a destination to route position data**

   You can add a destination that describes the IoT rule for processing the device data and route the updated position information to AWS IoT Core for LoRaWAN. You can also view the last known position of your resource on an Amazon Location map.

Configuring your resource position

You can configure the position of your resource using the AWS Management Console, the AWS IoT Wireless API, or the AWS CLI.

If your devices have the chip, you can activate positioning to compute the real-time position information. For your gateways, you can still enter the static position coordinates and use Amazon Location to track the gateway position on an Amazon Location map.

Configuring the position of LoRaWAN gateways

When you add your gateway to AWS IoT Core for LoRaWAN, you can specify the static position data. If you’ve activated Amazon Location Service maps, the position data is displayed on an Amazon Location map.

*Note*

The third-party solvers can't be used with LoRaWAN gateways. For gateways, you can still specify the static position coordinates. When solvers aren't used to compute the position, such as in the case of gateways, the accuracy information will be reported as 0.0.
You can configure the gateway position using the AWS Management Console, the AWS IoT Wireless API, or the AWS CLI.

Configuring position of your gateway using the console

To configure the position of your gateway resources by using the AWS Management Console, first sign in to the console and then go to the Gateways hub page of the AWS IoT console.

Add position information

To add a position configuration for your gateway

1. In the Gateways hub page, choose Add gateway.
2. Enter the gateway's EUI, frequency band (RFRegion), and any additional gateway details and LoRaWAN configuration information. For more information, see Add a gateway using the console (p. 1233).
3. Go to the Position information - Optional section, and enter the position information for your gateway using the latitude and longitude coordinates, and an optional altitude coordinate. The position information is based on the WGS84 coordinate system.

View gateway's position

After you've configured your gateway's position, AWS IoT Core for LoRaWAN creates an Amazon Location map called iotwireless.map. You can see this map in the details page of your gateway on the Position tab. Based on the position coordinates that you specified, the position of your gateway will be displayed as a marker on the map. You can zoom in or zoom out to clearly view the position of your gateway on the map. On the Position tab, you'll also see the accuracy information and the timestamp at which your gateway's position was determined.

Note

If you don't have Amazon Location Service maps installed, you'll see a message indicating that you must use Amazon Location Service to access the map and view the gateway position. Using Amazon Location Service maps may incur additional charges to your AWS account. For more information, see AWS IoT Core pricing.

The map, iotwireless.map, acts as a source of map data which is accessed using Get API operations, such as GetMapTile. For information about Get APIs used with maps, see Amazon Location Service API reference.

To get additional details about this map, go to the Amazon Location Service console, choose maps, and then choose iotwireless.map. For more information, see Maps in the Amazon Location Service developer guide.

Update gateway's position configuration

To change the gateway's position configuration, in the gateway details page, choose Edit and then update the position information and the destination.

Note

Information about historical position data isn't available. When you update the gateway's position coordinates, it overwrites the previously reported position data. After you've updated the position, in the Position tab of the gateway details, you'll see the new position information. The change in timestamp indicates that it corresponds to the last known position of the gateway.

Configure position of your gateway using the API

You can specify the position information and configure the gateway position using the AWS IoT Wireless API or the AWS CLI.
Important
The API actions `UpdatePosition`, `GetPosition`, `PutPositionConfiguration`, `GetPositionConfiguration`, and `ListPositionConfigurations` are no longer supported. Calls to update and retrieve the position information should use the `GetResourcePosition` and `UpdateResourcePosition` API operations instead.

**Add position information**

To add the static position information for a given wireless gateway, specify the coordinates using the `UpdateResourcePosition` API operation or the `update-resource-position` CLI command. Specify `WirelessGateway` as the `ResourceType`, the ID of the wireless gateway to be updated as the `ResourceIdentifier`, and the position information as a GeoJSON payload.

```bash
aws iotwireless update-resource-position \
  --resource-type WirelessGateway \
  --resource-id "12345678-a1b2-3c45-67d8-e90fa1b2c34d" \
  --cli-input-json file://gatewayposition.json
```

The following shows the contents of the `gatewayposition.json` file.

**Contents of gatewayposition.json**

```json
{
  "type": "Point",
  "coordinates": [33.3318, -22.2155, 13.123],
  "properties": {
    "timestamp": "2018-11-30T18:35:24Z"
  }
}
```

Running this command doesn't produce any output. To see the position information that you specified, use the `GetResourcePosition` API operation.

**Get position information**

To get the position information for a given wireless gateway, use the `GetResourcePosition` API operation or the `get-resource-position` CLI command. Specify `WirelessGateway` as the `resourceType` and provide the ID of the wireless gateway as the `resourceIdentifier`.

```bash
aws iotwireless get-resource-position \
  --resource-type WirelessGateway \n  --resource-id "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
```

Running this command displays the position information of your wireless gateway as a GeoJSON payload. You’ll see information about the position coordinates, the type of position information, and additional properties, such as the timestamp which corresponds to the last known position of the gateway.

```json
{
  "type": "Point",
  "coordinates": [33.3318, -22.2155, 13.123],
  "properties": {
    "timestamp": "2018-11-30T18:35:24Z"
  }
}
```
Configuring position of LoRaWAN devices

When you add your device to AWS IoT Core for LoRaWAN, you can specify the static position information, optionally activate positioning, and specify a destination. The destination describes the IoT rule that processes the device's position information and routes the updated position to Amazon Location Service. After you configure your device position, the position data is displayed on an Amazon Location map with the accuracy information, and the destination that you specified.

You can configure the position of your device using the AWS Management Console, the AWS IoT Wireless API, or the AWS CLI.

Frame ports and format of uplink messages

If you activate positioning, you must specify the geolocation frame port for communicating the Wi-Fi and GNSS scan data from the device to AWS IoT Core for LoRaWAN. The position information is communicated to AWS IoT Core for LoRaWAN using this frame port.

The LoRaWAN specification provides a data delivery field (FRMPayload) and a Port field (FPort) to distinguish between different types of messages. To communicate the position information, you can specify a value anywhere between 1 and 223 for the frame port. FPort 0 is reserved for MAC messages, FPort 224 is reserved for MAC compliance testing, and ports 225-255 are reserved for future standardized application extensions.

Uplink message from AWS IoT Core for LoRaWAN to rules engine

When you add a destination, it creates an AWS IoT rule to route the data to Amazon Location Service using the rules engine. The updated position information is then displayed on an Amazon Location map. If you haven't activated positioning, the destination routes the position data when you update the static position coordinates of your device.

The following code shows the format of the uplink message sent from AWS IoT Core for LoRaWAN with the position information, accuracy, solver configuration, and the wireless metadata. The fields highlighted below are optional. If there's no vertical accuracy information, the value is null.

```json
{
    // Position configuration parameters for given wireless device
    "WirelessDeviceId": "5b58245e-146c-4c30-9703-0ca942e3ff35",
    // Position information for a device in GeoJSON format. Altitude
    // is optional. If no vertical accuracy information is available
    // or positioning isn't activated, the value is set to null.
    // The position information coordinates are listed in the order
    // longitude, latitude, altitude.
    "coordinates": [33.33000183105469, -22.219999313354492, 99.0],
    "type": "Point",
    "properties": {
        "horizontalAccuracy": number,
        "verticalAccuracy": number,
        "timestamp": "2022-08-19T03:08:35.061Z"
    },
    // Parameters controlled by IoT Core for LoRaWAN
    "WirelessMetadata": {
        "LoRaWAN": {
        ...}
```
Configuring position of your devices using the console

To configure and manage the position of your devices by using the AWS Management Console, first sign in to the console and then go to the Devices hub page of the AWS IoT console.

Add position information

To add position information for your device:

1. In the Devices hub page, choose Add wireless device.
2. Enter the wireless device specification, device and service profiles, and the destination that defines the IoT rule for routing the data to other AWS services. For more information, see Onboard your devices to AWS IoT Core for LoRaWAN (p. 1238).
3. Enter the position information, optionally activate geolocation, and specify a position data destination that you want to use for routing messages.

   • Position information

   Specify the position data for your device using the latitude and longitude coordinates, and an optional altitude coordinate. The position information is based on the WGS84 coordinate system.

   • Geolocation

   Activate positioning if you want AWS IoT Core for LoRaWAN to use geolocation for computing the device position. It uses third-party GNSS and Wi-Fi solvers to identify the position of your device in real time.

   To enter the geolocation information, choose Activate positioning, and enter the geolocation frame port for communicating the GNSS and Wi-Fi scan data to AWS IoT Core for LoRaWAN. You'll see default FPorts populated for your reference. However, you can choose a different value anywhere between 1 and 223.

   • Position data destination
Choose a destination to describe the AWS IoT rule that processes the device's position data and forwards it to AWS IoT Core for LoRaWAN. Use this destination only to route position data. It must be different from the destination that you use for routing device data to other AWS services.

**View device's position configuration**

After you've configured your device's position, AWS IoT Core for LoRaWAN creates an Amazon Location map called `iotwireless.map`. You can see this map in the details page of your device on the Position tab. Based on the position coordinates that you specified or the position computed by the third-party solvers, the position of your device will be displayed as a marker on the map. You can zoom in or zoom out to clearly view the position of your device on the map. In the device's details page, on the Position tab, you'll also see the accuracy information, the timestamp at which your device's position was determined, and the position data destination that you specified.

**Note**

If you haven't activated Amazon Location Service maps, you'll see a message indicating that you'll have to use Amazon Location Service to access the map and view the position. Using Amazon Location Service maps may incur additional charges to your AWS account. For more information, see [AWS IoT Core pricing](https://aws.amazon.com/iot/core/pricing/).

The map, `iotwireless.map`, acts as a source of map data which is accessed using Get API operations, such as `GetMapTile`. For information about Get APIs used with maps, see [Amazon Location Service API reference](https://docs.aws.amazon.com/Location/latest/dg/API.html).

To get additional details about this map, go to the Amazon Location Service console, choose maps, and then choose `iotwireless.map`. For more information, see Maps in the [Amazon Location Service developer guide](https://docs.aws.amazon.com/Location/latest/dg/maps.html).

**Update device's position configuration**

To change the device's position configuration, in the device details page, choose Edit and then update the position information, any geolocation settings, and the destination.

**Note**

Information about historical position data isn't available. When you update the device's position coordinates, it overwrites the previously reported position data. After you've updated the position, in the Position tab of the device details, you'll see the new position information. The change in timestamp indicates that it corresponds to the last known position of the device.

**Configure device position using the API**

You can specify the position information, configure the device position, and activate optional geolocation using the AWS IoT Wireless API or the AWS CLI.

**Important**

The API actions `UpdatePosition`, `GetPosition`, `PutPositionConfiguration`, `GetPositionConfiguration`, and `ListPositionConfigurations` are no longer supported. Calls to update and retrieve the position information should use the `GetResourcePosition` and `UpdateResourcePosition` API operations instead.

**Add position information and configuration**

To add the position information for a given wireless device, specify the coordinates using the `UpdateResourcePosition` API operation or the `update-resource-position` CLI command. Specify `WirelessDevice` as the ResourceType, the ID of the wireless device to be updated as the ResourceIdentifier, and the position information.

```bash
aws iotwireless update-resource-position
```
The following shows the contents of the `deviceposition.json` file. To specify the FPort values for sending the geolocation data, use the `Positioning` object with the `CreateWirelessDevice` and `UpdateWirelessDevice` API operations.

**Contents of deviceposition.json**

```json
{
   "type": "Point",
   "coordinates": [33.3318, -22.2155, 13.123],
   "properties": {
      "verticalAccuracy": 707,
      "horizontalAccuracy":
      "timestamp": "2018-11-30T18:35:24Z"
   }
}
```

Running this command doesn't produce any output. To see the position information that you specified, use the `GetResourcePosition` API operation.

**Get position information and configuration**

To get the position information for a given wireless device, use the `GetResourcePosition` API or the `get-resource-position` CLI command. Specify `WirelessDevice` as the `resourceType` and provide the ID of the wireless device as the `resourceIdentifier`.

```
aws iotwireless get-resource-position
--resource-type WirelessDevice
--resource-id "1ffd32c8-8130-4194-96df-622f072a315f"
```

Running this command displays the position information of your wireless device as a GeoJSON payload. You'll see information about the position coordinates, the location type, and properties which can include the accuracy information and the timestamp which corresponds to the last known position of the device.

```
{
   "type": "Point",
   "coordinates": [33.3318, -22.2155, 13.123],
   "properties": {
      "verticalAccuracy": 707,
      "horizontalAccuracy": 389,
      "horizontalConfidenceLevel": 0.68,
      "verticalConfidenceLevel": 0.68,
      "timestamp": "2018-11-30T18:35:24Z"
   }
}
```

---

**Connecting to AWS IoT Core for LoRaWAN through a VPC interface endpoint**

You can connect directly to AWS IoT Core for LoRaWAN through Interface VPC endpoints (AWS PrivateLink) in your Virtual Private Cloud (VPC) instead of connecting over the public internet. When
you use a VPC interface endpoint, communication between your VPC and AWS IoT Core for LoRaWAN is conducted entirely and securely within the AWS network.

AWS IoT Core for LoRaWAN supports Amazon Virtual Private Cloud interface endpoints that are powered by AWS PrivateLink. Each VPC endpoint is represented by one or more Elastic Network Interfaces (ENIs) with private IP addresses in your VPC subnets.

For more information about VPC and endpoints, see What is Amazon VPC.

For more information about AWS PrivateLink, see AWS PrivateLink and VPC endpoints.

**AWS IoT Core for LoRaWAN privatelink architecture**

The following diagram shows the privatelink architecture of AWS IoT Core for LoRaWAN. The architecture uses a Transit Gateway and Route 53 Resolver to share the AWS PrivateLink interface endpoints between your VPC, the AWS IoT Core for LoRaWAN VPC, and an on-premises environment. You'll find a more detailed architecture diagram when setting up the connection to the VPC interface endpoints.

**AWS IoT Core for LoRaWAN endpoints**

AWS IoT Core for LoRaWAN has three public endpoints. Each public endpoint has a corresponding VPC interface endpoint. The public endpoints can be classified into control plane and data plane endpoints. For information about these endpoints, see AWS IoT Core for LoRaWAN API endpoints.

**Note**

AWS PrivateLink support for the endpoints is available only in US East (N. Virginia) and Europe (Ireland).

- **Control plane API endpoints**

  You can use control plane API endpoints to interact with the AWS IoT Wireless APIs. These endpoints can be accessed from a client that is hosted in your Amazon VPC by using AWS PrivateLink.

- **Data plane API endpoints**
Data plane API endpoints are LoRaWAN Network Server (LNS) and Configuration and Update Server (CUPS) endpoints that you can use to interact with the AWS IoT Core for LoRaWAN LNS and CUPS endpoints. These endpoints can be accessed from your LoRa gateways on premises by using AWS VPN or AWS Direct Connect. You get these endpoints when onboarding your gateway to AWS IoT Core for LoRaWAN. For more information, see Add a gateway to AWS IoT Core for LoRaWAN (p. 1232).

The following topics show how to onboard these endpoints.

Topics
• Onboard AWS IoT Core for LoRaWAN control plane API endpoint (p. 1259)
• Onboard AWS IoT Core for LoRaWAN data plane API endpoints (p. 1261)

Onboard AWS IoT Core for LoRaWAN control plane API endpoint

You can use AWS IoT Core for LoRaWAN control plane API endpoints to interact with the AWS IoT Wireless APIs. For example, you can use this endpoint to run the `SendDataToWirelessDevice` API to send data from AWS IoT to your LoRaWAN device. For more information, see AWS IoT Core for LoRaWAN Control Plane API Endpoints.

You can use the client hosted in your Amazon VPC to access the control plane endpoints that are powered by AWS PrivateLink. You use these endpoints to connect to the AWS IoT Wireless API through an interface endpoint in your Virtual Private Cloud (VPC) instead of connecting over the public internet.

To onboard the control plane endpoint:
• Create your Amazon VPC and subnet (p. 1259)
• Launch an Amazon EC2 instance in your subnet (p. 1260)
• Create Amazon VPC interface endpoint (p. 1260)
• Test your connection to the interface endpoint (p. 1261)

Create your Amazon VPC and subnet

Before you can connect to the interface endpoint, you must create a VPC and subnet. You’ll then launch an EC2 instance in your subnet, which you can use to connect to the interface endpoint.

To create your VPC:
1. Navigate to the VPCs page of the Amazon VPC console and choose Create VPC.
2. On the Create VPC page:
   • Enter a name for VPC Name tag - optional (for example, VPC-A).
   • Enter an IPv4 address range for your VPC in the IPv4 CIDR block (for example, 10.100.0.0/16).
3. Keep the default values for other fields and choose Create VPC.

To create your subnet:
1. Navigate to the Subnets page of the Amazon VPC console and choose Create subnet.
2. On the Create subnet page:
   • For VPC ID, choose the VPC that you created earlier (for example, VPC-A).
• Enter a name for **Subnet name** (for example, **Private subnet**).
• Choose the **Availability Zone** for your subnet.
• Enter your subnet's IP address block in the **IPv4 CIDR block** in CIDR format (for example, 10.100.0.0/24).

3. To create your subnet and add it to your VPC, choose **Create subnet**.

For more information, see [Work with VPCs and subnets](#).

### Launch an Amazon EC2 instance in your subnet

To launch your EC2 instance:

1. Navigate to the **Amazon EC2** console and choose **Launch Instance**.
2. For **AMI**, choose **Amazon Linux 2 AMI (HVM)**, **SSD Volume Type** and then choose the **t2 micro** instance type. To configure the instance details, choose **Next**.
3. In the **Configure Instance Details** page:
   • For **Network**, choose the VPC that you created earlier (for example, VPC-A).
   • For **Subnet**, choose the subnet that you created earlier (for example, **Private subnet**).
   • For **IAM role**, choose the role **AWSIoTWirelessFullAccess** to grant AWS IoT Core for LoRaWAN full access policy. For more information, see [AWSIoTWirelessFullAccess policy summary](#).
   • For **Assume Private IP**, use an IP address, for example, 10.100.0.42.
4. Choose **Next: Add Storage** and then choose **Next: Add Tags**. You can optionally add any tags to associate with your EC2 instance. Choose **Next: Configure Security Group**.
5. In the **Configure Security Group** page, configure the security group to allow:
   • Open **All TCP** for Source as 10.200.0.0/16.
   • Open **All ICMP - IPV4** for Source as 10.200.0.0/16.
6. To review the instance details and launch your EC2 instance, choose **Review and Launch**.

For more information, see [Get started with Amazon EC2 Linux instances](#).

### Create Amazon VPC interface endpoint

You can create a VPC endpoint for your VPC, which can then be accessed by the EC2 API. To create the endpoint:

1. Navigate to the **VPC Endpoints** console and choose **Create Endpoint**.
2. In the **Create Endpoint** page, specify the following information.
   • Choose **AWS services** for **Service category**.
   • For **Service Name**, search by entering the keyword **iotwireless**. In the list of iotwireless services displayed, choose the control plane API endpoint for your Region. The endpoint will be in the format com.amazonaws.region.iotwireless.api.
   • For **VPC and Subnets**, choose the VPC where you want to create the endpoint, and the Availability Zones (AZs) in which you want to create the endpoint network.
     **Note**
     The iotwireless service might not support all Availability Zones.
   • For **Enable DNS name**, choose **Enable for this endpoint**.

Choosing this option will automatically resolve the DNS and create a route in Amazon Route 53 Public Data Plane so that the APIs you use later to test the connection will go through the privatelink endpoints.
3. To create your VPC endpoint, choose Create endpoint.

Test your connection to the interface endpoint

You can use an SSH to access your Amazon EC2 instance and then use the AWS CLI to connect to the privatelink interface endpoints.

Before you connect to the interface endpoint, download the most recent AWS CLI version by following the instructions described in Installing, updating, and uninstalling AWS CLI version 2 on Linux.

The following examples show how you can test your connection to the interface endpoint using the CLI.

```bash
aws iotwireless create-service-profile
   --endpoint-url https://api.iotwireless.region.amazonaws.com
   --name='test-privatelink'
```  

The following shows an example of running the command.

Response:

```
{
   "Arn": "arn:aws:iotwireless:region:acct_number:ServiceProfile/1a2345ba-4c5d-67b0-ab67-e0c8342f2857",
   "Id": "1a2345ba-4c5d-67b0-ab67-e0c8342f2857"
}
```

Similarly, you can run the following commands to get the service profile information or list all service profiles.

```bash
aws iotwireless get-service-profile
   --endpoint-url https://api.iotwireless.region.amazonaws.com
   --id="1a2345ba-4c5d-67b0-ab67-e0c8342f2857"
```

The following shows an example for the list-device-profiles command.

```bash
aws iotwireless list-device-profiles
   --endpoint-url https://api.iotwireless.region.amazonaws.com
```

Onboard AWS IoT Core for LoRaWAN data plane API endpoints

AWS IoT Core for LoRaWAN data plane endpoints consist of the following endpoints. You get these endpoints when adding your gateway to AWS IoT Core for LoRaWAN. For more information, see Add a gateway to AWS IoT Core for LoRaWAN (p. 1232).

- **LoRaWAN Network Server (LNS) endpoints**

  The LNS endpoints are of the format account-specific-prefix.lns.lorawan.region.amazonaws.com. You can use this endpoint to establish a connection for exchanging LoRa uplink and downlink messages.

- **Configuration and Update Server (CUPS) endpoints**
The CUPS endpoints are of the format `account-specific-prefix.cups.lorawan.region.amazonaws.com`. You can use this endpoint for credentials management, remote configuration, and firmware update of gateways.

For more information, see Using CUPS and LNS protocols (p. 1268).

To find the Data Plane API endpoints for your AWS account and Region, use the `get-service-endpoint` CLI command shown here, or the GetServiceEndpoint REST API. For more information, see AWS IoT Core for LoRaWAN Data Plane API Endpoints.

You can connect your LoRaWAN gateway on premises to communicate with AWS IoT Core for LoRaWAN endpoints. To establish this connection, first connect your on premises gateway to your AWS account in your VPC by using a VPN connection. You can then communicate with the data plane interface endpoints in the AWS IoT Core for LoRaWAN VPC that are powered by privatelink.

The following shows how to onboard these endpoints.
- Create VPC interface endpoint and private hosted zone (p. 1262)
- Use VPN to connect LoRa gateways to your AWS account (p. 1264)

Create VPC interface endpoint and private hosted zone

AWS IoT Core for LoRaWAN has two data plane endpoints, Configuration and Update Server (CUPS) endpoint and LoRaWAN Network Server (LNS) endpoint. The setup process to establish a privatelink connection to both endpoints is the same, so we can use the LNS endpoint for illustration purposes.

For your data plane endpoints, the LoRa gateways first connect to your AWS account in your Amazon VPC, which then connects to the VPC endpoint in the AWS IoT Core for LoRaWAN VPC.

When connecting to the endpoints, the DNS names can be resolved within one VPC but can't be resolved across multiple VPCs. To disable private DNS when creating the endpoint, disable the Enable DNS name setting. You can use private hosted zone to provide information about how you want Route 53 to respond to DNS queries for your VPCs. To share your VPC with an on-premises environment, you can use a Route 53 Resolver to facilitate hybrid DNS.

To complete this procedure, perform the following steps.
- Create an Amazon VPC and subnet (p. 1262)
- Create an Amazon VPC interface endpoint (p. 1262)
- Configure private hosted zone (p. 1263)
- Configure Route 53 inbound resolver (p. 1264)
- Next steps (p. 1264)

Create an Amazon VPC and subnet

You can reuse your Amazon VPC and subnet that you created when onboarding your control plane endpoint. For information, see Create your Amazon VPC and subnet (p. 1259).

Create an Amazon VPC interface endpoint

You can create a VPC endpoint for your VPC, which is similar to how you would create one for your control plane endpoint.

1. Navigate to the VPC Endpoints console and choose Create Endpoint.
2. In the Create Endpoint page, specify the following information.
   - Choose AWS services for Service category.
For **Service Name**, search by entering the keyword **lNS**. In the list of lNS services displayed, choose the LNS data plane API endpoint for your Region. The endpoint will be of the format com.amazonaws.REGION.lorawan.lNS.

**Note**
If you're following this procedure for your CUPS endpoint, search for cups. The endpoint will be of the format com.amazonaws.REGION.lorawan.cups.

**For VPC and Subnets**, choose the VPC where you want to create the endpoint, and the Availability Zones (AZs) in which you want to create the endpoint network.

**Note**
The iotwireless service might not support all Availability Zones.

**For Enable DNS name**, make sure that **Enable for this endpoint** is not selected.

By not selecting this option, you can disable private DNS for the VPC endpoint and use private hosted zone instead.

- For **Security group**, choose the security groups you want to associate with the endpoint network interfaces.
- Optionally, you can add or remove tags. Tags are name-value pairs that you use to associate with your endpoint.

3. To create your VPC endpoint, choose **Create endpoint**.

**Configure private hosted zone**

After you create the privatelink endpoint, in the **Details** tab of your endpoint, you'll see a list of DNS names. You can use one of these DNS names to configure your private hosted zone. The DNS name will be of the format vpce-xxxx.lNS.lorawan.REGION.vpce.amazonaws.com.

**Create the private hosted zone**

To create the private hosted zone:

1. Navigate to the **Route 53 Hosted zones** console and choose **Create hosted zone**.
2. In the **Create hosted zone** page, specify the following information.
   - For **Domain name**, enter the full service name for your LNS endpoint, lNS.lorawan.REGION.amazonaws.com.
     **Note**
     If you're following this procedure for your CUPS endpoint, enter cups.lorawan.REGION.amazonaws.com.
   - For **Type**, choose **Private hosted zone**.
   - Optionally, you can add or remove tags to associate with your hosted zone.
3. To create your private hosted zone, choose **Create hosted zone**.

For more information, see [Creating a private hosted zone](#).

After you have created a private hosted zone, you can create a record that tells the DNS how you want traffic to be routed to that domain.

**Create a record**

After you have created a private hosted zone, you can create a record that tells the DNS how you want traffic to be routed to that domain. To create a record:

1. In the list of hosted zones displayed, choose the private hosted zone that you created earlier and choose **Create record**.
2. Use the wizard method to create the record. If the console presents you the Quick create method, choose Switch to wizard.
3. Choose Simple Routing for Routing policy and then choose Next.
4. In the Configure records page, choose Define simple record.
5. In the Define simple record page:
   - For Record name, enter the alias of your AWS account number. You get this value when onboarding your gateway or by using the GetServiceEndpoint REST API.
   - For Record type, keep the value as A - Routes traffic to an IPv4 address and some AWS resources.
   - For Value/Route traffic to, choose Alias to VPC endpoint. Then choose your Region and then choose the endpoint that you created previously, as described in Create an Amazon VPC interface endpoint (p. 1262) from the list of endpoints displayed.
6. Choose Define simple record to create your record.

Configure Route 53 inbound resolver

To share a VPC endpoint to an on-premises environment, a Route 53 Resolver can be used to facilitate hybrid DNS. The inbound resolver will enable you to route traffic from the on-premises network to the data plane endpoints without going over the public internet. To return the private IP address values for your service, create the Route 53 Resolver in the same VPC as the VPC endpoint.

When you create the inbound resolver, you only have to specify your VPC and the subnets that you created previously in your Availability Zones (AZs). The Route 53 Resolver uses this information to automatically assigns an IP address to route traffic to each of the subnets.

To create the inbound resolver:
1. Navigate to the Route 53 Inbound endpoints console and choose Create inbound endpoint.
   - Note
     Make sure that you’re using the same AWS Region that you used when creating the endpoint and private hosted zone.
2. In the Create inbound endpoint page, specify the following information.
   - Enter a name for Endpoint name (for example, VPC_A_Test).
   - For VPC in the region, choose the same VPC that you used when creating the VPC endpoint.
   - Configure the Security group for this endpoint to allow incoming traffic from the on premises network.
   - For IP address, choose Use an IP address that is selected automatically.
3. Choose Submit to create your inbound resolver.

For this example, let's assume that the IP addresses 10.100.0.145 and 10.100.192.10 were assigned for the inbound Route 53 Resolver for routing traffic.

Next steps

You've created the private hosted zone and an inbound resolver to route traffic for your DNS entries. You can now use either a Site-to-Site VPN or a Client VPN endpoint. For more information, see Use VPN to connect LoRa gateways to your AWS account (p. 1264).

Use VPN to connect LoRa gateways to your AWS account

To connect your gateways on premises to your AWS account, you can use either a Site-to-Site VPN connection or a Client VPN endpoint.
Before you can connect your on premises gateways, you must have created the VPC endpoint, and configured a private hosted zone and inbound resolver so that traffic from the gateways don't go over the public internet. For more information, see Create VPC interface endpoint and private hosted zone (p. 1262).

Site-to-Site VPN endpoint

If you don’t have the gateway hardware or want to test the VPN connection using a different AWS account, you can use a Site-to-Site VPN connection. You can use Site-to-Site VPN to connect to the VPC endpoints from the same AWS account or another AWS account that you might be using in a different AWS Region.

Note
If you’ve the gateway hardware with you and want to set up a VPN connection, we recommend that you use Client VPN instead. For instructions, see Client VPN endpoint (p. 1266).

To set up a Site-to-Site VPN:

1. Create another VPC in the site from which you want to set up the connection. For VPC-A, you can reuse the VPC that you created previously. To create another VPC (for example, VPC-B), use a CIDR block that doesn’t overlap with the CIDR block of the VPC you created previously.

   For information about setting up the VPCs, follow the instructions described in AWS setup Site-to-Site VPN connection.

   Note
   The Site-to-Site VPN VPN method described in the document uses OpenSWAN for the VPN connection, which supports only one VPN tunnel. If you use a different commercial software for the VPN, you might be able to set up two tunnels between the sites.

2. After you set up the VPN connection, update the /etc/resolv.conf file by adding the inbound resolver’s IP address from your AWS account. You use this IP address for the nameserver. For information about how to obtain this IP address, see Configure Route 53 inbound resolver (p. 1264). For this example, we can use the IP address 10.100.0.145 that was assigned when you created the Route 53 Resolver.

   options timeout:2 attempts:5
   ; generated by /usr/sbin/dhclient-script
   search region.compute.internal
   nameserver 10.100.0.145

3. We can now test whether the VPN connection uses the AWS PrivateLink endpoint instead of going over the public internet by using an nslookup command. The following shows an example of running the command.

   nslookup account-specific-prefix.lns.lorawan.region.amazonaws.com

   The following shows an example output of running the command, which shows a private IP address indicating that the connection has been established to the AWS PrivateLink LNS endpoint.

   Server: 10.100.0.145
   Address: 10.100.0.145
   Non-authoritative answer:
   Name: https://xxxxx.lns.lorawan.region.amazonaws.com
   Address: 10.100.0.204

For information about using a Site-to-Site VPN connection, see How Site-to-Site VPN works.
Client VPN endpoint

AWS Client VPN is a managed client-based VPN service that enables you to securely access AWS resources and resources in your on-premises network. The following shows the architecture for the client VPN service.

To establish a VPN connection to a Client VPN endpoint:

1. Create a Client VPN endpoint by following the instructions described in Getting started with AWS Client VPN.
2. Log in to your on-premises network (for example, a Wi-Fi router) by using the access URL for that router (for example, 192.168.1.1), and find the root name and password.
3. Set up your LoRaWAN gateway by following the instructions in the gateway's documentation and then add your gateway to AWS IoT Core for LoRaWAN. For information about how to add your gateway, see Onboard your gateways to AWS IoT Core for LoRaWAN (p. 1230).
4. Check whether your gateway's firmware is up to date. If the firmware is out of date, you can follow the instructions provided in the on-premises network to update your gateway's firmware. For more information, see Update gateway firmware using CUPS service with AWS IoT Core for LoRaWAN (p. 1272).
5. Check whether OpenVPN has been enabled. If it has been enabled, skip to the next step to configure the OpenVPN client inside the on-premises network. If it hasn’t been enabled, follow the instructions in Guide to install OpenVPN for OpenWrt.

   Note
   For this example, we use OpenVPN. You can use other VPN clients such as AWS VPN or AWS Direct Connect to set up your Client VPN connection.

6. Configure the OpenVPN client based on information from the client configuration and how you can use OpenVPN client using LuCi.
7. SSH to your on-premises network and update the /etc/resolv.conf file by adding the IP address of the inbound resolver in your AWS account (10.100.0.145).
8. For the gateway traffic to use AWS PrivateLink to connect to the endpoint, replace the first DNS entry for your gateway to the inbound resolver's IP address.

   For information about using a Site-to-Site VPN connection, see Getting started with Client VPN.

Connect to LNS and CUPS VPC endpoints

The following shows how you can test your connection to the LNS and CUPS VPC endpoints.
Test CUPS endpoint

To test your AWS PrivateLink connection to the CUPS endpoint from your LoRa gateway, run the following command:

curl -k -v -X POST https://xxxx.cups.region.iotwireless.iot:443/update-info
  -cacert cups.trust --cert cups.crt --key cups.key --header "Content-Type: application/json"
  --data '{
    "router": "xxxxxxxxxxxxx",
    "cupsUri": "https://xxxx.cups.lorawan.region.amazonaws.com:443",
    "cupsCredCrc":1234, "tcCredCrc":552384314
  }',
  --output cups.out

Test LNS endpoint

To test your LNS endpoint, first provision a LoRaWAN device that will work with your wireless gateway. You can then add your device and perform the *join* procedure after which you can start sending uplink messages.

Managing gateways with AWS IoT Core for LoRaWAN

Gateways act as a bridge and carry LoRaWAN device data to and from a Network Server, usually over high-bandwidth networks like Wi-Fi, Ethernet, or Cellular. LoRaWAN gateways connect wireless devices to AWS IoT Core for LoRaWAN.

Following are some important considerations when using your gateways with AWS IoT Core for LoRaWAN. For information about how to add your gateway to AWS IoT Core for LoRaWAN, see [Onboard your gateways to AWS IoT Core for LoRaWAN](p. 1230).

LoRa Basics Station software requirement

To connect to AWS IoT Core for LoRaWAN, your LoRaWAN gateway must have software called [LoRa Basics Station](https://github.com/semtech/LoraBasicsStation) running on it. LoRa Basics Station is an open source software that is maintained by Semtech Corporation and distributed by their [GitHub](https://github.com) repository. AWS IoT Core for LoRaWAN supports LoRa Basics Station version 2.0.4 and later.

Using qualified gateways from the AWS Partner Device Catalog

The [AWS Partner Device Catalog](https://aws.amazon.com/partnercatalog) contains gateways and developer kits that are qualified for use with AWS IoT Core for LoRaWAN. We recommend that you use these qualified gateways because you don't have to modify the embedding software for connecting the gateways to AWS IoT Core. These gateways already have a version of the BasicStation software compatible with AWS IoT Core for LoRaWAN.

**Note**

If you have a gateway that is not listed in the Partner Catalog as a qualified gateway with AWS IoT Core for LoRaWAN, you might still be able to use it if the gateway is running LoRa Basics Station software with version 2.0.4 and later. Make sure that you use TLS Server and Client Authentication for authenticating your LoRaWAN gateway.
Using CUPS and LNS protocols

LoRa Basics Station software contains two sub protocols for connecting gateways to network servers, LoRaWAN Network Server (LNS) and Configuration and Update Server (CUPS) protocols.

The LNS protocol establishes a data connection between a LoRa Basics Station compatible gateway and a network server. LoRa uplink and downlink messages are exchanged through this data connection over secure WebSockets.

The CUPS protocol enables credentials management, and remote configuration and firmware update of gateways. AWS IoT Core for LoRaWAN provides both LNS and CUPS endpoints for LoRaWAN data ingestion and remote gateway management respectively.

For more information, see [LNS protocol](#) and [CUPS protocol](#).

Configure beaconsing and filtering capabilities of your LoRaWAN gateways

When working with LoRaWAN devices, you can configure certain optional parameters for your LoRaWAN gateways. The parameters include:

- **Beaconing**

  You can configure beaconing parameters for your LoRaWAN gateways that are acting as a bridge for your class B LoRaWAN devices. These devices receive a downlink message at scheduled time slots, so you must configure the beaconing parameters for your gateways to transmit these time-synchronized beacons.

- **Filtering**

  You can configure the NetID and JoinEUI parameters for your LoRaWAN gateways to filter the device data traffic. Filtering the traffic helps conserve bandwidth usage and reduces the traffic flow between the gateways and LNS.

- **Sub-bands**

  You can configure the sub-bands for your gateway to specify the particular sub-band that you want to use. For wireless devices that can't hop between the various sub-bands, you can use this capability to communicate with the devices using only the frequency channels in that particular sub-band.

The following topics contain more information about these parameters and how to configure them. The beaconing parameters aren't available in the AWS Management Console and can only be specified using the AWS IoT Wireless API or the AWS CLI.

**Topics**

- [Configuring your gateways to send beacons to class B devices](#)
- [Configuring your gateway’s subbands and filtering capabilities](#)

Configuring your gateways to send beacons to class B devices

If you onboard class B wireless devices to AWS IoT Core for LoRaWAN, the devices receive downlink messages in scheduled time slots. The devices open these slots based on time-synchronized beacons that are transmitted by the gateway. For your gateways to transmit these time-synchronous beacons, you can use AWS IoT Core for LoRaWAN to configure certain beaconing-related parameters for the gateways.
To configure these beaconing parameters, your gateway must be running LoRa Basics Station software version 2.0.6. See Using qualified gateways from the AWS Partner Device Catalog (p. 1267).

**How to configure the beaconing parameters**

*Note*

You only need to configure the beaconing parameters for your gateway if it's communicating with a class B wireless device.

You configure the beaconing parameters when adding your gateway to AWS IoT Core for LoRaWAN using the `CreateWirelessGateway` API operation. When you invoke the API operation, specify the following parameters using the `Beaconing` object for your gateways. After you configure the parameters, the gateways will send the beacons to your devices at a 128-second interval.

- **DataRate**: The data rate for the gateways that are transmitting the beacons.
- **Frequencies**: The list of frequencies for the gateways to transmit the beacons.

The following example shows how you configure these parameters for the gateway. The `input.json` file will contain additional details, such as the gateway certificate and provisioning credentials. For more information about adding your gateway to AWS IoT Core for LoRaWAN using the `CreateWirelessGateway` API operation, see Add a gateway by using the API (p. 1234).

*Note*

The beaconing parameters aren't available when you add your gateway to AWS IoT Core for LoRaWAN using the AWS IoT console.

```bash
aws iotwireless create-wireless-gateway
   --name "myLoRaWANGateway"
   --cli-input-json file://input.json
```

The following shows the contents of the `input.json` file.

**Contents of input.json**

```json
{
   "Description": "My LoRaWAN gateway",
   "LoRaWAN": {
      "Beaconing": {
         "DataRate": 8,
         "Frequencies": ["923300000", "923900000"]
      },
      "GatewayEui": "a1b2c3d4567890ab",
      "RfRegion": "US915",
      "JoinEuiFilters": [
         "0000000000000001", "00000000000000ff",
         "000000000000ff00", "000000000000ffff"
      ],
      "NetIdFilters": ["000000", "000001"],
      "RfRegion": "US915",
      "SubBands": [2]
   }
}
```

The following code shows a sample output of running this command.

```json
{
   "Arn": "arn:aws:iotwireless:us-east-1:400252685877aa:WirelessGateway/a01b2c34-d44e-567f-abcd-0125e445663a",
   "Id": "a01b2c34-d44e-567f-abcd-0125e445663a"
}
```
Get information about the beaconing parameters

You can get information about the beaconing parameters for your gateway using the GetWirelessGateway API operation.

Note
If a gateway has already been onboarded, you can't use the UpdateWirelessGateway API operation to configure the beaconing parameters. To configure the parameters, you must delete the gateway and then specify the parameters when adding your gateway using the CreateWirelessGateway API operation.

```
aws iotwireless get-wireless-gateway \
   --identifier "12345678-a1b2-3c45-67d8-e90fa1b2c34d" \
   --identifier-type WirelessGatewayId
```

Running this command returns information about your gateway and the beaconing parameters.

Configuring your gateway's subbands and filtering capabilities

LoRaWAN gateways run a LoRa Basics Station software that enables the gateways to connect to AWS IoT Core for LoRaWAN. To connect to AWS IoT Core for LoRaWAN, your LoRa gateway first queries the CUPS server for the LNS endpoint, and then establishes a WebSockets data connection with that endpoint. After the connection is established, uplink and downlink frames can be exchanged through that connection.

Filtering of LoRa data frames received by gateway

After your LoRaWAN gateway establishes a connection to the endpoint, AWS IoT Core for LoRaWAN responds with a router_config message that specifies a set of parameters for the LoRa gateway's configuration, including filtering parameters NetID and JoinEui. For more information about router_config and how a connection is established with the LoRaWAN Network Server (LNS), see LNS protocol.

```
{
   "msgtype"    : "router_config",
   "NetID"      : [ INT, .. ] // ranges: beg,end inclusive
   "JoinEui"    : [ [INT,INT], .. ] // e.g. "EU863", "US902", ..
   "region"     : STRING    // e.g. "EU863", "US902", ..
   "hwspec"     : STRING
   "freq_range" : [ INT, INT ] // min, max (hz)
   "DRs"        : [ [INT,INT,INT], .. ] // sf,bw,dnonly
   "sx1301_conf": [ SX1301CONF, .. ]
   "nocca"      : BOOL
   "nodc"       : BOOL
   "nodwell"    : BOOL
}
```

The gateways carry LoRaWAN device data to and from LNS usually over high-bandwidth networks like Wi-Fi, Ethernet, or Cellular. The gateways usually pick up all messages and pass through the traffic that comes to it to AWS IoT Core for LoRaWAN. However, you can configure the gateways to filter some of the device data traffic, which helps conserve bandwidth usage and reduces the traffic flow between the gateway and LNS.

To configure your LoRa gateway to filter the data frames, you can use the parameters NetID and JoinEui in the router_config message. NetID is a list of NetID values that are accepted. Any LoRa data frame carrying a data frame other than those listed will be dropped. JoinEui is a list of pairs of integer values encoding ranges of JoinEUI values. Join request frames will be dropped by the gateway unless the field JoinEui in the message is within the range [BegEui,EndEui].
Configure beaconing and filtering
capabilities of your LoRaWAN gateways

**Frequency channels and subbands**

For US915 and AU915 RF regions, wireless devices have choices of 64 125KHz and 8 500KHz uplink channels to access the LoRaWAN networks using the LoRa gateways. The uplink frequency channels are divided into 8 subbands, each with 8 125KHz channels and one 500KHz channel. For each regular gateway in AU915 region, one or more subbands will be supported.

Some wireless devices can't hop between subbands and use the frequency channels in only one subband when connected to AWS IoT Core for LoRaWAN. For the uplink packets from those devices to be transmitted, configure the LoRa gateways to use that particular subband. For gateways in other RF regions, such as EU868, this configuration is not required.

**Configure your gateway to use filtering and subbands using the console**

You can configure your gateway to use a particular subband and also enable the capability to filter the LoRa data frames. To specify these parameters using the console:

1. Navigate to the [AWS IoT Core for LoRaWAN Gateways](https://aws.amazon.com/iot/core/gateways) page of the AWS IoT console and choose Add gateway.
2. Specify the gateway details such as the Gateway's Eui, Frequency band (RFRegion) and an optional Name and Description, and choose whether to associate an AWS IoT thing to your gateway. For more information about how to add a gateway, see [Add a gateway using the console](p. 1233).
3. In the **LoRaWAN configuration** section, you can specify the subbands and filtering information.
   - **SubBands**: To add a subband, choose Add SubBand and specify a list of integer values that indicate which subbands are supported by the gateway. The SubBands parameter can only be configured in the RFRegion US915 and AU915 and must have values in the range \([1, 8]\) within one of these supported regions.
   - **NetIdFilters**: To filter uplink frames, choose Add NetId and specify a list of string values that the gateway uses. The NetID of the incoming uplink frame from the wireless device must match at least one of the listed values, otherwise the frame is dropped.
   - **JoinEuiFilters**: Choose Add JoinEui range and specify a list of pairs of string values that a gateway uses to filter LoRa frames. The JoinEUI value specified as part of the join request from the wireless device must be within the range of at least one of the JoinEuiRange values, each listed as a pair of \([\text{BegEui}, \text{EndEui}]\), otherwise the frame is dropped.
4. You can then continue to configure your gateway by following the instructions described in [Add a gateway using the console](p. 1233).

After you've added a gateway, in the [AWS IoT Core for LoRaWAN Gateways](https://aws.amazon.com/iot/core/gateways) page of the AWS IoT console, if you select the gateway that you've added, you can see the SubBands and filters NetIdFilters and JoinEuiFilters in the **LoRaWAN specific details** section of the Gateway details page.

**Configure your gateway to use filtering and subbands using the API**

You can use the [CreateWirelessGateway](https://aws.amazon.com/iot/core/gateways) API that you use to create a gateway to configure the subbands you want to use and enable the filtering capability. Using the CreateWirelessGateway API, you can specify the subbands and filters as part of the gateway configuration information that you provide using the LoRaWAN field. The following shows the request token that includes this information.

```json
POST /wireless-gateways HTTP/1.1
Content-type: application/json

{
   "Description": "Using my first LoRaWAN gateway",
   "LoRaWAN": {
```

1271
You can also use the `UpdateWirelessGateway` API to update the filters but not the subbands. If the `JoinEuiFilters` and `NetIdFilters` values are null, it means there is no update for the fields. If the values aren't null and empty lists are included, then the update is applied. To get the values of the fields that you specified, use the `GetWirelessGateway` API.

**Update gateway firmware using CUPS service with AWS IoT Core for LoRaWAN**

The [LoRa Basics Station](https://www.lora-basics.org/) software that runs on your gateway provides credential management and firmware update interface using the Configuration and Update Server (CUPS) protocol. The CUPS protocol provides secure firmware update delivery with ECDSA signatures.

You'll have to frequently update your gateway's firmware. You can use the CUPS service with AWS IoT Core for LoRaWAN to provide firmware updates to the gateway where the updates can also be signed. To update the gateway's firmware, you can use the SDK or CLI but not the console.

The update process takes about 45 minutes to complete. It can take longer if you're setting up your gateway for the first time to connect to AWS IoT Core for LoRaWAN. Gateway manufacturers usually provide their own firmware update files and signatures so you can use that instead and proceed to `Upload the firmware file to an S3 bucket and add an IAM role (p. 1276)`.

If you don't have the firmware update files, see [Generate the firmware update file and signature (p. 1272)](https://docs.aws.amazon.com/iot-core/latest/developerguide/lorawan-update-firmware.html) for an example that you can use to adapt to your application.

**To perform your gateway's firmware update:**

- [Generate the firmware update file and signature (p. 1272)](https://docs.aws.amazon.com/iot-core/latest/developerguide/lorawan-update-firmware.html)
- [Upload the firmware file to an S3 bucket and add an IAM role (p. 1276)](https://docs.aws.amazon.com/iot-core/latest/developerguide/lorawan-update-firmware.html)
- [Schedule and run the firmware update by using a task definition (p. 1278)](https://docs.aws.amazon.com/iot-core/latest/developerguide/lorawan-update-firmware.html)

**Generate the firmware update file and signature**

The steps in this procedure are optional and depend on the gateway you're using. Gateway manufacturers provide their own firmware update in the form of an update file or a script and Basics Station runs this script in the background. In this case, you'll most likely find the firmware update file in the release notes of the gateway you're using. You can then use that update file or script instead and proceed to `Upload the firmware file to an S3 bucket and add an IAM role (p. 1276)`.

If you don't have this script, following shows the commands to run for generating the firmware update file. The updates can also be signed to ensure that the code was not altered or corrupted and devices run code published only by trusted authors.

**In this procedure, you'll:**
• Generate the firmware update file (p. 1273)
• Generate signature for the firmware update (p. 1274)
• Review the next steps (p. 1275)

Generate the firmware update file

The LoRa Basics Station software running on the gateway is capable of receiving firmware updates in the CUPS response. If you don't have a script provided by the manufacturer, refer to the following firmware update script that is written for the Raspberry Pi based RAKWireless Gateway. We have a base script and the new station binary, version file, and station.conf are attached to it.

Note
The script is specific to the RAKWireless Gateway, so you'll have to adapt it to your application depending on the gateway you're using.

Base script

Following shows a sample base script for the Raspberry Pi based RAKWireless Gateway. You can save the following commands in a file base.sh and then run the script in the terminal on the Raspberry Pi's web browser.

```bash
#!/bin/bash
execution_folder=/home/pi/Documents/basicstation/examples/aws_lorawan
station_path="${execution_folder}/station"
version_path="${execution_folder}/version.txt"
station_conf_path="${execution_folder}/station_conf"

# Function to find the Basics Station binary at the end of this script
# and store it in the station path
function prepare_station() {
    match=$(grep --text --line-number '^STATION:$' $0 | cut -d ':' -f 1)
    payload_start=${((match + 1))}
    match_end=$(grep --text --line-number '^END_STATION:$' $0 | cut -d ':' -f 1)
    payload_end=${((match_end - 1))}
    lines=${((payload_end-$payload_start+1))}
    head -n $payload_end $0 | tail -n $lines > $station_path
}

# Function to find the version.txt at the end of this script
# and store it in the location for version.txt
function prepare_version() {
    match=$(grep --text --line-number '^VERSION:$' $0 | cut -d ':' -f 1)
    payload_start=${((match + 1))}
    match_end=$(grep --text --line-number '^END_VERSION:$' $0 | cut -d ':' -f 1)
    payload_end=${((match_end - 1))}
    lines=${((payload_end-$payload_start+1))}
    head -n $payload_end $0 | tail -n $lines > $version_path
}

# Function to find the version.txt at the end of this script
# and store it in the location for version.txt
function prepare_station_conf() {
    match=$(grep --text --line-number '^CONF:$' $0 | cut -d ':' -f 1)
    payload_start=${((match + 1))}
    match_end=$(grep --text --line-number '^END_CONF:$' $0 | cut -d ':' -f 1)
    payload_end=${((match_end - 1))}
    lines=${((payload_end-$payload_start+1))}
    head -n $payload_end $0 | tail -n $lines > $station_conf_path
}
```
# Stop the currently running Basics station so that it can be overwritten
# by the new one
killall station

# Store the different files
prepare_station
prepare_versionp
prepare_station_conf

# Provide execute permission for Basics station binary
chmod +x $station_path

# Remove update.bin so that it is not read again next time Basics station starts
rm -f /tmp/update.bin

# Exit so that rest of this script which has binaries attached does not get executed
exit 0

Add payload script

To the base script, we append the Basics Station binary, the version.txt that identifies the version to
update to, and station.conf in a script called addpayload.sh. Then, run this script.

```bash
#!/bin/bash

# Add station
echo "STATION:" >> fwstation
cat $1 >> fwstation
echo "" >> fwstation
echo "END_STATION:" >> fwstation

# Add version.txt
echo "VERSION:" >> fwstation
cat $2 >> fwstation
echo "" >> fwstation
echo "END_VERSION:" >> fwstation

# Add station.conf
echo "CONF:" >> fwstation
cat $3 >> fwstation
echo "END_CONF:" >> fwstation

# executable
chmod +x fwstation
```

After you've run these scripts, you can run the following command in the terminal to generate the
firmware update file, fwstation.

```
$ ./addpayload.sh station version.txt station.conf
```

Generate signature for the firmware update

The LoRa Basics Station software provides signed firmware updates with ECDSA signatures. To support
signed updates, you'll need:

- A signature that must be generated by an ECDSA private key and less than 128 bytes.
- The private key that is used for the signature and must be stored in the gateway with file name of the
  format sig-%d.key. We recommend using the file name sig-0.key.
Update gateway firmware using CUPS service with AWS IoT Core for LoRaWAN

- A 32-bit CRC over the private key.

The signature and CRC will be passed to the AWS IoT Core for LoRaWAN APIs. To generate the previous files, you can use the following script `gen.sh` that is inspired by the basicstation example in the GitHub repository.

```
#!/bin/bash

# Generated key
function ecdsaKey() {
    # Key not password protected for simplicity
    openssl ecparam -name prime256v1 -genkey | openssl ec -out $1
}

# Generate ECDSA key
ecdsaKey sig-0.prime256v1.pem

# Generate public key
openssl ec -in sig-0.prime256v1.pem -pubout -out sig-0.prime256v1.pub

# Generate signature private key
openssl ec -in sig-0.prime256v1.pub -inform PEM -outform DER -pubin | tail -c 64 > sig-0.key

# Generate signature
openssl dgst -sha512 -sign sig-0.prime256v1.pem $1 > sig-0.signature

# Convert signature to base64
openssl enc -base64 -in sig-0.signature -out sig-0.signature.base64

# Print the crc
 crc_res=$(crc32 sig-0.key) printf "The crc for the private key=%d\n" $((16#$crc_res))

# Remove the generated files which won't be needed later
rm -rf sig-0.prime256v1.pem sig-0.signature sig-0.prime256v1.pub
```

The private key generated by the script should be saved into the gateway. The key file is in binary format.

```
./gen_sig.sh fwstation
read EC key
writing EC key
read EC key
writing EC key
read EC key
writing EC key
The crc for the private key=3434210794

$ cat sig-0.signature.base64
MEQC1DPI/psAcsgXISyPqB0qZtR+2eTJmX+WFBoStYWxbhSpQW3A5aBROen+XiIdMScv
AsVYFU/5Sc3CalkZVZh4esyS8mNiG4a=

$ ls sig-0.key
sig-0.key

$ scp sig-0.key pi@192.168.1.11:/home/pi/Documents/basicstation/examples/iotwireless
```

Review the next steps

Now that you have generated the firmware and signature, go to the next topic to upload the firmware file, fwstation, to an Amazon S3 bucket. The bucket is a container that will store the firmware update.
file as an object. You can add an IAM role that will give the CUPS server permission to read the firmware
update file in the S3 bucket.

Upload the firmware file to an S3 bucket and add an IAM role

You can use Amazon S3 to create a bucket, which is a container that can store your firmware update file. You can upload your file to the S3 bucket and add an IAM role that allows the CUPS server to read your update file from the bucket. For more information about Amazon S3, see Getting started with Amazon S3.

The firmware update file that you want to upload depends on the gateway you're using. If you followed a procedure similar to the one described in Generate the firmware update file and signature (p. 1272), you'll upload the fwstation file generated by running the scripts.

This procedure takes about 20 minutes to complete.

To upload your firmware file:

- Create an Amazon S3 bucket and upload the update file (p. 1276)
- Create an IAM role with permissions to read the S3 bucket (p. 1277)
- Review the next steps (p. 1278)

Create an Amazon S3 bucket and upload the update file

You'll create an Amazon S3 bucket by using the AWS Management Console and then upload your firmware update file into the bucket.

Create an S3 bucket

To create an S3 bucket, open the Amazon S3 console. Sign in if you haven't already and then perform the following steps:

1. Choose Create bucket.
2. Enter a unique and meaningful name for the Bucket name, (for example, iotwirelessfwupdate). For recommended naming convention for your bucket, see https://docs.aws.amazon.com/AmazonS3/latest/userguide/bucketnamingrules.html.
3. Make sure you selected the AWS Region selected as the one you used to create your LoRaWAN gateway and device, and the Block all public access setting is selected so that your bucket uses the default permissions.
4. Choose Enable for Bucket versioning which will help you keep multiple versions of the firmware update file in the same bucket.
5. Confirm Server-side encryption is set to Disable and choose Create bucket.

Upload your firmware update file

You can now see your bucket in the list of Buckets displayed in the AWS Management Console. Choose your bucket and complete the following steps to upload your file.

1. Choose your bucket and then choose Upload.
2. Choose Add file and then upload the firmware update file. If you followed the procedure described in Generate the firmware update file and signature (p. 1272), you'll upload the fwstation file, otherwise upload the file provided by your gateway manufacturer.
3. Make sure all settings are set to their default. Make sure that Predefined ACLs is set to private and choose Upload to upload your file.
4. Copy the S3 URI of the file you uploaded. Choose your bucket and you'll see the file you uploaded displayed in the list of Objects. Choose your file and then choose Copy S3 URI. The URI will be something like: s3://iotwirelessfwupdate/fwstation if you named your bucket similar to the example described previously (fwstation). You'll use the Amazon S3 URI when creating the IAM role.

**Create an IAM role with permissions to read the S3 bucket**

You'll now create an IAM role and policy that will give CUPS the permission to read your firmware update file from the S3 bucket.

**Create an IAM policy for your role**

To create an IAM policy for your AWS IoT Core for LoRaWAN destination role, open the [Policies hub of the IAM console](https://console.aws.amazon.com/iam/home?region=us-east-1#policies) and then complete the following steps:

1. Choose **Create policy**, and choose the **JSON** tab.
2. Delete any content from the editor and paste this policy document. The policy provides permissions to access the iotwireless bucket and the firmware update file, fwstation, stored inside an object.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "VisualEditor0",
      "Effect": "Allow",
      "Action": [
        "s3:ListBucketVersions",
        "s3:ListBucket",
        "s3:GetObject"
      ],
      "Resource": [
        "arn:aws:s3:::iotwirelessfwupdate/fwstation",
        "arn:aws:s3:::iotwirelessfwupdate"
      ]
    }
  ]
}
```

3. Choose **Review policy**, and in Name, enter a name for this policy (for example, IoTWirelessFwUpdatePolicy). You'll need this name to use in the next procedure.

4. Choose **Create policy**.

**Create an IAM role with the attached policy**

You'll now create an IAM role and attach the policy created previously for accessing the S3 bucket. Open the [Roles hub of the IAM console](https://console.aws.amazon.com/iam/home?region=us-east-1#roles) and complete the following steps:

1. Choose **Create role**.
2. In Select type of trusted entity, choose Another AWS account.
3. In Account ID, enter your AWS account ID, and then choose Next: Permissions.
4. In the search box, enter the name of the IAM policy that you created in the previous procedure. Check the IAM policy (for example, IoTWirelessFwUpdatePolicy) you created earlier in the search results and choose it.
5. Choose Next: Tags, and then choose Next: Review.
6. In **Role name**, enter the name of this role (for example, IoTWirelessFwUpdateRole), and then choose **Create role**.

**Edit trust relationship of the IAM role**

In the confirmation message displayed after you ran the previous step, choose the name of the role you created to edit it. You'll edit the role to add the following trust relationship.

1. In the **Summary** section of the role you created, choose the **Trust relationships** tab, and then choose **Edit trust relationship**.

2. In **Policy Document**, change the Principal property to look like this example.

   ```json
   "Principal": {
     "Service": "iotwireless.amazonaws.com"
   },
   ``

   After you change the Principal property, the complete policy document should look like this example.

   ```json
   {
     "Version": "2012-10-17",
     "Statement": [
       {
         "Effect": "Allow",
         "Principal": {
           "Service": "iotwireless.amazonaws.com"
         },
         "Action": "sts:AssumeRole",
         "Condition": {}
       }
     ]
   }
   ``

3. To save your changes and exit, choose **Update Trust Policy**.

4. Obtain the ARN for your role. Choose your IAM role and in the Summary section, you'll see a **Role ARN**, such as `arn:aws:iam::123456789012:role/IoTWirelessFwUpdateRole`. Copy this **Role ARN**.

**Review the next steps**

Now that you have created the S3 bucket and an IAM role that allows the CUPS server to read the S3 bucket, go to the next topic to schedule and run the firmware update. Keep the **S3 URI** and **Role ARN** that you copied previously so that you can enter them to create a task definition that will be run to perform the firmware update.

**Schedule and run the firmware update by using a task definition**

You can use a task definition to include details about the firmware update and define the update. AWS IoT Core for LoRaWAN provides a firmware update based on information from the following three fields associated with the gateway.

- **Station**
  
  The version and build time of the Basics Station software. To identify this information, you can also generate it by using the Basics Station software that is being run by your gateway (for example, `2.0.5(rpi/std) 2021-03-09 03:45:09`).

- **PackageVersion**
The firmware version, specified by the file `version.txt` in the gateway. While this information might not be present in the gateway, we recommend it as a way to define your firmware version (for example, 1.0.0).

- **Model**
  
The platform or model that is being used by the gateway (for example, Linux).

This procedure takes 20 minutes to complete.

**To complete this procedure:**
- [Get the current version running on your gateway](p. 1279)
- [Create a wireless gateway task definition](p. 1280)
- [Run the firmware update task and track progress](p. 1281)

**Get the current version running on your gateway**

To determine your gateway's eligibility for a firmware update, the CUPS server checks all three fields, `Station`, `PackageVersion`, and `Model`, for a match when the gateway presents them during a CUPS request. When you use a task definition, these fields are stored as part of the `CurrentVersion` field.

You can use the AWS IoT Core for LoRaWAN API or AWS CLI to get the `CurrentVersion` for your gateway. Following commands show how to get this information using the CLI.

1. If you've already provisioned a gateway, you can get information about the gateway using the `get-wireless-gateway` command.

   ```bash
   aws iotwireless get-wireless-gateway \
   --identifier 5a11b0a85a11b0a8 \
   --identifier-type GatewayEui
   ```

   Following shows a sample output for the command.

   ```json
   {
   "Name": "Raspberry Pi",
   "Id": "1352172b-0602-4b40-896f-54da9ed16b57",
   "Description": "Raspberry Pi",
   "LoRaWAN": {
   "GatewayEui": "5a11b0a85a11b0a8",
   "RfRegion": "US915"
   },
   }
   ```

2. Using the wireless gateway ID reported by the `get-wireless-gateway` command, you can use the `get-wireless-gateway-firmware-information` command to get the `CurrentVersion`.

   ```bash
   aws iotwireless get-wireless-gateway-firmware-information \
   --id "3039b406-5cc9-4307-925b-9948c63da25b"
   ```

   Following shows a sample output for the command, with information from all three fields displayed by the `CurrentVersion`.

   ```json
   {
   "LoRaWAN": {
   ```
Create a wireless gateway task definition

When you create the task definition, we recommend that you specify automatic creation of tasks by using the AutoCreateTasks parameter. AutoCreateTasks applies to any gateway that has a match for all three parameters mentioned previously. If this parameter is disabled, the parameters have to be manually assigned to the gateway.

You can create the wireless gateway task definition by using the AWS IoT Core for LoRaWAN API or AWS CLI. Following commands show how to create the task definition using the CLI.

1. Create a file, input.json, that'll contain the information to pass to the CreateWirelessGatewayTaskDefinition API. In the input.json file, provide the following information that you obtained earlier:

   - **UpdateDataSource**
     
     Provide the link to your object containing the firmware update file that you uploaded to the S3 bucket. (for example, s3://iotwirelessfwupdate/fwstation).

   - **UpdateDataRole**
     
     Provide the link to the Role ARN for the IAM role that you created, which provides permissions to read the S3 bucket. (for example, arn:aws:iam::123456789012:role/IoTWirelessFwUpdateRole).

   - **SigKeyCRC and UpdateSignature**
     
     This information might be provided by your gateway manufacturer, but if you followed the procedure described in Generate the firmware update file and signature (p. 1272), you'll find this information when generating the signature.

   - **CurrentVersion**
     
     Provide the CurrentVersion output that you obtained previously by running the get-wireless-gateway-firmware-information command.

```plaintext
cat input.json
```

Following shows the contents of the input.json file.

```json
{
    "AutoCreateTasks": true,
    "Name": "FirmwareUpdate",
    "Update": {
        "UpdateDataSource": "s3://iotwirelessfwupdate/fwstation",
        "UpdateDataRole": "arn:aws:iam::123456789012:role/IoTWirelessFwUpdateRole",
        "LoRaWAN": {
            "SigKeyCrc": 3434210794,
            "UpdateSignature": "MEQCIDPY/p2ssgXIPNC0gZr+NzeTLpX+WFoStYWbh5pQWN3AiBROen+XiIdMScvAsFvFU/ZscjCalkWNZh4esyS8mNIgA==",
            "CurrentVersion": {
                "PackageVersion": "1.0.0",
                "Model": "rpi",
                "Station": "2.0.5(rpi/std) 2021-03-09 03:45:09"
            }
        }
    }
}
```
2. Pass the input.json file to the `create-wireless-gateway-task-definition` command to create the task definition.

```bash
aws iotwireless create-wireless-gateway-task-definition --cli-input-json file://input.json
```

Following shows the output of the command.

```json
{
  "Id": "4ac46ff4-efc5-44fd-9def-e8517077bb12",
  "Arn": "arn:aws:iotwireless:us-east-1:231894231068:WirelessGatewayTaskDefinition/4ac46ff4-efc5-44fd-9def-e8517077bb12"
}
```

Run the firmware update task and track progress

The gateway is ready to receive the firmware update and, once powered on, it connects to the CUPS server. When the CUPS server finds a match in the version of the gateway, it schedules a firmware update.

A task is a task definition in process. As you specified automatic task creation by setting `AutoCreateTasks` to `True`, the firmware update task starts as soon as a matching gateway is found.

You can track the progress of the task by using the `GetWirelessGatewayTask` API. When you run the `get-wireless-gateway-task` command the first time, it will show the task status as `IN_PROGRESS`.

```bash
aws iotwireless get-wireless-gateway-task --id 1352172b-0602-4b40-896f-54da9ed16b57
```

Following shows the output of the command.

```json
{
  "WirelessGatewayId": "1352172b-0602-4b40-896f-54da9ed16b57",
  "WirelessGatewayTaskDefinitionId": "ec11f9e7-b037-4fcc-aa60-a43b839f5de3",
  "LastUplinkReceivedAt": "2021-03-12T09:56:12.047Z",
  "TaskCreatedAt": "2021-03-12T09:56:12.047Z",
  "Status": "IN_PROGRESS"
}
```

When you run the command the next time, if the firmware update takes effect, it will show the updated fields, `Package`, `Version`, and `Model` and the task status changes to `COMPLETED`.

```bash
aws iotwireless get-wireless-gateway-task --id 1352172b-0602-4b40-896f-54da9ed16b57
```

The following shows the output of the command.

```json
{
  "WirelessGatewayId": "1352172b-0602-4b40-896f-54da9ed16b57",
  "Package": "1.0.0",
  "Model": "rpi",
  "Station": "2.0.5(rpi/std) 2021-03-09 03:45:09"
}
```
Choosing gateways to receive the LoRaWAN downlink data traffic

When you send a downlink message from AWS IoT Core for LoRaWAN to your device, you can choose the gateways you want to use for the downlink data traffic. You can specify an individual gateway or choose from a list of gateways to receive the downlink traffic.

**How to specify the gateway list**

You can specify an individual gateway or the list of gateways to use when sending a downlink message from AWS IoT Core for LoRaWAN to your device using the `SendDataToWirelessDevice` API operation. When you invoke the API operation, specify the following parameters using the `ParticipatingGateways` object for your gateways.

- **DownlinkMode**: Indicates whether to send the downlink message in sequential mode or concurrent mode. For class A devices, specify `UsingUplinkGateway` to use only the chosen gateways from the previous uplink message transmission.
- **GatewayList**: The list of gateways that you want to use for sending the downlink data traffic. The downlink payload will be sent to the specified gateways with the specified frequency. This is indicated using a list of `GatewayListItem` objects, that consists of `GatewayId` and `DownlinkFrequency` pairs.
- **TransmissionInterval**: The duration of time for which AWS IoT Core for LoRaWAN will wait before transmitting the payload to the next gateway.

```bash
aws iotwireless delete-wireless-gateway-task 
--id 1352172b-0602-4b40-896f-54da9ed16b57
```
Note
You can specify this list of gateways to use only when sending the downlink message to a class B or a class C wireless device. If you use a class A device, the gateway that you chose when sending the uplink message will be used when a downlink message is sent to the device.

The following example shows how you specify these parameters for the gateway. The input.json file will contain additional details. For more information about sending a downlink message using the SendDataToWirelessDevice API operation, see Perform downlink queue operations by using the API (p. 1289).

Note
The parameters for specifying the list of participating gateways aren't available when you send a downlink message from AWS IoT Core for LoRaWAN using the AWS IoT console.

```
aws iotwireless send-data-to-wireless-device \
  --id "11aa5eae-2f56-4b8e-a023-b28d98494e49" \
  --transmit-mode "1" \
  --payload-data "SGVsbG8gVG8gRGV2c2lt" \
  --cli-input-json file://input.json
```

The following shows the contents of the input.json file.

Contents of input.json

```
{
  "WirelessMetadata": {
    "LoRaWAN": {
      "FPort": "1",
      "ParticipatingGateways": {
        "DownlinkMode": "SEQUENTIAL",
        "TransmissionInterval": 1200,
        "GatewayList": [
          {
            "DownlinkFrequency": 100000000,
            "GatewayID": "a01b2c34-d44e-567f-abcd-0123e445663a"
          },
          {
            "DownlinkFrequency": 100000101,
            "GatewayID": "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
          }
        ]
      }
    }
  }
}
```

The output of running this command generates a MessageId for the downlink message. In some cases, even if you receive the MessageId, packets can get dropped. For more information about how you can resolve the error, see Troubleshoot downlink message queue errors (p. 1290).

```
{
  MessageId: "6011dd36-0043d6eb-0072-0008"
}
```

Get information about the list of participating gateways

You can get information about the list of gateways that are participating in receiving the downlink message by listing messages in the downlink queue. To list messages, use the ListQueuedMessages API.
Managing devices with AWS IoT Core for LoRaWAN

LoRaWAN devices communicate with AWS IoT Core for LoRaWAN through LoRaWAN gateways. Adding devices to AWS IoT Core for LoRaWAN lets AWS IoT process the messages received from the devices for use by AWS IoT and other services.

Following are some important considerations when using your devices with AWS IoT Core for LoRaWAN. For information about how to add your device to AWS IoT Core for LoRaWAN, see Onboard your devices to AWS IoT Core for LoRaWAN (p. 1238).

Device considerations

When selecting a device that you want to use for communicating with AWS IoT Core for LoRaWAN, consider the following.

- Available sensors
- Battery capacity
- Energy consumption
- Cost
- Antenna type and transmission range

Using devices with gateways qualified for AWS IoT Core for LoRaWAN

The devices that you use can be paired with wireless gateways that are qualified for use with AWS IoT Core for LoRaWAN. You can find these gateways and developer kits in the AWS Partner Device Catalog. We also recommend that you consider proximity of these devices to your gateways. For more information, see Using qualified gateways from the AWS Partner Device Catalog (p. 1267).

LoRaWAN version

AWS IoT Core for LoRaWAN supports all devices that comply to 1.0.x or 1.1 LoRaWAN specifications standardized by LoRa Alliance.

Activation modes

Before your LoRaWAN device can send uplink data, you must complete a process called activation or join procedure. To activate your device, you can either use OTAA (Over the air activation) or ABP (Activation by personalization). We recommend that you use OTAA to activate your device because new session keys are generated for each activation, which makes it more secure.

Your wireless device specification is based on the LoRaWAN version and activation mode, which determines the root keys and session keys generated for each activation. For more information, see Add your wireless device specification to AWS IoT Core for LoRaWAN using the console (p. 1240).
Device classes

LoRaWAN devices can send uplink messages at any time. Listening to downlink messages consumes battery capacity and reduces battery duration. The LoRaWAN protocol specifies three classes of LoRaWAN devices.

- Class A devices sleep most of the time and listen for downlink messages only for a short period of time. These devices are mostly battery-powered sensors with a battery lifetime of up to 10 years.
- Class B devices can receive messages in scheduled downlink slots. These devices are mostly battery-powered actuators.
- Class C devices never sleep and continuously listen to incoming messages and so there isn’t much delay in receiving the messages. These devices are mostly mains-powered actuators.

For more information about these wireless device considerations, refer to the resources mentioned in Learn more about LoRaWAN (p. 1226).

Manage communication between your LoRaWAN devices and AWS IoT

After you’ve connected your LoRaWAN device to AWS IoT Core for LoRaWAN, your devices can start sending messages to the cloud. Uplink messages are messages that are sent from your device and received by AWS IoT Core for LoRaWAN. Your LoRaWAN devices can send uplink messages at any time, which are then forwarded to other AWS services and cloud-hosted applications. Messages that are sent from AWS IoT Core for LoRaWAN and other AWS services and applications to your devices are called downlink messages.

The following shows how you can view and manage uplink and downlink messages that are sent between your devices and the Cloud. You can maintain a queue of downlink messages and send these messages to your devices in the order in which they were added to the queue.

Topics
- View format of uplink messages sent from LoRaWAN devices (p. 1285)
- Queue downlink messages to send to LoRaWAN devices (p. 1288)

View format of uplink messages sent from LoRaWAN devices

After you’ve connected your LoRaWAN device to AWS IoT Core for LoRaWAN, you can observe the format of the uplink message that you’ll receive from your wireless device.

Before you can observe the uplink messages

You must have onboarded your wireless device and connected your device to AWS IoT so that it can transmit and receive data. For information about onboarding your device to AWS IoT Core for LoRaWAN, see Onboard your devices to AWS IoT Core for LoRaWAN (p. 1238).

What do the uplink messages contain?

LoRaWAN devices connect to AWS IoT Core for LoRaWAN by using LoRaWAN gateways. The uplink message that you receive from the device will contain the following information.

- Payload data that corresponds to the encrypted payload message that is sent from the wireless device.
- Wireless metadata that includes:
• Device information such as DevEui, the data rate, and the frequency channel in which the device is operating.
• Optional additional parameters and the gateway information for gateways that are connected to the device. The gateway parameters include the gateway's EUI, the SNR, and RSSI.

By using the wireless metadata, you can obtain useful information about the wireless device and the data that is transmitted between your device and AWS IoT. For example, you can use the AckedMessageId parameter to check whether the last confirmed downlink message has been received by the device. Optionally, if you choose to include the gateway information, you can identify whether you want to switch to a stronger gateway channel that's closer to your device.

How to observe the uplink messages?

After you've onboarded your device, you can use the MQTT test client on the Test page of the AWS IoT console to subscribe to the topic that you specified when creating your destination. You’ll start to see messages after your device is connected and starts sending payload data.

This diagram identifies the key elements in a LoRaWAN system connected to AWS IoT Core for LoRaWAN, which shows the primary data plane and how data flows through the system.

When the wireless device starts sending uplink data, AWS IoT Core for LoRaWAN wraps the wireless metadata information with the payload and then sends it to your AWS applications.

Uplink message example

The following example shows the format of the uplink message received from your device.

Note
If your devices send an uplink message without a value for Fport, AWS IoT Core for LoRaWAN will add the value 225 to the Fport in the uplink message received.

```javascript
{
    "WirelessDeviceId": "5b58245e-146c-4c30-9703-0ca942e3ff35",
    "PayloadData": "Cc48AAAAAAAAAAA=",
    "WirelessMetadata": {
        "LoRaWAN": {
            "ADR": false,
            "Bandwidth": 125,
```
The following table shows a description of fields used in the uplink metadata:

**LoRaWAN uplink message fields**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Type</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>WirelessDeviceID</td>
<td>ID of the wireless device sending the data.</td>
<td>String</td>
<td>Yes</td>
</tr>
<tr>
<td>PayloadData</td>
<td>The binary message received from the device, encoded in base64.</td>
<td>String</td>
<td>Yes</td>
</tr>
<tr>
<td>WirelessMetadata</td>
<td>Metadata about the LoRaWAN device and the message request. This includes</td>
<td>Enumeration</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>information such as the device identifiers, data and code rate,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the message timestamp, whether ADR (adaptive data rate) is enabled, and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>the gateway metadata.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Exclude gateway metadata from uplink metadata**

If you want to exclude the gateway metadata information from your uplink metadata, disable the **AddGwMetadata** parameter when you create the service profile. For information about disabling this parameter, see [Add service profiles](#).

In this case, you won't see the Gateways section in the uplink metadata, as illustrated in the following example.

```json
{
    "WirelessDeviceId": "0d9a439b-e77a-4573-a791-49d5c0f4db95",
    "PayloadData": "AAAAAAAA//8",
    "WirelessMetadata": {
        "LoRaWAN": {
            "ClassB": false,
            "CodeRate": "4/5",
            "DataRate": "0",
            "DevAddr": "00b96cd4",
            "DevEui": "58a0cb000202c99",
            "F0ptLen": 2,
            "FCnt": 1,
            "Fport": 136,
            "Frequency": "868100000",
            "Gateways": [
                {
                    "GatewayEui": "80029cfff5ff1cc",
                    "Snr": -29,
                    "Rssi": 9.75
                }
            ],
            "MIC": "7255cb07",
            "MType": "UnconfirmedDataUp",
            "Major": "LoRaWANR1",
            "Modulation": "LORA",
            "PolarizationInversion": false,
            "SpreadingFactor": 12,
            "Timestamp": "2021-04-29T04:19:43Z"
        }
    }
}
```
Queue downlink messages to send to LoRaWAN devices

Cloud-hosted applications and other AWS services can send downlink messages to your wireless devices. Downlink messages are messages that are sent from AWS IoT Core for LoRaWAN to your wireless device. You can schedule and send downlink messages for each device that you've onboarded to AWS IoT Core for LoRaWAN.

If you have multiple devices for which you want to send a downlink message, you can use a multicast group. Devices in a multicast group share the same multicast address, which is then distributed to an entire group of recipient devices. For more information, see Create multicast groups to send a downlink payload to multiple devices (p. 1298).

How a downlink message queue works

The device class of your LoRaWAN device determines how the messages in your queue are sent to the device. Class A devices send an uplink message to AWS IoT Core for LoRaWAN to indicate that the device is available to receive downlink messages. Class B devices can receive messages at regular downlink slots. Class C devices can receive downlink messages at any time. For more information about device classes, see Device classes (p. 1285).

The following shows how messages are queued and sent to your class A devices.

1. AWS IoT Core for LoRaWAN buffers the downlink message that you added to the queue with the frame port, payload data, and the acknowledge mode parameters that you specified by using the AWS IoT console or the AWS IoT Wireless API.
2. Your LoRaWAN device sends an uplink message to indicate that it's online and can start receiving downlink messages.
3. If you added more than one downlink message to the queue, AWS IoT Core for LoRaWAN sends the first downlink message in the queue to your device with the acknowledge (ACK) flag set.
4. Your device either sends an uplink message to AWS IoT Core for LoRaWAN immediately, or it sleeps until the next uplink message and includes the ACK flag in the message.
5. When AWS IoT Core for LoRaWAN receives the uplink message with the ACK flag, it clears the downlink message from the queue, indicating that your device has successfully received the downlink message. If the ACK flag is missing from the uplink message after checking three times, the message is discarded.

Perform downlink queue operations by using the console

You can use the AWS Management Console to queue downlink messages and clear individual messages, or the entire queue, as needed. For class A devices, after an uplink is received from the device to indicate that it's online, the queued messages are then sent to the device. After the message is sent, it's automatically cleared from the queue.

Queue downlink messages

To create a downlink message queue
1. Go to the Devices hub of the AWS IoT console and choose the device for which you want to queue downlink messages.
2. In the Downlink messages section of the device details page, choose Queue downlink messages.
3. Specify the following parameters to configure your downlink message:
   - **FPort**: Choose the frame port for the device to communicate with AWS IoT Core for LoRaWAN.
   - **Payload**: Specify the payload message that you want to send to your device. The maximum payload size is 242 bytes. If adaptive data rate (ADR) is enabled, AWS IoT Core for LoRaWAN uses it to choose the optimal data rate for your payload size. You can further optimize the data rate as needed.
   - ** Acknowledge mode**: Confirm whether your device has received the downlink message. If a message requires this mode, you'll see an uplink message with the ACK flag in your data stream, and the message will be cleared from the queue.
4. To add your downlink message to the queue, choose Submit.

Your downlink message has now been added to the queue. If you don't see your message or you receive an error, you can troubleshoot the error as described in Troubleshoot downlink message queue errors (p. 1290).

**Note**

After your downlink message has been added to the queue, you can no longer edit the parameters FPort, Payload, and Acknowledge mode. To send a downlink message with different values for these parameters, you can delete this message and queue a new downlink message with the updated parameter values.

The queue lists the downlink messages you've added. To see the payload for the uplink and downlink messages that are exchanged between your devices and AWS IoT Core for LoRaWAN, you can use network analyzer. For more information, see Monitoring your wireless resource fleet in real time using network analyzer (p. 1318).

**List downlink message queue**

The downlink message that you created is added to the queue. Each subsequent downlink message is added to the queue after this message. You can see a list of downlink messages in the Downlink messages section of the device details page. After an uplink is received, the messages are sent to the device. After a downlink message has been received by your device, it will be removed from the queue. The next message then moves up in the queue to be sent to your device.

**Delete individual downlink messages or clear entire queue**

Each downlink message is cleared from the queue automatically after it's sent to your device. You can also delete individual messages or clear the entire downlink queue. These actions can't be undone.

- If you find messages in the queue that you don't want to send, choose the messages and choose Delete.
- If you don't want to send any messages from the queue to your device, you can clear the entire queue by choosing Clear downlink queue.

**Perform downlink queue operations by using the API**

You can use the AWS IoT Wireless API to queue downlink messages and clear individual messages, or the entire queue, as needed.

**Queue downlink messages**

To create a downlink message queue, use the `SendDataToWirelessDevice` API operation or the `send-data-to-wireless-device` CLI command.
Note
When sending a downlink message using the `SendDataToWirelessDevice` API, you can choose the gateways that you want to use for the downlink data traffic. For more information, see Choosing gateways to receive the LoRaWAN downlink data traffic (p. 1282).

```bash
aws iotwireless send-data-to-wireless-device \
--id "11aa5eae-2f56-4b8e-a023-b28d98494e49" \
--transmit-mode "1" \
--payload-data "SGVsbG8gVG8gRGV2c2lt" \
--wireless-metadata LoRaWAN={FPort=1}
```

The output of running this command generates a `MessageId` for the downlink message. In some cases, even if you receive the `MessageId`, packets can get dropped. For more information about how you can resolve the error, see Troubleshoot downlink message queue errors (p. 1290).

```
{
    MessageId: "6011dd36-0043d6eb-0072-0008"
}
```

List downlink messages in the queue
To list all downlink messages in the queue, use the `ListQueuedMessages` API operation or the `list-queued-messages` CLI command.

```bash
aws iotwireless list-queued-messages
```

By default, a maximum of 10 downlink messages are displayed when running this command.

Remove individual downlink messages or clear entire queue
To remove individual messages from the queue or to clear the entire queue, use the `DeleteQueuedMessages` API operation or the `delete-queued-messages` CLI command.

- To remove individual messages, provide the `messageID` for messages you want to remove for your wireless device, specified by the `wirelessDeviceId`.
- To clear the entire downlink queue, specify `messageID` as * for your wireless device, specified by the `wirelessDeviceId`.

Troubleshoot downlink message queue errors
Here are some things to check if you're not seeing the expected results:

- **Downlink messages don't appear in the AWS IoT console**
  If you don't see your downlink message in the queue after adding it as described in Perform downlink queue operations by using the console (p. 1288), it might be because your device hasn't completed a process called **activation or join procedure**. This procedure is completed when your device onboards with AWS IoT Core for LoRaWAN. For more information, see Add your wireless device specification to AWS IoT Core for LoRaWAN using the console (p. 1240).

  After onboarding your device to AWS IoT Core for LoRaWAN, you can monitor your device to check whether join and rejoin succeeded by using the network analyzer or Amazon CloudWatch. For more information, see Monitoring and logging for AWS IoT Wireless using Amazon CloudWatch (p. 1390).

- **Missing downlink message packets when using the API**
  When you use the `SendDataToWirelessDevice` API operation, the API returns a unique `MessageId`. However, it can't confirm whether your LoRaWAN device has received the downlink message. The
Managing LoRaWAN traffic from public LoRaWAN networks (Everynet)

You can connect your LoRaWAN devices to the cloud in minutes by using publicly available LoRaWAN networks. AWS IoT Core for LoRaWAN now supports Everynet's network coverage in the US and UK. When using the public network, you'll be charged a public network connectivity charge for each device every month. The pricing applies to all AWS Regions where public network connectivity is offered. For information about pricing for this feature, see the AWS IoT Core pricing page.

Important
The public network is operated and provided as a service directly by Everynet. Before using this feature, see the applicable AWS Service Terms. In addition, if you use a public network through AWS IoT Core for LoRaWAN, certain LoRaWAN device information such as DevEUI and JoinEUI will be replicated across regions where AWS IoT Core for LoRaWAN is available.

AWS IoT Core for LoRaWAN supports the public LoRaWAN network according to the LoRa Alliance specification, as described in LoRaWAN Backend Interfaces 1.0 Specification.

Benefits of using a public LoRaWAN network

Your LoRaWAN devices can use a public network to connect to the cloud, which reduces the time to deployment, and reduces the time and cost that are required to maintain a private LoRaWAN network.

By using a public LoRaWAN network, you'll receive benefits such as coverage extension, running core without radio network, and coverage densification. This feature can be used to:

- Provide coverage to devices when they move out of their home network, such as Device A in figure shown in the Public LoRaWAN network support architecture (p. 1292) section.
- Extend coverage to devices that don't have a LoRa gateway to connect to, such as Device B in figure shown in the Public LoRaWAN network support architecture (p. 1292) section. The device can then use the gateway provided by the partner to connect to the home network.

The following sections describe the public network support architecture, how public LoRaWAN network support works, and how to use this feature.

Topics
- How LoRaWAN public network support works (p. 1291)
- How to use the public network support (p. 1294)

How LoRaWAN public network support works

AWS IoT Core for LoRaWAN supports the passive roaming feature, according to the LoRa Alliance specification. With passive roaming, the roaming process is entirely transparent to the end device.
End devices that roam outside the home network can connect to gateways in the public network and exchange uplink and downlink data using the application server. The devices stay connected to the home network throughout the entire roaming process.

**Note**
AWS IoT Core for LoRaWAN supports only the stateless feature of passive roaming. Handover roaming is not supported. In handover roaming, your device will switch to a different carrier when it travels outside the home network.

**Topics**
- Public LoRaWAN network concepts (p. 1292)
- Public LoRaWAN network support architecture (p. 1292)

**Public LoRaWAN network concepts**

The following concepts are used by the public network support with AWS IoT Core for LoRaWAN.

**LoRaWAN network server (LNS)**

An LNS is a standalone private server that can run on your premises or can be a cloud-based service. AWS IoT Core for LoRaWAN is an LNS that offers services on the cloud.

**Home network server (hNS)**

The home network is the network that the device belongs to. The home network server (hNS) is an LNS where AWS IoT Core for LoRaWAN stores the provisioning data of the device, such as the DevEUI, AppEUI, and session keys.

**Visited network server (vNS)**

The visited network is the network that the device gets coverage from when it leaves the home network. The visited network server (vNS) is an LNS that has a business and technical agreement with the hNS for being able to serve the end device. AWS partner, Everynet, acts as the visited network to provide coverage.

**Serving network server (sNS)**

The serving network server (sNS) is an LNS that handles the MAC commands for the device. There can be only one sNS for one LoRa session.

**Forwarding network server (fNS)**

The forwarding network server (fNS) is an LNS that manages the radio gateways. There can be zero or more fNS involved in one LoRa session. This network server manages the forwarding of data packets that are received from the device to the home network.

**Public LoRaWAN network support architecture**

The following architecture diagram shows how AWS IoT Core for LoRaWAN partners with Everynet to provide public network connectivity. In this case, Device A is connected to the hNS (home network server) provided by AWS IoT Core for LoRaWAN through a LoRa gateway. When Device A moves out of the home network, it enters a visited network, and is covered by the visited network server (vNS) provided by Everynet. The vNS also extends coverage to Device B which doesn't have a LoRa gateway to connect to.

You can view the public network coverage information in the AWS IoT console as described in the following section.
AWS IoT Core for LoRaWAN uses a roaming hub functionality, in accordance with the LoRa Alliance LoRaWAN Roaming Hub Technical Recommendation. The roaming hub provides an endpoint for Everynet to route the traffic received from the end device. In this case, Everynet acts as a forwarding network server (fNS) to forward the traffic received from the device. It uses an HTTP RESTful API, as defined by the LoRa Alliance specification.

**Note**
If your device moves from its home network and enters a location where both your home network and Everynet can offer coverage, it uses first-come-first-serve policy to determine whether to connect to your LoRa gateway, or to Everynet's gateway.

When visiting a public network, the hNS and serving network server (sNS) are separated. Uplink and downlink packets are then exchanged between the sNS and hNS.
How to use the public network support

To enable Everynet's public network support, you specify certain parameters when creating a service profile. The following sections describe the parameters and how you can enable them using the AWS IoT console, the AWS IoT Wireless API, and the AWS CLI.

**Note**
You can enable public network support only when creating a new service profile. You can't update an existing profile to enable public network using these parameters.

**Topics**
- Roaming parameters (p. 1294)
- Enable public network support for devices (p. 1294)

Roaming parameters

Specify the following parameters when creating a service profile for your device. You can enable these parameters by choosing a public network when adding a service profile from the Profiles hub of the AWS IoT console, or using the AWS IoT Wireless API operation, `CreateServiceProfile`, or the AWS CLI command, `create-service-profile`.

**Note**
AWS IoT Core for LoRaWAN does not support handover roaming. When creating the service profile, you can't enable the HrAllowed parameter that specifies whether to use handover roaming.

- Roaming activation allowed (RaAllowed): This parameter specifies whether to enable roaming activation. Roaming activation enables an end device to activate under the coverage of a vNS. When using the roaming feature, RaAllowed must be set to true.
- Passive roaming allowed (PrAllowed): This parameter specifies whether to enable passive roaming. When using the roaming feature, PrAllowed must be set to true.

Enable public network support for devices

To enable public LoRaWAN network support on your devices, run the following procedure.

**Note**
You can enable the public network capability only for OTAA devices. This feature is not supported for devices that use ABP as the activation method.

1. Create service profile with roaming parameters

Create a service profile by enabling the roaming parameters.

**Note**
When you create a device profile for the device that you'll associate with this service profile, we recommend that you specify a large value for the `RxDelay1` parameter, at least greater than 2s.

- Using the AWS IoT console

  Go to the Profiles hub of the AWS IoT console and choose Add service profile. When creating the profile, choose Enable public network.

- Using the AWS IoT Wireless API

  To specify the roaming parameters when creating a service profile, use the `CreateServiceProfile` API operation or the `create-service-profile` CLI command, as shown in example below.
aws iotwireless create-service-profile \
  --region us-east-1 \
  --name roamingprofile1 \
  --lorawan '{"AddGwMetadata":true,"PrAllowed":true,"RaAllowed":true}'

Running this command returns the ARN and ID of the service profile as output.

```
{
  "Arn": "arn:aws:iotwireless:us-east-1:123456789012:ServiceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
  "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
}
```

2. Check roaming parameters in service profile

To check the roaming parameters that you specified, you can view the service profile in the console, or using the `get-service-profile` CLI command, as shown in example below.

- **Using the AWS IoT console**

  Go to the Profiles hub of the AWS IoT console and choose the profile that you created. In the Profile configuration tab of the details page, you'll see RaAllowed and PrAllowed set to true.

- **Using the AWS IoT Wireless API**

  To view the roaming parameters that you enabled, use the `GetServiceProfile` API operation or the `get-service-profile` CLI command, as shown in example below.

```
aws iotwireless get-service-profile \
  --region us-east-1 \
  --id 12345678-a1b2-3c45-67d8-e90fa1b2c34d
```

Running this command returns the service profile details as output, including the values for roaming parameters, RaAllowed and PrAllowed.

```
{
  "Arn": "arn:aws:iotwireless:us-east-1:123456789012:ServiceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
  "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d",
  "Name": "roamingprofile1"
  "LoRaWAN": { 
    "UlRate": 60,
    "UlBucketSize": 4096,
    "DlRate": 60,
    "DlBucketSize": 4096,
    "AddGwMetadata": true,
    "DevStatusReqFreq": 24,
    "ReportDevStatusBattery": false,
    "ReportDevStatusMargin": false,
    "DrMin": 0,
    "DrMax": 15,
    "PrAllowed": true,
    "RaAllowed": true,
    "NwkGeoLoc": false,
    "TargetPer": 5,
    "MinGwDiversity": 1
  }
}
```
3. **Attach service profile to devices**

Attach the service profile that you created with the roaming parameters to your end devices. You can also create a device profile and add a destination for your wireless devices. You'll use this destination to route uplink messages that are sent from your device. For more information about creating device profiles and a destination, see Add device profiles (p. 1241) and Add destinations to AWS IoT Core for LoRaWAN (p. 1243).

- **Onboarding new devices**
  
  If you haven't already onboarded your devices, you specify this service profile to be used when adding your device to AWS IoT Core for LoRaWAN. The following command shows how you can use the `create-wireless-device` CLI command to add a device using the ID of the service profile that you created. For information about adding a device and attaching the service profile to it using the console, see Add your wireless device specification to AWS IoT Core for LoRaWAN using the console (p. 1240).

  ```bash
  aws iotwireless create-wireless-device --cli-input-json file://createdevice.json
  ```

  The following shows the contents of the file `createdevice.json`.

  **Contents of createdevice.json**

  ```json
  {
      "Name": "DeviceA",
      "Type": "LoRaWAN",
      "DestinationName": "RoamingDestination1",
      "LoRaWAN": {
        "DeviceProfileId": "ab0c23d3-b001-45ef-6a01-2bc3de4f5333",
        "ServiceProfileId": "12345678-a1b2-3c45-67d8-e90fa1b2c34d",
        "OtaaV1_1": {
          "AppKey": "3f4ca100e2fc675ea123f4eb12c4a012",
          "JoinEui": "b4c231a359bc2e3d",
          "NwkKey": "01c3f004a2d6efffe32c4eda14bcd2b4"
        },
        "DevEui": "ac12efc654d23fc2"
      }
  }
  ```

  The output of running this command produces the ARN and ID of the wireless device as output.

  ```json
  {
    "Arn": "arn:aws:iotwireless:us-east-1:123456789012:WirelessDevice/1ffdf32c8-8130-4194-96df-622f072a315f",
    "Id": "1ffdf32c8-8130-4194-96df-622f072a315f"
  }
  ```

- **Updating existing devices**
  
  If you have already onboarded your devices, you can update your existing wireless devices to use this service profile. The following command shows how you can use the `update-wireless-device` CLI command to update a device using the ID of the service profile that you created.

  ```bash
  aws iotwireless update-wireless-device \
  --id "1ffdf32c8-8130-4194-96df-622f072a315f" \
  --service-profile-id "12345678-a1b2-3c45-67d8-e90fa1b2c34d" \
  --description "Using roaming service profile A"
  ```
This command doesn't produce any output. You can use the GetWirelessDevice API or the `get-wireless-device` CLI command to get the updated information.

4. **Connect device to cloud using Everynet**

As roaming has been enabled, your device must now perform a join to obtain a new DevAddr. Your LoRaWAN device sends a join request and the Network Server can allow the request. It can then connect to the AWS Cloud using the network coverage provided by Everynet.

**Note**
You can enable the roaming capability for devices that use OTAA as the activation method. ABP devices aren't supported. For instructions on how to perform the activation procedure or join for your device, see the device documentation. See *Activation modes* (p. 1284).

5. **Exchange uplink and downlink messages**

After your device has joined to AWS IoT Core for LoRaWAN, you can start exchanging messages between your device and the Cloud.

- **View uplink messages**

When you send uplink messages from your devices, AWS IoT Core for LoRaWAN delivers these messages to your AWS account using the destination that you configured earlier. These messages will be sent from your device to the Cloud over Everynet's network.

You can use either view the messages using the AWS IoT rule name or use the MQTT client to subscribe to the MQTT topic that was specified when creating the destination. For more information about the rule name and other destination details that you specify, see *Add a destination using the console* (p. 1243).

For more information about viewing uplink message and the format, see *View format of uplink messages sent from LoRaWAN devices* (p. 1285).

- **Send downlink messages**

You can queue and send downlink messages to your devices from the console, or by using the AWS IoT Wireless API command, `SendDataToWirelessDevice`, or the AWS CLI command, `send-data-to-wireless-device`. For information about queuing and sending downlink messages, see *Queue downlink messages to send to LoRaWAN devices* (p. 1288).

The following code shows an example of how you can send a downlink message using the `send-data-to-wireless-device` CLI command. You specify the ID of the wireless device to receive the data, the payload, whether to use the acknowledge mode, and the wireless metadata.

```
aws iotwireless send-data-to-wireless-device \
  --id "1ffd32c8-8130-4194-96df-622f072a315f" \
  --transmit-mode "1" \
  --payload-data "SGVsbG8gVG8gRGV2c2lt" \
  --wireless-metadata LoRaWAN={FPort=1}
```

The output of running this command generates a MessageId for the downlink message.

**Note**
In some cases, even if you receive the MessageId, packets can get dropped. For information about troubleshooting such scenarios and resolving them, see *Troubleshoot downlink message queue errors* (p. 1290).

```json
{
  MessageId: "6011dd36-0043d6eb-0072-0008"
}
```
6. **View coverage information**

After you've enabled the public network, you can view the network coverage information in the AWS IoT console. Go to the **Coverage** hub of the AWS IoT console and then search for locations to see the coverage information of your devices on the map.

**Note**
This feature uses the Amazon Location Service to display the coverage information of your devices on an Amazon Location map. Before using Amazon Location maps, review the Terms and Conditions for Amazon Location Service. Note that AWS may transmit your API queries to your chosen third party data provider, which may be outside of the AWS Region that you are currently using. For more information, see [AWS Service Terms](#).

**Create multicast groups to send a downlink payload to multiple devices**

To send a downlink payload to multiple devices, create a multicast group. Using multicast, a source can send data to a single multicast address, which is then distributed to an entire group of recipient devices.

Devices in a multicast group share the same multicast address, session keys, and frame counter. By using the same session keys, devices in a multicast group can decrypt the message when a downlink transmission is initiated. A multicast group only supports downlink. It doesn't confirm whether the downlink payload has been received by the devices.

With AWS IoT Core for LoRaWAN's multicast groups, you can:

- Filter your list of devices by using the device profile, RFRegion, or device class, and then add these devices to a multicast group.
- Schedule and send one or more downlink payload messages to devices in a multicast group, within a 48-hour distribution window.
- Have devices temporarily switch to Class B or class C mode at the start of your multicast session for receiving the downlink message.
- Monitor your multicast group setup and the state of its devices, and also troubleshoot any issues.
- Use Firmware Updates-Over-The-Air (FUOTA) to securely deploy firmware updates to devices in a multicast group.

AWS IoT Core for LoRaWAN's support for FUOTA and multicast groups is based on the LoRa Alliance's following specifications:

- LoRaWAN Remote Multicast Setup Specification, TS005-1.0.0
- LoRaWAN Fragmented Data Block Transportation Specification, TS004-1.0.0
- LoRaWAN Application Layer Clock Synchronization Specification, TS003-1.0.0

**Note**
AWS IoT Core for LoRaWAN automatically performs the clock synchronization for the device according to the LoRa Alliance specification. Using function `AppTimeReq`, it replies the server-side time to the devices that request it using ClockSync signaling.

The following shows how to create your multicast group and schedule a downlink message.

**Topics**
- Prepare devices for multicast and FUOTA configuration (p. 1299)
- Create multicast groups and add devices to the group (p. 1301)
- Monitor and troubleshoot status of your multicast group and devices in the group (p. 1304)
- Schedule a downlink message to send to devices in your multicast group (p. 1306)

### Prepare devices for multicast and FUOTA configuration

When you add your wireless device to AWS IoT Core for LoRaWAN, you can prepare your wireless device for multicast setup and FUOTA configuration by using the console or the CLI. If you're performing this configuration for the first time, we recommend that you use the console. To manage your multicast group and add or remove a number of devices from your group, we recommend using the CLI to manage a large number of resources.

**GenAppKey and FPorts**

When you add your wireless device, before you can add your devices to multicast groups or perform FUOTA updates, configure the following parameters. Before you configure these parameters, make sure that your devices support FUOTA and multicast and your wireless device specification is either OTAA v1.1 or OTAAv1.0.x.

- **GenAppKey**: For devices that support the LoRaWAN version 1.0.x and to use multicast groups, the GenAppKey is the device-specific root key from which the session keys for your multicast group are derived.

  **Note**
  For LoRaWAN devices that use the wireless specification OTAA v1.1, the AppKey is used for the same purpose as the GenAppKey.

  To set up the parameters to initiate the data transfer, AWS IoT Core for LoRaWAN distributes session keys with the end devices. For more information about LoRaWAN versions, see [LoRaWAN version](p. 1284).

  **Note**
  AWS IoT Core for LoRaWAN stores the GenAppKey information that you provide in an encrypted format.

- **FPorts**: According to the LoRaWAN specifications for FUOTA and multicast groups, AWS IoT Core for LoRaWAN assigns the default values for the following fields of the FPorts parameter. If you have already assigned any of the following FPort values, then you can choose a different value that is available, from 1 to 223.

  - **Multicast**: 200
    This FPort value is used for multicast groups.

  - **FUOTA**: 201
    This FPort value is used for FUOTA.

  - **ClockSync**: 202
    This FPort value is used for the clock synchronization.

### Device profiles for multicast and FUOTA

At the start of a multicast session, a class B or class C distribution window is used to send the downlink message to the devices in your group. The devices that you add for multicast and FUOTA must support class B or class C modes of operation. Depending on the device class that your device supports, choose a device profile for your device that has either or both class B or class C modes enabled.

For information about device profiles, see [Add profiles to AWS IoT Core for LoRaWAN](p. 1241).
Prepare devices for multicast and FUOTA by using the console

To specify the FPorts and GenAppKey parameters for multicast setup and FUOTA by using the console:

1. Navigate to the [Devices hub of the AWS IoT console](https://aws.amazon.com/iot/get-started/) and choose **Add wireless device**.
2. Choose the **Wireless device specification**. Your device must use OTAA for device activation. When you choose OTAA v1.0.x or OTAA v1.1, a **FUOTA configuration-Optional** section appears.
3. Enter the EUI (Extended Unique Identifier) parameters for your wireless device.
4. Expand the **FUOTA configuration-Optional** section and then choose **This device supports firmware updates over the air (FUOTA)**. You can now enter the FPort values for multicast, FUOTA, and clock sync. If you chose OTAA v1.0.x for the wireless device specification, enter the **GenAppKey**.
5. Add your device to AWS IoT Core for LoRaWAN by choosing your profiles and a destination for routing messages. For the device profile linked to the device, make sure you select one or both **Supports Class B** or **Supports Class C** modes.

**Note**
To specify the FUOTA configuration parameters, you must use the [Devices hub of the AWS IoT console](https://aws.amazon.com/iot/get-started/). These parameters don't appear if you onboard your devices by using the **Intro** page of the AWS IoT console.

For more information about the wireless device specification and onboarding your device, see [Add your wireless device to AWS IoT Core for LoRaWAN](https://aws.amazon.com/iot/get-started/) (p. 1239).

**Note**
You can specify these parameters only when you create the wireless device. You can't change or specify parameters when you update an existing device.

Prepare devices for multicast and FUOTA by using the API operation

To use multicast groups or to perform FUOTA updates, configure these parameters by using the **CreateWirelessDevice** API operation or the **create-wireless-device** CLI command. In addition to specifying the application key and FPorts parameters, make sure that the device profile that's linked to the device supports one or both class B or class C modes.

You can provide an input.json file as input to the **create-wireless-device** command.

```bash
aws iotwireless create-wireless-device \
--cli-input-json file://input.json
```

where:

**Contents of input.json**

```json
{
   "Description": "My LoRaWAN wireless device",
   "DestinationName": "IoTWirelessDestination",
   "LoRaWAN": {
      "DeviceProfileId": "ab0c23d3-b001-45ef-6a01-2bc3de4f5333",
      "ServiceProfileId": "fe98dc76-cd12-001e-2d34-5550432da100",
      "FPorts": {
         "ClockSync": 202,
         "Fuota": 201,
         "Multicast": 200
      },
      "OtaaV1_0_x": {
         "AppKey": "3f4ca100e2fc675ea123f4eb124a012",
         "AppEui": "b4c231a359bc2e3d",
         "GenAppKey": "01c3f004a2d6efffe32c4eda14bcd2b4"
      }
   }
}
```
Create multicast groups to send a
downlink payload to multiple devices

For information about the CLI commands that you can use, see AWS CLI reference.

**Note**
After you specify the values of these parameters, you can't update them by using the UpdateWirelessDevice API operation. Instead, you can create a new device with the values for the parameters GenAppKey and FPorts.

To get information about the values specified for these parameters, you can use the GetWirelessDevice API operation or the get-wireless-device CLI command.

**Next steps**

After you've configured the parameters, you can create multicast groups and FUOTA tasks to send downlink payload or update the firmware of your LoRaWAN devices.

- For information about creating multicast groups, see Create multicast groups and add devices to the group (p. 1301).
- For information about creating FUOTA tasks, see Create FUOTA task and provide firmware image (p. 1310).

**Create multicast groups and add devices to the group**

You can create multicast groups by using the console or the CLI. If you're creating your multicast group for the first time, we recommend that you use the console to add your multicast group. When you want to manage your multicast group and add or remove devices from your group, you can use the CLI.

After exchanging signaling with the end devices you added, AWS IoT Core for LoRaWAN establishes the shared keys with the end devices and sets up the parameters for the data transfer.

**Prerequisites**

Before you can create multicast groups and add devices to the group:

- Prepare your devices for multicast and FUOTA setup by specifying the FUOTA configuration parameters GenAppKey and FPorts. For more information, see Prepare devices for multicast and FUOTA configuration (p. 1299).
- Check whether the devices support class B or class C modes of operation. Depending on the device class that your device supports, choose a device profile that has one or both Supports Class B or Supports Class C modes enabled. For information about device profiles, see Add profiles to AWS IoT Core for LoRaWAN (p. 1241).

At the start of the multicast session, a class B or class C distribution window is used to send downlink messages to the devices in your group.

**Create multicast groups by using the console**

To create multicast groups by using the console, go to the Multicast groups page of the AWS IoT console and choose Create multicast group.

1. **Create a multicast group**

   To create your multicast group, specify the multicast properties and tags for your group.
Create multicast groups to send a downlink payload to multiple devices

1. **Specify multicast properties**

   To specify multicast properties, enter the following information for your multicast group.
   - **Name**: Enter a unique name for your multicast group. The name must contain only letters, numbers, hyphens, and underscores. It can't contain spaces.
   - **Description**: You can provide an optional description for your multicast group. The description length can be up to 2,048 characters.

2. **Tags for multicast group**

   You can optionally provide any key-value pairs as Tags for your multicast group. To continue creating your multicast group, choose Next.

2. **Add devices to a multicast group**

   You can add individual devices or a group of devices to your multicast group. To add devices:

   1. **Specify RFRegion**

      Specify the RFRegion or frequency band for your multicast group. The RFRegion for your multicast group must match the RFRegion of devices that you add to the multicast group. For more information about the RFRegion, see Consider selection of LoRa frequency bands for your gateways and device connection (p. 1231).

   2. **Select a multicast device class**

      Choose whether you want devices in the multicast group to switch to a class B or class C mode at the start of the multicast session. A class B session can receive downlink messages at regular downlink slots and a class C session can receive downlink messages at anytime.

   3. **Choose the devices you want to add to the group**

      Choose whether you want to add devices individually or in bulk to the multicast group.
      - To add devices individually, enter the wireless device ID of each device that you want to add to your group.
      - To add devices in bulk, you can filter the devices you want to add by device profile or tags. For device profile, you can add devices with a profile that supports class B, class C, or both device classes.

   4. To create your multicast group, choose Create.

   The multicast group details and the devices you added appear in the group. For information about the status of the multicast group and your devices and for troubleshooting any issues, see Monitor and troubleshoot status of your multicast group and devices in the group (p. 1304).

After creating a multicast group, you can choose Action to edit, delete, or add devices to the multicast group. After you've added the devices, you can schedule a session for the downlink payload to be sent to the devices in your group.

**Create multicast groups by using the API**

To create multicast groups and add devices to the group by using the API:

1. **Create a multicast group**

   To create your multicast group, use the CreateMulticastGroup API operation or the create-multicast-group CLI command. You can provide an input.json file as input to the create-multicast-group command.

   ```bash
   aws iotwireless create-multicast-group
   ```
Create multicast groups to send a downlink payload to multiple devices

```bash
--cli-input-json file://input.json
```

where:

**Contents of input.json**

```json
{
    "Description": "Multicast group to send downlink payload and perform FUOTA updates."

    "LoRaWAN": {
        "DlClass": "ClassB",
        "RfRegion": "US915"
    },
    "Name": "MC_group_FUOTA"
}
```

After you create your multicast group, you can use the following API operations or CLI commands to update, delete, or get information about your multicast groups.

- **UpdateMulticastGroup** or `update-multicast-group`
- **GetMulticastGroup** or `get-multicast-group`
- **ListMulticastGroups** or `list-multicast-groups`
- **DeleteMulticastGroup** or `delete-multicast-group`

2. **Add devices to a multicast group**

You can add devices to your multicast group individually or in bulk.

- To add devices in bulk to your multicast group, use the **StartBulkAssociateWirelessDeviceWithMulticastGroup** API operation or the `start-bulk-associate-wireless-device-with-multicast-group` CLI command. To filter the devices you want to associate in bulk to your multicast group, provide a query string. The following shows how you can add a group of devices that has a device profile with the specified ID linked to it.

```bash
aws iotwireless start-bulk-associate-wireless-device-with-multicast-group \
--id "12abd34e-5f67-89c2-9293-593b1bd862e0" \
--cli-input-json file://input.json
```

where:

**Contents of input.json**

```json
{
    "QueryString": "DeviceProfileName: MyWirelessDevice AND DeviceProfileId: d6d8ef8e-7045-496d-b3f4-ebca1d564bf",
    "Tags": [
        {
            "Key": "Multicast",
            "Value": "ClassB"
        }
    ]
}
```

Here, multicast-groups/d6d8ef8e-7045-496d-b3f4-ebca1d564bf/bulk is the URL that's used to associate devices with the group.

- To add devices individually to your multicast group, use the **AssociateWirelessDeviceWithMulticastGroup** API operation or the `associate-
Create multicast groups to send a downlink payload to multiple devices

wireless-device-with-multicast-group CLI. Provide the wireless device ID for each device you want to add to your group.

```shell
aws iotwireless associate-wireless-device-with-multicast-group \
--id "12abd34e-5f67-89c2-9293-593b1bd862e0" \
--wireless-device-id "ab0c23d3-b001-45ef-6a01-2bc3de4f5333"
```

After you create your multicast group, you can use the following API operations or CLI commands to get information about your multicast group or to disassociate devices.

- `DisassociateWirelessDeviceFromMulticastGroup` or `disassociate-wireless-device-from-multicast-group`
- `StartBulkDisassociateWirelessDeviceFromMulticastGroup` or `start-bulk-disassociate-wireless-device-from-multicast-group`
- `ListWirelessDevices` or `list-wireless-devices`

**Note**
The `ListWirelessDevices` API operation can be used to list wireless devices in general, and wireless devices that are associated with a multicast group or a FUOTA task.

- To list wireless devices associated with a multicast group, use the `ListWirelessDevices` API operation with `MulticastGroupID` as the filter.
- To list wireless devices associated with a FUOTA task, use the `ListWirelessDevices` API operation with `FuotaTaskID` as the filter.

**Next steps**

After you've created a multicast group and added devices, you can continue adding devices and monitor the status of the multicast group and your devices. If your devices have been added successfully to the group, you can configure and schedule a downlink message to be sent to the devices. Before you can send a downlink message, your devices' status must be **Multicast setup ready**. After you schedule a downlink message, the status changes to **Session attempting**. For more information, see **Schedule a downlink message to send to devices in your multicast group** (p. 1306).

If you want to update the firmware of the devices in the multicast group, you can perform Firmware Updates Over-The-Air (FUOTA) with AWS IoT Core for LoRaWAN. For more information, see **Firmware Updates Over-The-Air (FUOTA) for AWS IoT Core for LoRaWAN devices** (p. 1308).

If your devices weren't added or if you see an error in the multicast group or device statuses, you can hover over the error to get more information and resolve it. If you still see an error, for information about how to troubleshoot and resolve the issue, see **Monitor and troubleshoot status of your multicast group and devices in the group** (p. 1304).

**Monitor and troubleshoot status of your multicast group and devices in the group**

After you've added devices and created your multicast group, open the AWS Management Console. Navigate to the **Multicast groups** page of the AWS IoT console and choose the multicast group you created to view its details. You'll see information about the multicast group, the number of devices that have been added, and device status details. You can use the status information to track progress of your multicast session and troubleshoot any errors.

**Multicast group status**

Your multicast group can have one of the following status messages displayed in the AWS Management Console.
Create multicast groups to send a downlink payload to multiple devices

- **Pending**

  This status indicates that you've created a multicast group but it doesn't yet have a multicast session. You'll see this status message displayed when your group has been created. During this time, you can update your multicast group, and associate or disassociate devices with your group. After the status changes from **Pending**, additional devices can't be added to the group.

- **Session attempting**

  After your devices have been added successfully to the multicast group, when your group has a scheduled multicast session, you'll see this status message displayed. During this time, you can't update or add devices to your multicast group. If you cancel your multicast session, the group status changes to **Pending**.

- **In session**

  When it's the earliest session time for your multicast session, you'll see this status message displayed. A multicast group also continues to be in this state when it's associated with a FUOTA task that has an ongoing firmware update session.

  If you don't have an associated FUOTA task in session, and if the multicast session is canceled because the session time exceeded the time out or you canceled your multicast session, the group status changes to **Pending**.

- **Delete waiting**

  If you delete your multicast group, its group status changes to **Delete waiting**. Deletions are permanent and can't be undone. This action can take time and the group status will be **Delete_Waiting** until the multicast group has been deleted. After your multicast group enters this state, it can't transition to one of the other states.

**Status of devices in multicast group**

The devices in your multicast group can have one of the following status messages displayed in the AWS Management Console. You can hover over each status message to get more information about what it indicates.

- **Package attempting**

  After your devices have been associated with the multicast group, the device status is **Package attempting**. This status indicates that AWS IoT Core for LoRaWAN has not yet confirmed whether the device supports multicast setup and operation.

- **Package unsupported**

  After your devices have been associated with the multicast group, AWS IoT Core for LoRaWAN checks whether your device's firmware is capable of multicast setup and operation. If your device doesn't have the supported multicast package, its status is **Package unsupported**. To resolve the error, check whether your device's firmware is capable of multicast setup and operation.

- **Multicast setup attempting**

  If the devices associated with your multicast group are capable of multicast setup and operation, the status is **Multicast setup attempting**. This status indicates that the device hasn't completed the multicast setup yet.

- **Multicast setup ready**

  Your device has completed the multicast setup and has been added to the multicast group. This status indicates that the devices are ready for a multicast session and a downlink message can be sent to those devices. The status also indicates when you can use FUOTA to update the firmware of the devices in the group.
• **Session attempting**

A multicast session has been scheduled for the devices in your multicast group. At the start of a multicast group session, the device status is **Session attempting**, and requests are sent for whether a class B or class C distribution window can be initiated for the session. If the time it takes to set up the multicast session exceeds the timeout or if you cancel the multicast session, the status changes to **Multicast setup done**.

• **In session**

This status indicates that a class B or class C distribution window has been initiated and your device has an ongoing multicast session. During this time, downlink messages can be sent from AWS IoT Core for LoRaWAN to devices in the multicast group. If you update your session time, it overrides the current session and the status changes to **Session attempting**. When the session time ends or if you cancel the multicast session, the status changes to **Multicast setup ready**.

**Next steps**

Now that you've learned the different statuses of your multicast group and the devices in your group, and how you can troubleshoot any issues such as when a device is not capable of multicast setup, you can schedule a downlink message to be sent to the devices and your multicast group will be in **In session**. For information about scheduling a downlink message, see [Schedule a downlink message to send to devices in your multicast group](p. 1306).

**Schedule a downlink message to send to devices in your multicast group**

After you've successfully added devices to your multicast group, you can start a multicast session and configure a downlink message to be sent to those devices. The downlink message must be scheduled within 48 hours and the start time for the multicast must be at least 30 minutes later than the current time.

**Note**

Devices in a multicast group can't acknowledge when a downlink message has been received.

**Prerequisites**

Before you can send a downlink message, you must have created a multicast group and successfully added devices to the group for which you want to send a downlink message. You can't add more devices after a start time has been scheduled for your multicast session. For more information, see [Create multicast groups and add devices to the group](p. 1301).

If any of the devices weren't added successfully, the multicast group and device status will contain information to help you resolve the errors. If the errors still persist, for information about troubleshooting these errors, see [Monitor and troubleshoot status of your multicast group and devices in the group](p. 1304).

**Schedule a downlink message by using the console**

To send a downlink message by using the console, go to the **Multicast groups** page of the AWS IoT console and choose the multicast group you created. In the multicast group details page, choose **Schedule downlink message** and then choose **Schedule downlink session**.

1. **Schedule downlink message window**

   You can set up a time window for a downlink message to be sent to the devices in your multicast group. The downlink message must be scheduled within 48 hours.

   To schedule your multicast session, specify the following parameters:
Create multicast groups to send a downlink payload to multiple devices

• **Start date** and **Start time**: The start date and time must be at least 30 minutes after and 48 hours before the current time.

  **Note**
  The time that you specify is in UTC so consider checking the time difference with your time zone when scheduling the downlink window.

• **Session timeout**: The time after which you want the multicast session to timeout if no downlink message has been received. The minimum timeout allowed is 60 seconds. The maximum timeout value is 2 days for class B multicast groups and 18 hours for class C multicast groups.

2. **Configure your downlink message**

To configure your downlink message, specify the following parameters:

• **Data rate**: Choose a data rate for your downlink message. The data rate depends on RFRegion and payload size. The default data rate is 8 for the US915 region and 0 for the EU868 region.

• **Frequency**: Choose a frequency for sending your downlink message. To avoid messaging conflicts, choose an available frequency depending on the RFRegion.

• **FPort**: Choose an available frequency port for sending the downlink message to your devices.

• **Payload**: Specify the maximum size of your payload depending on the data rate. Using the default data rate, you can have a maximum payload size of 33 bytes in the US915 RFRegion and 51 bytes in the EU868 RFRegion. Using larger data rates, you can transfer up to a maximum payload size of 242 bytes.

To schedule your downlink message, choose **Schedule**.

**Schedule a downlink message by using the API**

To schedule a downlink message by using the API, use the **StartMulticastGroupSession** API operation or the **start-multicast-group-session** CLI command. You can get information about the multicast group using the **GetMulticastGroupSession** API operation or the **get-multicast-group-session** CLI command.

To send data to a multicast group after the session has been started, use the **SendDataToMulticastGroup** API operation or the **send-data-to-multicast-group** CLI command.

**Next steps**

After you've configured a downlink message to be sent to the devices, the message is sent at the start of the session. The devices in a multicast group can't confirm whether the message has been received.

**Configure additional downlink messages**

You can also configure additional downlink messages to be sent to the devices in your multicast group:

• To configure additional downlink messages from the console:
  1. Go to the **Multicast groups** page of the AWS IoT console and choose the multicast group you created.
  2. In the multicast group details page, choose **Schedule downlink message** and then choose **Configure additional downlink message**.
  3. Specify the parameters **Data rate**, **Frequency**, **FPort**, and **Payload**, similar to how you configured these parameters for your first downlink message.

• To configure additional downlink messages using the API or CLI, call the **SendDataToMulticastGroup** API operation or the **send-data-to-multicast-group** CLI command for each additional downlink message.
Update session schedule

You can also update the session schedule to use a new start date and time for your multicast session. The new session schedule will override the previously scheduled session.

**Note**
Update your multicast session only when required. These updates can cause a group of devices to wake up for a long duration and drain the battery.

- **To update the session schedule from the console:**
  1. Go to the [Multicast groups](#) page of the AWS IoT console and choose the multicast group you created.
  2. In the multicast group details page, choose **Schedule downlink message** and then choose **Update session schedule**.
  3. Specify the parameters **State date**, **Start time**, and **Session timeout**, similar to how you specified these parameters for your first downlink message.

- **To update the session schedule from the API or CLI, use the** [StartMulticastGroupSession](#) API operation or the [start-multicast-group-session](#) CLI command.

Firmware Updates Over-The-Air (FUOTA) for AWS IoT Core for LoRaWAN devices

Use Firmware Updates Over-The-Air (FUOTA) to deploy firmware updates to AWS IoT Core for LoRaWAN devices.

Using FUOTA, you can send firmware updates to individual devices or to a group of devices. You can also send firmware updates to multiple devices by creating a multicast group. First add your devices to the multicast group, and then send your firmware update image to all those devices. We recommend that you digitally sign the firmware images so that devices receiving the images can verify that they're coming from the right source.

With AWS IoT Core for LoRaWAN's FUOTA updates, you can:

- Deploy new firmware images or delta images to a single device or a group of devices.
- Verify the authenticity and integrity of new firmware after it's deployed to devices.
- Monitor the progress of a deployment and debug issues in case of a failed deployment.
- Perform firmware updates OTA when using a public network provided by Everynet instead of your own private gateways.

AWS IoT Core for LoRaWAN's support for FUOTA and multicast groups is based on the [LoRa Alliance's](#) following specifications:

- LoRaWAN Remote Multicast Setup Specification, TS005-1.0.0
- LoRaWAN Fragmented Data Block Transportation Specification, TS004-1.0.0
- LoRaWAN Application Layer Clock Synchronization Specification, TS003-1.0.0

**Note**
AWS IoT Core for LoRaWAN automatically performs the clock synchronization according to the LoRa Alliance specification. It uses the function `AppTimeReq` to reply the server-side time to the devices that request it using ClockSync signaling.

The following shows how to perform FUOTA updates.
FUOTA process overview

The following diagram shows how AWS IoT Core for LoRaWAN performs the FUOTA process for your end devices. If you're adding individual devices to your FUOTA session, you can skip the steps for creating and configuring your multicast group. You can add your devices directly to a FUOTA session, and AWS IoT Core for LoRaWAN will then start the firmware update process.

To perform FUOTA updates for your devices, first create your digitally signed firmware image and configure the devices and multicast groups that you want to add to your FUOTA task. After you start a FUOTA session, your end devices collect all fragments, reconstruct the image from the fragments, report the status to AWS IoT Core for LoRaWAN, and then apply the new firmware image.

The following illustrates the different steps in the FUOTA process:

1. **Create a firmware image or delta image with a digital signature**

   For AWS IoT Core for LoRaWAN to perform FUOTA updates for your LoRaWAN devices, we recommend that you digitally sign the firmware image or the delta image when sending firmware updates over the air. The devices that receive the images can then verify that it's coming from the right source.

   Your firmware image must not be larger than 1 megabyte in size. The larger your firmware size, the longer it can take for your update process to complete. For faster data transfer or if your new image is larger than 1 Megabyte, use a delta image, which is the part of your new image that's the delta between your new firmware image and the previous image.

   **Note**

   AWS IoT Core for LoRaWAN doesn't provide the digital signature generation tool and the firmware version management system. You can use any third-party tool to generate the digital signature for your firmware image. We recommend that you use a digital signature
2. **Identify and configure the devices for FUOTA**

After you identify the devices for FUOTA, send firmware updates to individual or multiple devices.

- To send your firmware updates to multiple devices, create a multicast group, and configure the multicast group with end devices. For more information, see Create multicast groups to send a downlink payload to multiple devices (p. 1298).
- To send firmware updates to individual devices, add those devices to your FUOTA session and then perform the firmware update.

3. **Schedule a distribution window and set up fragmentation session**

If you created a multicast group, you can specify the class B or class C distribution window to determine when the devices can receive the fragments from AWS IoT Core for LoRaWAN. Your devices might be operating in class A before they switch to class B or class C mode. You must also specify the start time of the session.

Class B or class C devices wake up at the specified distribution window and start receiving the downlink packets. Devices operating in class C mode can consume more power than class B devices. For more information, see Device classes (p. 1285).

4. **End devices report status to AWS IoT Core for LoRaWAN and update firmware image**

After you set up a fragmentation session, your end devices and AWS IoT Core for LoRaWAN perform the following steps to update the firmware of your devices.

1. Because LoRaWAN devices have a low data rate, to start the FUOTA process, AWS IoT Core for LoRaWAN sets up a fragmentation session to fragment the firmware image. Then it sends these fragments to the end devices.

2. After AWS IoT Core for LoRaWAN sends the image fragments, your LoRaWAN end devices perform the following tasks.
   a. Collect the fragments and then reconstruct the binary image from these fragments.
   b. Check the digital signature of the reconstructed image to authenticate the image and verify that it's coming from the right source.
   c. Compare the firmware version from AWS IoT Core for LoRaWAN to the current version.
   d. Report the status of the fragmented images that were transferred to AWS IoT Core for LoRaWAN, and then apply the new firmware image.

   **Note**
   In some cases, the end devices report the status of the fragmented images that were transferred to AWS IoT Core for LoRaWAN before checking the digital signature of the firmware image.

Now that you've learned the FUOTA process, you can create your FUOTA task and add devices to the task for updating their firmware. For more information, see Create FUOTA task and provide firmware image (p. 1310).

**Create FUOTA task and provide firmware image**

To update the firmware of your LoRaWAN devices, first create a FUOTA task and provide the digitally signed firmware image you want to use for the update. You can then add your devices and multicast groups to the task and schedule a FUOTA session. When the session starts, AWS IoT Core for LoRaWAN sets up a fragmentation session and your end devices collect the fragments, reconstruct the image, and apply the new firmware. For information about the FUOTA process, see FUOTA process overview (p. 1309).
The following shows how you can create a FUOTA task and upload the firmware image or delta image that you'll store in an S3 bucket.

**Prerequisites**

Before you can perform FUOTA updates, the firmware image must be digitally signed so that your end devices can verify the authenticity of the image when applying the image. You can use any third-party tool to generate the digital signature for your firmware image. We recommend that you use a digital signature tool such as the one embedded in the [ARM Mbed GitHub repository](https://github.com/ARMmbed), which also includes tools for generating the delta image and for devices to use that image.

**Create FUOTA task and upload firmware image by using the console**

To create a FUOTA task and upload your firmware image by using the console, go to the FUOTA tasks tab of the console and then choose **Create FUOTA task**.

1. **Create FUOTA task**

   To create your FUOTA task, specify the task properties and tags.

   1. **Specify FUOTA task properties**

      To specify FUOTA task properties, enter the following information for your FUOTA task.

      - **Name**: Enter a unique name for your FUOTA task. The name must contain only letters, numbers, hyphens, and underscores. It can't contain spaces.
      - **Description**: You can provide an optional description for your multicast group. The description field can be up to 2,048 characters.
      - **RFRegion**: Set the frequency band for your FUOTA task. The frequency band must match the one you used to provision your wireless devices or multicast groups.

   2. **Tags for FUOTA task**

      You can optionally provide any key-value pairs as **Tags** for your FUOTA task. To continue creating your task, choose **Next**.

2. **Upload firmware image**

   Choose the firmware image file that you want to use to update the firmware of the devices you add to the FUOTA task. The firmware image file is stored in an S3 bucket. You can provide AWS IoT Core for LoRaWAN the permissions to access the firmware image on your behalf. We recommend that you digitally sign the firmware images so that its authenticity is verified when the firmware update is performed.

   1. **Choose firmware image file**

      You can either upload a new firmware image file to an S3 bucket or choose an existing image that has already been uploaded to an S3 bucket.

      **Note**
      
      The firmware image file must not be larger than 1 megabyte in size. The larger your firmware size, the longer it can take for your update process to complete.

      - To use an existing image, choose **Select an existing firmware image**, choose **Browse S3**, and then choose the firmware image file you want to use.

      - **To upload a new firmware image**.

        a. Choose **Upload a new firmware image** and upload your firmware image. The image file must not be larger than 1 megabyte.
b. To create an S3 bucket and enter a **Bucket name** for storing your firmware image file, choose **Create S3 bucket**.

2. **Permissions to access the bucket**

You can either create a new service role or choose an existing role to allow AWS IoT Core for LoRaWAN to access the firmware image file in the S3 bucket on your behalf. Choose **Next**.

To create a new role, you can enter a role name or leave it blank for a random name to be generated automatically. To view the policy permissions that grant access to the S3 bucket, choose **View policy permissions**.

**Note**

If the S3 bucket encryption is specified as SSE-KMS, you must add the service role used by the FUOTA task as a user of this KMS key. This service role is either generated by the FUOTA task or assigned to the FUOTA task when creating the task.

For more information about using an S3 bucket to store your image and granting AWS IoT Core for LoRaWAN permissions to access it, see [Upload the firmware file to an S3 bucket and add an IAM role](p. 1276).

3. **Review and create**

To create your FUOTA task, review the FUOTA task and configuration details that you specified and choose **Create task**.

### Create FUOTA task and upload firmware image by using the API

To create a FUOTA task and specify your firmware image file by using the API, use the **CreateFuotaTask** API operation or the **create-fuota-task** CLI command. You can provide an input.json file as input to the **create-fuota-task** command. When you use the API or CLI, the firmware image file that you provide as input must be already uploaded to an S3 bucket. You also specify the IAM role that gives AWS IoT Core for LoRaWAN access to the firmware image in the S3 bucket.

```bash
aws iotwireless create-fuota-task \
--cli-input-json file://input.json
```

where:

**Contents of input.json**

```json
{
  "Description": "FUOTA task to update firmware of devices in multicast group.",
  "FirmwareUpdateImage": "S3:/firmware_bucket/firmware_image",
  "FirmwareUpdateRole": "arn:aws:iam::123456789012:role/service-role/ACF1zBEI",
  "LoRaWAN": {
    "RFRegion": "US915"
  },
  "Name": "FUOTA_Task_MC"
}
```

After you create your FUOTA task, you can use the following API operations or CLI commands to update, delete, or get information about your FUOTA task.

- **UpdateFuotaTask** or **update-fuota-task**
- **GetFuotaTask** or **get-fuota-task**
- **ListFuotaTasks** or **list-fuota-tasks**
Next steps

Now that you've created a FUOTA task and provided the firmware image, you can add devices to the task for updating their firmware. You can either add individual devices or multicast groups to the task. For more information, see Add devices and multicast groups to a FUOTA task and schedule a FUOTA session (p. 1313).

Add devices and multicast groups to a FUOTA task and schedule a FUOTA session

After you've created a FUOTA task, you can add devices to your task for which you want to update the firmware. After your devices have been added successfully to the FUOTA task, you can schedule a FUOTA session to update the device firmware.

- If you have only a small number of devices, you can add those devices directly to your FUOTA task.
- If you have a large number of devices that you want to update firmware for, you can add these devices to your multicast groups, and then add the multicast groups to your FUOTA task. For information about creating and using multicast groups, see Create multicast groups to send a downlink payload to multiple devices (p. 1298).

**Note**

You can add either individual devices or multicast groups to the FUOTA task. You can't add both devices and multicast groups to the task.

After you've added your devices or multicast groups, you can start a firmware update session. AWS IoT Core for LoRaWAN collects the firmware image, fragments the images, and then stores the fragments in an encrypted format. Your end devices collect the fragments and apply the new firmware image. The time that it takes for the firmware update depends on the image size and how the images were fragmented. After the firmware update is complete, the encrypted fragments of the firmware image stored by AWS IoT Core for LoRaWAN is deleted. You can still find the firmware image in the S3 bucket.

Prerequisites

Before you can add devices or multicast groups to your FUOTA task, do the following.

- You must have already created the FUOTA task and provided your firmware image. For more information, see Create FUOTA task and provide firmware image (p. 1310).
- Provision the wireless devices that you want to update the device firmware for. For more information about onboarding your device, see Onboard your devices to AWS IoT Core for LoRaWAN (p. 1238).
- To update the firmware of multiple devices, you can add them to a multicast group. For more information, see Create multicast groups to send a downlink payload to multiple devices (p. 1298).
- When you onboard the devices to AWS IoT Core for LoRaWAN, specify the FUOTA configuration parameter FPort. If you're using a LoRaWAN v1.0.x device, you must also specify the GenAppKey. For more information about the FUOTA configuration parameters, see Prepare devices for multicast and FUOTA configuration (p. 1299).

Add devices to a FUOTA task and schedule a FUOTA session by using the console

To add devices or multicast groups and schedule a FUOTA session by using the console, go to the FUOTA tasks tab of the console. Then, choose the FUOTA task that you want to add devices to and perform the firmware update.
Add devices and multicast groups

1. You can add either individual devices or multicast groups to your FUOTA task. However, you can't add both individual devices and multicast groups to the same FUOTA task. To add devices using the console, do the following.

   1. In the **FUOTA task details**, choose **Add device**.
   2. Choose the frequency band or **RFRegion** for the devices you add to the task. This value must match the **RFRegion** that you chose for the FUOTA task.
   3. Choose whether you want to add individual devices or multicast groups to the task.
      - To add individual devices, choose **Add individual devices** and enter the device ID of each device that you want to add to your FUOTA task.
      - To add multicast groups, choose **Add multicast groups** and add your multicast groups to the task. You can filter the multicast groups you want to add to the task by using the device profile or tags. When you filter by device profile, you can choose multicast groups that have devices that have a profile with **Supports Class B** or **Supports Class C** enabled.

2. Schedule FUOTA session

   After your devices or multicast groups have been added successfully, you can schedule a FUOTA session. To schedule a session, do the following.

   1. Choose the FUOTA task for which you want to update the device firmware and then choose **Schedule FUOTA session**.
   2. Specify a **Start date** and **Start time** for your FUOTA session. Make sure that the start time is 30 minutes or later from the current time.

Add devices to a FUOTA task and schedule a FUOTA session by using the API

You can use the AWS IoT Wireless API or the CLI to add your wireless devices or multicast groups to your FUOTA task. You can then schedule a FUOTA session.

1. **Add devices and multicast groups**

   You can associate either wireless devices or multicast groups with your FUOTA task.

   - To associate individual devices to your FUOTA task, use the **AssociateWirelessDeviceWithFuotaTask** API operation or the **associate-wireless-device-with-fuota-task** CLI command, and provide the WirelessDeviceID as input.

     ```bash
     aws iotwireless associate-wireless-device-with-fuota-task \
     --id "01a23cde-5678-4a5b-ab1d-33456808ecb2" \
     --wireless-device-id "ab0c23d3-b001-45ef-6a01-2bc3de4f5333"
     ```

   - To associate multicast groups to your FUOTA task, use the **AssociateMulticastGroupWithFuotaTask** API operation or the **associate-multicast-group-with-fuota-task** CLI command, and provide the MulticastGroupID as input.

     ```bash
     aws iotwireless associate-multicast-group-with-FUOTA-task \
     --id 01a23cde-5678-4a5b-ab1d-33456808ecb2" \
     --multicast-group-id
     ```

   After you've associated your wireless devices or multicast group to your FUOTA task, use the following API operations or CLI commands to list your devices or multicast groups or to disassociate them from your task.
Firmware Updates Over-The-Air (FUOTA) for AWS IoT Core for LoRaWAN devices

• **DisassociateWirelessDeviceFromFuotaTask** or **disassociate-wireless-device-from-fuota-task**
• **DisassociateMulticastGroupFromFuotaTask** or **disassociate-multicast-group-from-fuota-task**
• **ListWirelessDevices** or **list-wireless-devices**
• **ListMulticastGroups** or **list-multicast-groups-by-fuota-task**

**Note**
The API:
• **ListWirelessDevices** can list wireless devices in general, and devices associated with a multicast group, when MulticastGroupID is used as the filter. The API lists wireless devices associated with a FUOTA task when FuotaTaskID is used as the filter.
• **ListMulticastGroups** can list multicast groups in general and multicast groups associated with a FUOTA task when FuotaTaskID is used as the filter.

2. **Schedule FUOTA session**

After your devices or multicast groups have been successfully added to the FUOTA task, you can start a FUOTA session to update the device firmware. The start time must be 30 minutes or later from the current time. To schedule a FUOTA session by using the API or CLI, use the **StartFuotaTask** API operation or the **start-fuota-task** CLI command.

After you've started a FUOTA session, you can no longer add devices or multicast groups to the task. You can get information about the status of your FUOTA session by using the **GetFuotaTask** API operation or the **get-fuota-task** CLI command.

**Monitor and troubleshoot the status of your FUOTA task and devices added to the task**

After you have provisioned the wireless devices and created any multicast groups that you might want to use, you can start a FUOTA session by performing the following steps.

**FUOTA task status**

Your FUOTA task can have one of the following status messages displayed in the AWS Management Console.

• **Pending**
  This status indicates that you've created a FUOTA task, but it doesn't yet have a firmware update session. You'll see this status message displayed when your task has been created. During this time, you can update your FUOTA task, and associate or disassociate devices or multicast groups with your task. After the status changes from **Pending**, additional devices can't be added to the task.

• **FUOTA session waiting**
  After your devices have been added successfully to the FUOTA task, when your task has a scheduled firmware update session, you'll see this status message displayed. During this time, you can't update or add devices to your FUOTA session. If you cancel your FUOTA session, the group status changes to **Pending**.

• **In FUOTA session**
  When your FUOTA session begins, you'll see this status message displayed. The fragmentation session starts and your end devices collect the fragments, reconstruct the firmware image, compare the new firmware version with the original version, and apply the new image.

• **FUOTA done**
After your end devices report to AWS IoT Core for LoRaWAN that the new firmware image has been applied, or when the session times out, the FUOTA session is marked as done, and you'll see this status displayed.

You'll also see this status displayed in any of the following cases so be sure to check whether the firmware update was applied correctly to the devices.

- When the FUOTA task status was **FUOTA session waiting**, and there's an S3 bucket error, such as the link to the image file in the S3 bucket is incorrect or AWS IoT Core for LoRaWAN doesn't have sufficient permissions to access the file in the bucket.
- When the FUOTA task status was **FUOTA session waiting**, and there's a request to start a FUOTA session, but a response isn't received from the devices or multicast groups in your FUOTA task.
- When the FUOTA task status was **In FUOTA session**, and the devices or multicast groups haven't sent any fragments for a certain time period, which results in the session to timeout.
- **Delete waiting**

If you delete your FUOTA task that's in any of the other states, you'll see this status displayed. A deletion action is permanent and can't be undone. This action can take time and the task status will be **Delete waiting** until the FUOTA task has been deleted. After your FUOTA task enters this state, it can't transition to one of the other states.

**Status of devices in a FUOTA task**

The devices in your FUOTA task can have one of the following status messages displayed in the AWS Management Console. You can hover over each status message to get more information about what it indicates.

- **Initial**

  When it's the start time of your FUOTA session, AWS IoT Core for LoRaWAN checks whether your device has the supported package for the firmware update. If your device has the supported package, the FUOTA session for the device starts. The firmware image is fragmented and the fragments are sent to your device. When you see this status displayed, it indicates that the FUOTA session for the device hasn't started yet.

- **Package unsupported**

  If the device doesn't have the supported FUOTA package, you'll see this status displayed. If the firmware update package isn't supported, the FUOTA session for your device can't start. To resolve this error, check whether your device's firmware can receive firmware updates using FUOTA.

- **Fragmentation algorithm unsupported**

  At the start of your FUOTA session, AWS IoT Core for LoRaWAN sets up a fragmentation session for your device. If you see this status displayed, it means that the type of fragmentation algorithm used can't be applied for your device's firmware update. The error occurs because your device doesn't have the supported FUOTA package. To resolve this error, check whether your device's firmware can receive firmware updates using FUOTA.

- **Not enough memory**

  After AWS IoT Core for LoRaWAN sends the image fragments, your end devices collect the image fragments and reconstruct the binary image from these fragments. This status is displayed when your device doesn't have enough memory to assemble the incoming fragments of the firmware image, which can result in your firmware update session ending prematurely. To resolve the error, check whether your device's hardware can receive this update. If your device can't receive this update, use a delta image to update the firmware.

- **Fragmentation index unsupported**
The fragmentation index identifies one of the four simultaneously possible fragmentation sessions. If your device doesn't support the indicated fragmentation index value, this status is displayed. To resolve this error, do one or more of the following.

- Start a new FUOTA task for the device.
- If the error persists, switch from unicast to multicast mode.
- If the error still isn't resolved, check your device firmware.

**Memory error**

This status indicates that your device has experienced a memory error when receiving the incoming fragments from AWS IoT Core for LoRaWAN. If this error occurs, your device might not be capable of receiving this update. To resolve the error, check whether your device's hardware can receive this update. If needed, use a delta image to update the device firmware.

**Wrong descriptor**

Your device doesn't support the indicated descriptor. The descriptor is a field that describes the file that will be transported during the fragmentation session. If you see this error, contact AWS Support Center.

**Session count replay**

This status indicates that your device has previously used this session count. To resolve the error, start a new FUOTA task for the device.

**Missing fragments**

As your device collects the image fragments from AWS IoT Core for LoRaWAN, it reconstructs the new firmware image from the independent, coded fragments. If your device hasn't received all the fragments, the new image can't be reconstructed, and you'll see this status. To resolve the error, start a new FUOTA task for the device.

**MIC error**

When your device reconstructs the new firmware image from the collected fragments, it performs a MIC (Message Integrity Check) to verify the authenticity of your image and whether it's coming from the right source. If your device detects a mismatch in the MIC after reassembling the fragments, this status is displayed. To resolve the error, start a new FUOTA task for the device.

**Successful**

The FUOTA session for your device was successful.

*Note*

While this status message indicates that the devices have reconstructed the image from the fragments and verified it, the device firmware might not have been updated when the device reports the status to AWS IoT Core for LoRaWAN. Check whether your device firmware has been updated.

**Next steps**

You've learned about the different statuses of the FUOTA task and its devices and how you can troubleshoot any issues. For more information about each of these statuses, see the LoRaWAN Fragmented Data Block Transportation Specification, TS004-1.0.0.
Monitoring your wireless resource fleet in real time using network analyzer

Network analyzer uses a default WebSocket connection to receive real-time trace message logs for your wireless connectivity resources. By using network analyzer, you can add the resources you want to monitor, activate a trace messaging session, and start receiving trace messages in real time.

**Note**
To monitor your resources, you can also use Amazon CloudWatch. To use CloudWatch, you set up an IAM role to configure logging and then wait for the log entries to be displayed in the console. For more information, see [Monitoring and logging for AWS IoT Wireless using Amazon CloudWatch](p. 1390).

Network analyzer significantly reduces the time that it takes to set up a connection and start receiving trace messages, providing you with just-in-time log information for your fleet of resources. By reducing your setup time and using the information from the trace messages, you can monitor your resources more effectively, get meaningful insights, and troubleshoot errors. The wireless resources that you can monitor include LoRaWAN devices, LoRaWAN gateways, and multicast groups. For example, you can quickly identify a join error when onboarding one of your LoRaWAN devices. To debug the error, use the information in the provided trace message log.

The wireless resources that you can monitor include LoRaWAN devices, LoRaWAN gateways, and multicast groups. You can also use network analyzer to debug and troubleshoot any issues with your FUOTA task. For example, consider a FUOTA task that has a multicast group, *multicast group A*, and you have devices *device A* and *device B* added to that group. You can then add both the multicast group, *multicast group A*, and devices *device A* and *device B*, to your network analyzer configuration for monitoring them and debugging your FUOTA task.

**How to use network analyzer**
To monitor your resource fleet and start receiving trace messages, perform the following steps.

1. **Create network analyzer configuration and add resources**
   Before you can activate trace messaging, create a network analyzer configuration and add resources to your configuration. First, specify the configuration settings, which include log levels, and wireless device and multicast frame information. Then, add the wireless resources you want to monitor by using the wireless gateway, wireless device, and multicast group identifiers.

2. **Stream trace messages with WebSockets**
   You can generate a presigned request URL using the credentials for your IAM role to stream network analyzer trace messages by using the WebSocket protocol.

3. **Activate trace messaging session and monitor trace messages**
   To start receiving trace messages, activate your trace messaging session. To avoid incurring additional costs, you can either deactivate or close your network analyzer trace messaging session.

The following shows how to create your configuration, add resources, and activate your trace messaging session.

**Topics**
- Add necessary IAM role for network analyzer (p. 1319)
- Create a network analyzer configuration and add resources (p. 1320)
- Stream network analyzer trace messages with WebSockets (p. 1326)
- View and monitor network analyzer trace message logs in real time (p. 1335)
• Debug and troubleshoot your multicast groups and FUOTA tasks using network analyzer (p. 1337)

Add necessary IAM role for network analyzer

When you use network analyzer, you must grant a user permission to use the API operations UpdateNetworkAnalyzerConfiguration and GetNetworkAnalyzerConfiguration to access network analyzer resources. The following shows the IAM policies that you use to grant permissions.

IAM policies for network analyzer

Use either of the following:

• Full access wireless policy

Grant AWS IoT Core for LoRaWAN the full access policy by attaching the policy AWSIoTWirelessFullAccess to your role. For more information, see AWSIoTWirelessFullAccess policy summary.

• Scoped IAM policy for Get and Update API

Create the following IAM policy by going to the Create policy page of the IAM console, and on the Visual editor tab:
1. Choose IoTWireless for Service.
2. Under Access level, expand Read and choose GetNetworkAnalyzerConfiguration, and then expand Write and choose UpdateNetworkAnalyzerConfiguration.
3. Choose Next:Tags, and enter a Name for the policy, such as IoTWirelessNetworkAnalyzerPolicy. Choose Create policy.

The following shows the policy IoTWirelessNetworkAnalyzerPolicy that you created. For more information about creating a policy, see Create IAM policies.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
        "Sid": "VisualEditor0",
        "Effect": "Allow",
        "Action": [
          "iotwireless:GetNetworkAnalyzerConfiguration",
          "iotwireless:UpdateNetworkAnalyzerConfiguration"
        ],
        "Resource": "*"
      }
   ]
}
```

Scoped policy to access specific resources

To configure more fine-grained access control, you must add the wireless gateways, devices, and any multicast groups to the Resource field. The following policy uses the wildcard ARN to grant access to all gateways, devices, and multicast groups. You can control access to specific gateways and devices by using the WirelessGatewayId, WirelessDeviceId, and the MulticastGroupId.

```json
{
   "Version": "2012-10-17",
   "Statement": [
      {
        "Sid": "VisualEditor1",
        "Effect": "Allow",
        "Action": [
          "iotwireless:GetNetworkAnalyzerConfiguration",
          "iotwireless:UpdateNetworkAnalyzerConfiguration"
        ],
        "Resource": "*"
      }
   ]
}
```
To grant a user permission to use network analyzer but not to use any wireless resources or multicast groups, use the following policy. Unless specified, permissions to use the resources are implicitly denied.

```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Sid": "VisualEditor0",
            "Effect": "Allow",
            "Action": [
                "iotwireless:GetNetworkAnalyzerConfiguration",
                "iotwireless:UpdateNetworkAnalyzerConfiguration"
            ],
            "Resource": [
                "arn:aws:iotwireless:*:{accountId}:NetworkAnalyzerConfiguration/*"
            ]
        }
    ]
}
```

**Next steps**

Now that you've created the policy, you can add resources to your network analyzer configuration and receive trace messaging information for those resources. For more information, see Create a network analyzer configuration and add resources (p. 1320).

**Create a network analyzer configuration and add resources**

Before you can stream trace messages, create a network analyzer configuration and add the resources you want to monitor to this configuration. When you create a configuration, you can:

- Specify a configuration name and optional description.
- Customize the configuration settings such as frame info and level of detail for your log messages.
- Add the resources that you want to monitor. The resources can include wireless devices, wireless gateways, and multicast groups.

The configuration settings that you specify will determine the trace messaging information that you'll receive for resources you add to the configuration. You may also want to create multiple configurations depending on your monitoring use case.

The following shows how to create a configuration and add resources.
Create a network analyzer configuration

Before you can monitor your wireless resources or multicast groups, you must create a network analyzer configuration. When creating the configuration, you only need to specify a configuration name. You can customize your configuration settings and add the resources that you want to monitor to your configuration even after it's created. The configuration settings determine the trace messaging information that you'll receive for those resources.

Depending on the resources you want to monitor and the level of information you want to receive for them, you may want to create multiple configurations. For example, you can create a configuration that displays only error information for a set of gateways in your AWS account. You can also create a configuration that displays all information about a wireless device that you want to monitor.

The following sections show the various configuration settings and how to create your configuration.

Configuration settings

When creating or updating your network analyzer configuration, you can also customize the following parameters to filter the log stream information.

- **Frame info**
  This setting is the frame info for your wireless device resources for trace messages. The frame info can be used to debug the communication between your network server and the end devices. It is enabled by default.

- **Log levels**
  
  You can view Info or Error logs, or you can turn off logging.
  
  - **Info**
    Logs with a log level of **Info** are more verbose and contain both error log streams and informational log streams. The informational logs can be used to view changes to the state of a device or gateway.
  
    **Note**
    Collecting more verbose log streams can incur additional costs. For more information about pricing, see [AWS IoT Core pricing](https://aws.amazon.com/iot/core/pricing/).
  
  - **Error**
    Logs with a log level of **Error** are less verbose and display only error information. You can use these logs when an application has an error, such as a device connection error. By using the information from the log stream, you can identify and troubleshoot errors for resources in your fleet.

- **Multicast frame info**
  
  If you have multicast groups that you want to monitor, you can use multicast frame info to troubleshoot devices that are attempting to join the group.

Create a configuration using the console

You can create a network analyzer configuration and customize the optional parameters using the AWS IoT console or the AWS IoT Wireless API. You can also create multiple configurations and later delete any configurations that you're no longer using.
Create a network analyzer configuration

1. Open the Network Analyzer hub of the AWS IoT console and choose Create configuration.
2. Specify the configuration settings.
   - Name, description, and tags
     Specify a unique Configuration name, an optional Description, and Tags to add key-value pairs of metadata about the configuration. For more information about naming and describing your resources, see Describe your AWS IoT Core for LoRaWAN resources (p. 1229)
   - Configuration settings
     Choose whether to disable frame info, and use Select log levels to choose the log levels that you want to use for your trace message logs. If you have multicast groups that you want to monitor, choose Multicast data message (multicast groups only). Choose Next.
3. Add resources to your configuration. You can either add your resources now or choose Create and then add your resources later. To add resources later, choose Create.

In the Network Analyzer hub page, you'll see the configuration that you created along with its settings. To view the details of the new configuration, choose the configuration name.

Delete your network analyzer configuration

You can create multiple network analyzer configurations depending on the resources you want to monitor and the level of trace messaging information that you want to receive for them.

To remove configurations from the console

1. Go to the Network Analyzer hub of the AWS IoT console and choose the configuration that you want to remove.
2. Choose Actions, and then choose Delete.

Create a configuration using the API

To create a network analyzer configuration using the API, use the CreateNetworkAnalyzerConfiguration API operation or the create-network-analyzer-configuration CLI command.

When you create your configuration, you only need to specify a configuration name. You can also use this API operation to specify the configuration settings and add resources when creating the configuration.

Note
When using the CreateNetworkAnalyzerConfiguration API operation to add resources, for each API request, you can specify only up to 99 wireless resources. A single network analyzer configuration can have up to 250 wireless devices and 250 wireless gateways combined. To add additional resources, use the AWS IoT console, as described in the above section.

- Create a configuration

When you create your configuration, you must specify a name. For example, the following command creates a configuration by providing only a name and an optional description. By default, the configuration has frame info activated and uses a log level of INFO.

```
aws iotwireless create-network-analyzer-configuration \
  --configuration-name My_Network_Analyzer_Config \
  --description "My first network analyzer configuration"
```

Running this command displays the ARN and ID of your network analyzer configuration.
Create a network analyzer configuration and add resources

To customize the configuration settings, use the `trace-content` parameter. To add resources, use the `WirelessDevices`, `WirelessGateways`, and `MulticastGroups` parameters to specify the gateways, devices, and multicast groups that you want to add to your configuration. For example, the following command customizes the configuration settings and adds to your configuration the wireless resources.

```
aws iotwireless create-network-analyzer-configuration 
   --configuration-name My_NetworkAnalyzer_Config 
   --trace-content WirelessDeviceFrameInfo=DISABLED,MulticastFrameInfo=ENABLED,LogLevel="ERROR" 
   --wireless-gateways "12345678-a1b2-3c45-67d8-e90fa1b2c34d" "90123456-de1f-2b3b-4c5c-bb1112223cd1" 
   --wireless-devices "1ffd32c8-8130-4194-96df-622f072a315f" 
   --multicast-groups "12abd34e-5f67-89c2-9293-593b1bd862e0"
```

The following example shows the output of running the command:

```
{
   "Arn": "arn:aws:iotwireless:us-east-1:123456789012:NetworkAnalyzerConfiguration/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
   "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
}
```

List network analyzer configurations

You can create multiple network analyzer configurations depending on the resources that you want to monitor and the level of detail of trace messaging information that you want to receive for the resources. After you create these configurations, you can use the `ListNetworkAnalyzerConfigurations` API operation or the `list-network-analyzer-configuration` CLI command to get a list of these configurations.

```
aws iotwireless list-network-analyzer-configurations
```

Running this command displays all the network analyzer configurations in your AWS account. You can also use the `max-results` parameter to specify how many configurations you want to display. The following shows the output of running this command.

```
{
   "NetworkAnalyzerConfigurationList": [
      {
         "Arn": "arn:aws:iotwireless:us-east-1:123456789012:NetworkAnalyzerConfiguration/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
         "Name": "My_Network_Analyzer_Config1"
      },
      {
         "Arn": "arn:aws:iotwireless:us-east-1:123456789012:NetworkAnalyzerConfiguration/90123456-a1a2-9a87-65b4-c12bf3c2d09a",
         "Name": "My_Network_Analyzer_Config2"
      }]
```
Create a network analyzer configuration and add resources

Delete your network analyzer configuration

You can delete a configuration that you're no longer using with the `DeleteNetworkAnalyzerConfiguration` API operation or the `delete-network-analyzer-configuration` CLI command.

```
aws iotwireless delete-network-analyzer-configuration \
  --configuration-name My_NetworkAnalyzer_Config
```

Running this command doesn't produce any output. To see the available configurations, you can use the `ListNetworkAnalyzerConfigurations` API operation.

Next steps

Now that you've created a network analyzer configuration, you can add resources to your configuration or update your configuration settings. For more information, see Add resources and update the network analyzer configuration (p. 1324).

Add resources and update the network analyzer configuration

Before you can activate trace messaging, add the resources that you want to monitor to your network analyzer configuration. Resources can be LoRaWAN devices, LoRaWAN gateways, or multicast groups.

Prerequisites

Before you can add resources:

1. You must have onboarded the gateways and devices, and added any multicast groups that you want to monitor to AWS IoT Core for LoRaWAN. For more information, see Connecting gateways and devices to AWS IoT Core for LoRaWAN (p. 1228).
2. You must have created a network analyzer configuration for which you'll be adding resources. For more information, see Create a network analyzer configuration (p. 1321).

Add resources and update configuration settings by using the console

You can add resources and customize the optional parameters by using the AWS IoT console or the AWS IoT Wireless API. In addition to resources, you can also edit your configuration settings and save the updated configuration.

Add resources to your configuration

1. Open the Network Analyzer hub of the AWS IoT console and choose the configuration for which you want to add resources.
2. Choose Actions and then choose Add resources.
3. Add the resources you want to monitor by using the wireless gateway and wireless device identifiers. You can choose multiple resources, and add up to 250 wireless gateways or wireless devices.
4. After you've added all the resources, choose Add.

You'll see the number of gateways and devices that you added in the Network Analyzer hub page. You can continue adding and removing resources until you activate the trace messaging session. After the session has been activated, to add resources, you'll have to deactivate the session.
Update your configuration settings

1. Open the Network Analyzer hub of the AWS IoT console and choose the configuration for which you want to update the settings.
2. Choose Actions and then choose Edit.
3. Choose whether to disable frame info and use Select log levels to choose the log levels that you want to use for your trace message logs. Choose Save.

You’ll see the configuration settings that you specified in the details page of your network analyzer configuration.

Add resources and update configuration settings by using the API

To add resources or update your configuration settings, use the UpdateNetworkAnalyzerConfiguration API or the update-network-analyzer-configuration CLI.

Note
When using the UpdateNetworkAnalyzerConfiguration API operation to add or update resources, for each API request, you can specify only up to 99 wireless resources. A single network analyzer configuration can have up to 250 wireless devices and 250 wireless gateways combined. To add additional resources, use the AWS IoT console, as described in the above section.

- Update configuration settings

To update your configuration settings, use the TraceContent parameter to specify the log level and whether to enable frame info. For example, the following command updates the configuration settings by disabling the frame info and by setting the log level to ERROR.

```
aws iotwireless update-network-analyzer-configuration \
--configuration-name NetworkAnalyzerConfig_Default \
--trace-content WirelessDeviceFrameInfo=DISABLED,LogLevel="ERROR"
```

- Add resources

To add resources, use the WirelessDevicesToAdd, WirelessGatewaysToAdd, and MulticastGroupsToAdd parameters to specify the gateways, devices, and multicast groups that you want to add to your configuration. For example, the following command updates the configuration settings and adds to your configuration the wireless resources, specified by their WirelessGatewayId, WirelessDeviceId, and MulticastGroupId.

```
aws iotwireless update-network-analyzer-configuration \
--configuration-name NetworkAnalyzerConfig_Default \
--trace-content WirelessDeviceFrameInfo=DISABLED,LogLevel="ERROR" \
--wireless-gateways-to-add "12345678-a1b2-3c45-67d8-e90fa1b2c34d" "90123456-de1f-2b3b-4c5c-bb1112223cd1" \
--wireless-devices-to-add "1ffd32c8-8130-4194-96df-622f072a315f" \
--multicast-groups-to-add "12abd34e-5f67-89c2-9293-593b1bd862e0"
```

To remove devices or gateways, use the WirelessDevicesToRemove, WirelessGatewaysToRemove, and MulticastGroupsToRemove parameters of the API.

Get information about the configuration
Running the UpdateNetworkAnalyzerConfiguration API doesn't produce any output. To view your configuration settings and the gateways or devices that you've added, use the GetNetworkAnalyzerConfiguration API operation or the get-network-analyzer-configuration command. Provide the name of the network analyzer configuration as input.

```
aws iotwireless get-network-analyzer-configuration \
  --configuration-name NetworkAnalyzerConfig_Default
```

Running this command produces the following output.

```
{
  "TraceContent": {
    "WirelessDeviceFrameInfo": "DISABLED",
    "LogLevel": "ERROR"
  },
  "WirelessDevices": [],
  "WirelessGateways": [
    "a0dd70e5-8f15-41a5-89cf-310284e691a1",
    "41682155-de4f-4f8f-84bf-bb5557221fc8"
  ]
}
```

**Next steps**

Now that you've added resources and specified any optional configuration settings for your configuration, you can use the WebSocket protocol to establish a connection with AWS IoT Core for LoRaWAN for using network analyzer. You can then activate trace messaging and start receiving trace messages for your resources. For more information, see Stream network analyzer trace messages with WebSockets (p. 1326).

**Stream network analyzer trace messages with WebSockets**

When you use the WebSocket protocol, you can stream network analyzer trace messages in real time. When you send a request, the service responds with a JSON structure. After you activate trace messaging, you can use the message logs to get information about your resources and troubleshoot errors. For more information, see WebSocket protocol.

The following shows how to stream network analyzer trace messages with WebSockets.

**Generate a presigned request with the WebSocket library**

The following shows how you to generate a presigned request so that you can use the WebSocket library to send requests to the service.

**Add a policy for WebSocket requests to your IAM role**

To use the WebSocket protocol to call network analyzer, attach the following policy to the AWS Identity and Access Management (IAM) role that makes this request.
Create a presigned URL

Construct a URL for your WebSocket request that contains the information needed to set up communication between your application and the network analyzer. To verify the identity of the request, WebSocket streaming uses the Amazon Signature Version 4 process for signing requests. For more information about Signature Version 4, see Signing AWS API Requests in the Amazon Web Services General Reference.

To call network analyzer, use the StartNetworkAnalyzerStream request URL. The request will be signed using the credentials for the IAM role mentioned previously. The URL has the following format with line breaks added for readability. You must add the configuration name below the line &X-Amz-SignedHeaders=host. Any additional parameters should be added below this line sorted by alphabetical order.

The following example shows how to use this request URL with the configuration name, NaConfig:

```
&X-Amz-Credential=Signature Version 4 credential scope
&X-Amz-Date=date
&X-Amz-Expires=time in seconds until expiration
&X-Amz-Security-Token=security-token
&X-Amz-Signature=Signature Version 4 signature
&X-Amz-SignedHeaders=host
```

**Note**

If your URL doesn't include the configuration name, AWS IoT Core for LoRaWAN will include the default name for the network analyzer configuration, NetworkAnalyzerConfig_Default.

Use the following values for the Signature Version 4 parameters:

- **X-Amz-Algorithm** – The algorithm you're using in the signing process. The only valid value is AWS4-HMAC-SHA256.
- **X-Amz-Credential** – A string separated by slashes ("/") that is formed by concatenating your access-key ID and your credential scope components. Credential scope includes the date in YYYYMMDD format, the AWS Region, the service name, and a termination string (aws4_request).
- **X-Amz-Date** – The date and time that the signature was created. Generate the date and time by following the instructions in Handling Dates in Signature Version 4 in the Amazon Web Services General Reference.
• **X-Amz-Expires** – The length of time in seconds until the credentials expire. The maximum value is 300 seconds (5 minutes).
• **X-Amz-Security-Token** – (optional) A Signature Version 4 token for temporary credentials. If you specify this parameter, include it in the canonical request. For more information, see Requesting Temporary Security Credentials in the AWS Identity and Access Management User Guide.
• **X-Amz-Signature** – The Signature Version 4 signature that you generated for the request.
• **X-Amz-SignedHeaders** – The headers that are signed when creating the signature for the request. The only valid value is host.

**Construct the request URL and create Signature Version 4 signature**

To construct the URL for the request and create the Signature Version 4 signature, use the following steps.

**Note**
The examples in this section are in pseudocode. For a sample Python code that shows how to create the signature, see Sample Python code to generate presigned URL (p. 1330).

**Task 1: Create a canonical request**

Create a string that includes information from your request in a standardized format. This ensures that when AWS receives the request, it can calculate the same signature that you calculate in Task 3: Calculate the signature (p. 1330). For more information, see Create a Canonical Request for Signature Version 4 in the Amazon Web Services General Reference.

1. Define variables for the request in your application.

```python
# HTTP verb
method = "GET"

# Service name
service = "iotwireless"

# AWS Region
region = "AWS Region"

# Service streaming endpoint
dregion = "wss://api.iotwireless.REGION.amazonaws.com"

# Host
dregion = "api.iotwireless.<region>.amazonaws.com"

# Date and time of request
amz-date = YYYYMMDD'T'HHMMSS'Z'

# Date without time for credential scope
datestamp = YYYYMMDD
```

2. Create a canonical URI (uniform resource identifier). The canonical URI is the part of the URI between the domain and the query string.

```python
canonical_uri = "start-network-analyzer-stream"
```

3. Create the canonical headers and signed headers. Note the trailing \n in the canonical headers.

- Append the lowercase header name followed by a colon.
- Append a comma-separated list of values for that header. Don't sort the values in headers that have multiple values.
- Append a new line (\n).
4. Match the algorithm to the hashing algorithm. You must use SHA-256.

   algorithm = "AWS4-HMAC-SHA256"

5. Create the credential scope, which scopes the derived key to the date, Region, and service to which the request is made.

   credential_scope = datestamp + "/" + region + "/" + service + "/" + "aws4_request"

6. Create the canonical query string. Query string values must be URI-encoded and sorted by name.

   • Sort the parameter names by character code point in ascending order. Parameters with duplicate names should be sorted by value. For example, a parameter name that begins with the uppercase letter F precedes a parameter name that begins with a lowercase letter b.
   • Do not URI-encode any of the unreserved characters that RFC 3986 defines: A–Z, a–z, 0–9, hyphen (-), underscore (_), period (.), and tilde (~).
   • Percent-encode all other characters with %XY, where X and Y are hexadecimal characters (0–9 and uppercase A–F). For example, the space character must be encoded as %20 (not using '+', as some encoding schemes do) and extended UTF-8 characters must be in the form %XY%ZA%BC.
   • Double-encode any equals (=) characters in parameter values.

   canonical_querystring = "X-Amz-Algorithm=" + algorithm
   canonical_querystring += "&X-Amz-Credential=" + URI-encode(access key + "/" + credential_scope)
   canonical_querystring += "&X-Amz-Date=" + amz_date
   canonical_querystring += "&X-Amz-Expires=300"
   canonical_querystring += "&X-Amz-Security-Token=" + token
   canonical_querystring += "&X-Amz-SignedHeaders=" + signed_headers

7. Create a hash of the payload. For a GET request, the payload is an empty string.

   payload_hash = HashSHA256("\"\".Encode("utf-8")\"\".HexDigest()

8. Combine all of the elements to create the canonical request.

   canonical_request = method + "\n"
   + canonical_uri + "\n"
   + canonical_querystring + "\n"
   + canonical_headers + "\n"
   + signed_headers + "\n"
   + payload_hash

Task 2: Create the string to sign

The string to sign contains meta information about your request. You use the string to sign in the next step when you calculate the request signature. For more information, see Create a String to Sign for Signature Version 4 in the Amazon Web Services General Reference.

   string_to_sign=algorithm + "\n"
   + amz_date + "\n"
   + credential_scope + "\n"
Task 3: Calculate the signature

You derive a signing key from your AWS secret access key. For a greater degree of protection, the derived key is specific to the date, service, and AWS Region. You use the derived key to sign the request. For more information, see Calculate the Signature for AWS Signature Version 4 in the Amazon Web Services General Reference.

The code assumes that you have implemented the GetSignatureKey function to derive a signing key. For more information and example functions, see Examples of How to Derive a Signing Key for Signature Version 4 in the Amazon Web Services General Reference.

The function HMAC(key, data) represents an HMAC-SHA256 function that returns the results in binary format.

```python
# Create the signing key
signing_key = GetSignatureKey(secret_key, datestamp, region, service)

# Sign the string_to_sign using the signing key
signature = HMAC.new(signing_key, (string_to_sign).Encode("utf-8"), Sha256()).HexDigest
```

Task 4: Add signing information to request and create request URL

After you calculate the signature, add it to the query string. For more information, see Add the Signature to the Request in the Amazon Web Services General Reference.

You can then use a WebSocket library to request the presigned URL. For an example WebSocket client to use with Python, see websocket-client 1.4.1.

```python
# Add the authentication information to the query string
canonical_querystring += "&X-Amz-Signature=" + signature

# Sign the string_to_sign using the signing key
request_url = endpoint + canonical_uri + '?' + canonical_querystring
```

Next steps

You can now use the request URL with your WebSocket library to make the request to the service and observe the messages. For a sample Python code that shows how to generate the presigned URL, see Sample Python code to generate presigned URL (p. 1330).

Sample Python code to generate presigned URL

The following code shows an example for generating the pre-signed URL using Python as the programming language.

Pre-requisites

To use the Python programming language to generate requests, you must have:

- Python installed on your computer. You can either run the following command or download the Python installer and then run it.
  ```bash
  sudo apt install python3
  ```
- The Python requests library. You can either run the following command or download the Requests library, which is used in the example script to make web requests.
pip install requests

- An access key that consists of the access key ID and secret access key in environment variables named AWS_ACCESS_KEY_ID and AWS_SECRET_ACCESS_KEY. Alternatively, you can keep these values in a credentials file and read them from that file.

  **Note**
  As a best practice, we recommend that you do not embed credentials in code. For more information, see Best Practices for AWS accounts in the AWS Account Management Reference Guide.

```bash
$ export AWS_ACCESS_KEY_ID=My_Access_Key
$ export AWS_SECRET_ACCESS_KEY=My_Secret_Key
```

- A network analyzer configuration created in your account. To run the script, you specify the name of your network analyzer configuration as a variable. This example refers to a configuration by the name My_Network_Analyzer_Config.

  **Note**
  If you don't specify a configuration name, the default configuration will be used, NetworkAnalyzerConfig_Default.

**Sample Python code**

The Python code generates the pre-signed URL that the WebSocket library can use to send requests to the service. The function creates a canonical request, then creates the string to sign which is used to calculate the signature, and then adds the signature to the HTTP request to create the pre-signed URL. You can then use the WebSocket library to request the pre-signed URL.

To run the script, generate_presigned_url.py, run the following command if you're running it from the same path where the script is located.

```bash
python generate_presigned_url.py
```

The following shows the contents of the generate_presigned_url.py script.

**Contents of generate_presigned_url.py**

```python
# Copyright Amazon.com, Inc. or its affiliates. All Rights Reserved.
# SPDX-License-Identifier: Apache-2.0

# Version 4 signing example

   Sample Python code to generate the pre-signed URL. You can change the parameters in this code to your own values, such as the variables that are required for the request URL, the network analyzer configuration name, and Region.

# Step 1. Import the required libraries and define the functions
# sign and getSignatureKey that will be used to derive a signing key.
#                           ____________________________________________
import sys, os, base64, datetime, hashlib, hmac, urllib.parse
```
import requests  
# pip install requests

def sign(key, msg):
    return hmac.new(key, msg.encode("utf-8"), hashlib.sha256).digest()

def getSignatureKey(key, dateStamp, regionName, serviceName):
    kDate = sign(("AWS4" + key).encode("utf-8"), dateStamp)
    kRegion = sign(kDate, regionName)
    kService = sign(kRegion, serviceName)
    kSigning = sign(kService, "aws4_request")
    return kSigning

# Step 2. Define the variables required for the request URL. Replace
# values for the variables, such as region, with your own values.
# ------------------------------------------------------------------
method = "GET"
service = "iotwireless"
region = "us-east-1"

# Host and endpoint information.
host = "api.iotwireless." + region + ".amazonaws.com"
endpoint = "wss://" + host

t = datetime.datetime.utcnow()
amz_date = t.strftime("%Y%m%dT%H%M%SZ")
datestamp = t.strftime("%Y%m%d")

# Step 3. Create the canonical URI and canonical headers for the request.
# -------------------------------------------------------------------
canonical_uri = "/start-network-analyzer-stream"
configuration_name = "My_Network_Analyzer_Config"

canonical_headers = "host:" + host + "\n"
signed_headers = "host"
algorithm = "AWS4-HMAC-SHA256"
credential_scope = datestamp + "/" + region + "/" + service + "/" + "aws4_request"

# IMPORTANT: Best practice is NOT to embed credentials in code.
access_key = os.environ.get("AWS_ACCESS_KEY_ID")
secret_key = os.environ.get("AWS_SECRET_ACCESS_KEY")
token = os.environ.get("AWS_SESSION_TOKEN")

if access_key is None or secret_key is None:
    print("No access key is available.")
sys.exit()

if access_key.startswith("ASIA") and token is None:
    print("Detected temporary credentials. You must specify a token.")
sys.exit()

# Step 5. Create the canonical query string. Query string values must be
# URI-encoded and sorted by name. Query headers must in alphabetical order.
# ----------------------------------------------------------------------
canonical_querystring  = "X-Amz-Algorithm=" + algorithm + "&X-Amz-Credential=
"
canonical_querystring += "&X-Amz-Credential=" + \
    urllib.parse.quote(access_key + "/" + credential_scope, safe="~-_.")

canonical_querystring += "&X-Amz-Date=" + amz_date
canonical_querystring += "&X-Amz-Expires=300"

if access_key.startswith("ASIA"):
    # percent encode the token and double encode ","
    canonical_querystring += "&X-Amz-Security-Token=" + \
        urllib.parse.quote(token, safe="-_.-~").replace("=", ",%253D")

canonical_querystring += "&X-Amz-SignedHeaders=" + signed_headers
canonical_querystring += "&configuration-name=" + configuration_name

# Step 6. Create a hash of the payload.
# ---------------------------------------------------------------------------
payload_hash = hashlib.sha256("".encode("utf-8")).hexdigest()

# Step 7. Combine the elements, which includes the query string, the
# headers, and the payload hash, to form the canonical request.
# ---------------------------------------------------------------------------
canonical_request = method + "\n" + canonical_uri + "\n" + canonical_querystring + "\n" + canonical_headers + "\n" + signed_headers + "\n" + payload_hash

# Step 8. Create the metadata string to store the information required to
# calculate the signature in the following step.
# ---------------------------------------------------------------------------
string_to_sign = algorithm + "\n" + amz_date + "\n" + \
    credential_scope + "\n" + hashlib.sha256(canonical_request.encode("utf-8")).hexdigest()

# Step 9. Calculate the signature by using a signing key that"s obtained
# from your secret key.
# ---------------------------------------------------------------------------

# Create the signing key from your secret key.
signing_key = getSignatureKey(secret_key, datestamp, region, service)

# Sign the string_to_sign using the signing key.
signature = hmac.new(signing_key, (string_to_sign).encode("utf-8"),
                    hashlib.sha256()).hexdigest()

# Step 10. Create the request URL using the calculated signature and by
# combining it with the canonical URI and the query string.
# ---------------------------------------------------------------------------
canonical_querystring += "&X-Amz-Signature=" + signature

request_url = endpoint + canonical_uri + "?" + canonical_querystring

print("\n-----------PRESIGNED URL-----------")
print(request_url)

Next steps

You can now use the request URL with your WebSocket library to make the request to the service and
observe the messages.

To install a WebSocket library to use with Python, run the following command. For information about
how you can use a WebSocket client with Python, see WebSocket client for Python with low level API
options.
After you install the client and make the request, you'll see messages and status codes that indicate the status of your request. For more information, see WebSocket messages and status codes (p. 1334).

### WebSocket messages and status codes

After you've created a presigned request, you can use the request URL with your WebSocket library, or a library that's suited to your programming language, to make requests to the service. For more information about how you can generate this presigned request, see Generate a presigned request with the WebSocket library (p. 1326).

#### WebSocket messages

The WebSocket protocol can be used to establish a bi-directional connection. Messages can be transmitted from client to server and from server to client. However, network analyzer supports only messages that are sent from server to client. Any message received from the client is unexpected and the server will automatically close the WebSocket connection if a message is received from client.

When the request is received and a trace messaging session has started, the server responds with a JSON structure, which is the payload. For more information about the payload and how you can activate trace messaging from the AWS Management Console, see View and monitor network analyzer trace message logs in real time (p. 1335).

#### WebSocket status codes

The following shows the WebSocket status codes for the communication from the server to client. The WebSocket status codes follow the RFC Standard of Normal closure of connections.

The following shows the supported status codes:

- **1000**
  
  This status code indicates a normal closure, which means that the WebSocket connection has been established and the request has been fulfilled. This status can be observed when a session is idle, causing the connection to time out.

- **1002**
  
  This status code indicates that the endpoint is terminating the connection because of a protocol error.

- **1003**
  
  This status code indicates an error status where the endpoint terminated the connection because it received data in a format that it can't accept. The endpoint supports only text data and might display this status code if it receives a binary message or a message from the client that's using an unsupported format.

- **1008**
  
  This status code indicates an error status where the endpoint terminated the connection because it received a message that violates its policy. This status is generic and is displayed when the other status codes, such as 1003 or 1009, aren't applicable. You'll also see this status displayed if there's a need to hide the policy, or when there's an authorization failure, such as an expired signature.

- **1011**
  
  This status code indicates an error status where the server is terminating the connection because it encountered an unexpected condition or internal error that prevented it from fulfilling the request.
Next steps

Now that you've learned how to generate a presigned request and how you can observe messages from the server by using the WebSocket connection, you can activate trace messaging and start receiving message logs for your wireless gateway and wireless device resources. For more information, see View and monitor network analyzer trace message logs in real time (p. 1335).

View and monitor network analyzer trace message logs in real time

If you've added resources to your network analyzer configuration, you can activate trace messaging to start receiving trace messages for your resources. You can use either the AWS Management Console, the AWS IoT Wireless API, or the AWS CLI.

Prerequisites

Before you can activate trace messaging by using network analyzer, you must have:

- Added the resources that you want to monitor to your default network analyzer configuration. For more information, see Add resources and update the network analyzer configuration (p. 1324).
- Generated a presigned request by using the StartNetworkAnalyzerStream request URL. The request will be signed using the credentials for the AWS Identity and Access Management role that makes this request. For more information, see Create a presigned URL (p. 1327)

Activate trace messaging by using the console

To activate trace messaging

1. Open the Network Analyzer hub of the AWS IoT console and choose your network analyzer configuration, NetworkAnalyzerConfig_Default.
2. In the details page of your network analyzer configuration, choose Activate trace messaging and then choose Activate.

You'll start receiving trace messages where the newest trace message appears first in the console.

Note

After the messaging session starts, receiving trace messages can incur additional costs until you deactivate the session or leave the trace session. For more information about pricing, see AWS IoT Core pricing.

View and monitor trace messages

After you activate trace messaging, the WebSocket connection is established and trace messages start appearing in real time, newest first. You can customize the preferences to specify the number of trace messages to be displayed in each page and to display only the relevant fields for each message. For example, you can customize the trace message log to show only logs for wireless gateway resources that have Log level set to ERROR, so that you can quickly identify and debug errors with your gateways. The trace messages contain the following information:

- **Message Number**: A unique number that shows the last message received first.
- **Resource ID**: The wireless gateway or wireless device ID of the resource.
- **Timestamp**: The time when the message was received.
- **Message ID**: An identifier that AWS IoT Core for LoRaWAN assigns to each received message.
- **FPort**: The frequency port for communicating with the device by using the WebSocket connection.
- **DevEui**: The extended unique identifier (EUI) for your wireless device.
- **Resource**: Whether the monitored resource is a wireless device or a wireless gateway.
- **Event**: The event for a log message for a wireless device, which can be Join, Rejoin, Uplink_Data, Downlink_Data, or Registration.
- **Log level**: Information about INFO or ERROR log streams for your device.

### Network analyzer JSON log message

You can also choose one trace message at a time to view the JSON payload for that message. Depending on the message that you select in the trace message logs, you'll see information in the JSON payload that indicates contains 2 parts: **CustomerLog** and **LoRaFrame**.

#### CustomerLog

The **CustomerLog** part of the JSON displays the type and identifier of the resource that received the message, the log level, and the message content. The following example shows a **CustomerLog** log message. You can use the message field in the JSON to get more information about the error and how it can be resolved.

#### LoRaFrame

The **LoRaFrame** part of the JSON has a **Message ID** and contains information about the physical payload for the device and the wireless metadata.

The following shows the structure of the trace message.

**Note**

If your devices send an uplink message without a value for Fport, AWS IoT Core for LoRaWAN network analyzer will display an fPort value of 225 in the trace message received.

```typescript
export type TraceMessage = {
  ResourceId: string;
  Timestamp: string;
  LoRaFrame:
  {
    MessageId: string;
    PhysicalPayload: any;
    WirelessMetadata:
    {
      fPort: number;
      dataRate: number;
      devEui: string;
      frequency: number,
      timestamp: string;
    },
  },
  CustomerLog:
  {
    resource: string;
    wirelessDeviceId: string;
    wirelessDeviceType: string;
    event: string;
    logLevel: string;
    messageId: string;
    message: string;
  },
};
```
Review and next steps

In this section, you've viewed trace messages and learned how you can use the information to debug errors. After you've viewed all messages, you can:

- **Deactivate trace messaging**

  To avoid incurring any additional costs, you can deactivate the trace messaging session. Deactivating the session disconnects your WebSocket connection so you won't receive any additional trace messages. You can still continue viewing the existing messages in the console.

- **Edit frame info for your configuration**

  You can edit the network analyzer configuration and choose whether to deactivate frame info and choose the log levels for your messages. Before you update your configuration, consider deactivating your trace messaging session. To make these edits, open the Network Analyzer details page in the AWS IoT console and choose **Edit**. You can then update your configuration with the new configuration settings and activate trace messaging to see the updated messages.

- **Add resources to your configuration**

  You can also add more resources to your network analyzer configuration and monitor them in real time. You can add up to a combined total of 250 wireless gateway and wireless device resources. To add resources, on the Network Analyzer details page of the AWS IoT console, choose the **Resources** tab and choose **Add resources**. You can then update your configuration with the new resources and activate trace messaging to see the updated messages for the additional resources.

For more information about updating your network analyzer configuration by editing the configuration settings and adding resources, see [Add resources and update the network analyzer configuration](p. 1324).

Debug and troubleshoot your multicast groups and FUOTA tasks using network analyzer

The wireless resources that you can monitor using network analyzer include LoRaWAN devices, LoRaWAN gateways, and multicast groups. You can also use network analyzer to debug and troubleshoot any issues with your FUOTA task. You can also monitor and track messages related to setup, data transmission, and status query when the FUOTA task is in progress.

To monitor your FUOTA task, if the task contains multicast groups, you must add both the multicast group and the devices in the group to your network analyzer configuration. You must also activate frame info and multicast frame info. This allows you to track the unicast and multicast messages that are exchanged with the multicast group and the devices while the FUOTA task is in progress.

To monitor multicast groups, you can add them to your network analyzer configuration. You can use multicast frame info to troubleshoot multicast downlink messages that are sent to these groups. For troubleshooting devices that are attempting to join a group where unicast communication is used, you must also include these devices in the network analyzer configuration. To monitor only the unicast communication with the devices in the group, activate the frame info for your wireless devices. This approach ensures comprehensive monitoring and diagnostics for both multicast groups and devices that are joining the group.

The following sections describe how to debug and troubleshoot your multicast groups and FUOTA tasks using network analyzer.
Debug your multicast groups and FUOTA tasks using network analyzer

Topics
- Debug FUOTA tasks that only contain devices (p. 1338)
- Debug FUOTA tasks with multicast groups (p. 1338)
- Debug devices that are attempting to join a multicast group (p. 1338)
- Debug a multicast group session (p. 1339)

Debug FUOTA tasks that only contain devices

You can use network analyzer to debug a FUOTA task that only has LoRaWAN devices added to the task. For information about adding devices to a FUOTA task, see Add devices and multicast groups to a FUOTA task and schedule a FUOTA session (p. 1313). To debug the FUOTA task, perform the following steps:

1. Create a network analyzer configuration by activating frame info for the wireless devices. This allows you to monitor the FUOTA uplink and downlink messages that are exchanged with the devices while the task is in progress.
2. Add the devices in your FUOTA task to the network analyzer configuration by using their wireless device identifiers.
3. Activate trace messaging to start receiving trace messages for the devices in your network analyzer configuration.

In the applicationCommandType column of the trace message information, you'll receive unicast downlink messages related to data transmission and fragmentation setup.

Note
If you don't see the applicationCommandType column in the trace message table, you can adjust the table settings to show this column.

You can also see the applicationCommandType and other detailed messages in the JSON log message under WirelessMetadata > ApplicationInfo.

Debug FUOTA tasks with multicast groups

You can use network analyzer to debug a FUOTA task that has multicast groups and LoRaWAN devices added to the group. For information about adding devices to a FUOTA task, see Add devices and multicast groups to a FUOTA task and schedule a FUOTA session (p. 1313). To debug the FUOTA task, perform the following steps:

1. Create a network analyzer configuration by activating the frame info and multicast frame info settings for the wireless devices and multicast groups.
2. Add the multicast group in your FUOTA task to the network analyzer configuration by using their multicast group identifier. By enabling multicast frame info, you can debug the firmware data message and FUOTA status query messages that are sent to the group while the FUOTA task is in progress.
3. Add the devices in your multicast group to the network analyzer configuration by using their wireless device identifiers. By activating frame info, you can monitor uplink and downlink messages that are exchanged directly with the devices while the FUOTA task is in progress.
4. Activate trace messaging to start receiving trace messages for the devices and multicast groups in your network analyzer configuration.

You can then view the trace messages and debug them using the applicationCommandType column of the trace message table. You can also use the details in the JSON log message as described in Debug FUOTA tasks that only contain devices (p. 1338).
Debug devices that are attempting to join a multicast group

You can use network analyzer to debug devices that are attempting to join a multicast group. For information about adding devices to a multicast group, see Create multicast groups and add devices to the group (p. 1301). To debug the multicast group, perform the following steps:

1. Create a network analyzer configuration by activating frame info for the wireless devices.
2. Add the devices you want to monitor to the network analyzer configuration by using their wireless device identifiers.
3. Activate trace messaging to start receiving trace messages for the devices in your network analyzer configuration.
4. Start associating the devices to the multicast group after trace messaging has been activated for the devices in the group.

Debug a multicast group session

You can use network analyzer to debug a multicast group session. For more information, see Schedule a downlink message to send to devices in your multicast group (p. 1306). To debug a multicast group session, perform the following steps:

1. Create a network analyzer configuration by activating multicast frame info for the multicast group.
2. Add the multicast group that you want to monitor to the network analyzer configuration by using their multicast group identifier.
3. Before the multicast session starts, activate trace messaging to start receiving trace messages for the multicast group session.
4. Start the multicast group session and monitor the status by viewing the messages that are displayed in the trace message table and the JSON log message.

In the trace message table, the MulticastAddr will be displayed in the DevAddr column. In the JSON log message, you can view detailed information such as the MulticastGroupId under WirelessMetadata > ApplicationInfo.

Data security with AWS IoT Core for LoRaWAN

Two methods secure the data from your AWS IoT Core for LoRaWAN devices:

- The security that wireless devices use to communicate with the gateways.

  The LoRaWAN devices follow the security practices described in LoRaWAN™ SECURITY: A White Paper Prepared for the LoRa Alliance™ by Gemalto, Actility, and Semtech to communicate with the gateways.

- The security that AWS IoT Core uses to connect gateways to AWS IoT Core for LoRaWAN and send the data to other AWS services.

  AWS IoT Core security is described in Data protection in AWS IoT Core (p. 385).

How data is secured throughout the system

This diagram identifies the key elements in a LoRaWAN system connected to AWS IoT Core for LoRaWAN to identify how data is secured throughout.
LoRaWAN device and gateway transport security

LoRaWAN devices and AWS IoT Core for LoRaWAN store pre-shared root keys. Session keys are derived by both LoRaWAN devices and AWS IoT Core for LoRaWAN following the protocols. The symmetric session keys are used for encryption and decryption in a standard AES-128 CTR mode. A 4-byte message integrity code (MIC) is also used to check the data integrity following a standard AES-128 CMAC algorithm. The session keys can be updated by using the Join/Rejoin process.

The security practice for LoRa gateways is described in the LoRaWAN specifications. LoRa gateways connect to AWS IoT Core for LoRaWAN through a web socket using a Basics Station. AWS IoT Core for LoRaWAN supports only Basics Station version 2.0.4 and later.

Before the web socket connection is established, AWS IoT Core for LoRaWAN uses the TLS Server and Client Authentication mode to authenticate the gateway. AWS IoT Core for LoRaWAN also maintains a Configuration and Update Server (CUPS) that configures and updates the certificates and keys used for TLS authentication.
AWS IoT Core for Amazon Sidewalk

AWS IoT Core for Amazon Sidewalk provides the cloud services that you can use to connect your Sidewalk end devices to the AWS Cloud and use other AWS services.

Amazon Sidewalk is a secure, shared network that enables devices in your community to get connected and stay connected. Amazon Sidewalk transfers data between Sidewalk end devices and Sidewalk gateways, and between Sidewalk gateways and the Sidewalk cloud.

How to use AWS IoT Core for Amazon Sidewalk?

You can onboard your Sidewalk end devices to AWS IoT by using the console or the AWS IoT Wireless API operations. After your devices are onboarded, their messages are sent to AWS IoT Core. You can then start developing your business applications on the AWS Cloud, which uses the data from your Amazon Sidewalk end devices.

Using the console

To onboard your Sidewalk end devices, sign in to the AWS Management Console and navigate to the Devices page on the AWS IoT console. After your devices are onboarded, you can view and manage them on this page of the IoT console.

Using the API or CLI

You can onboard both Sidewalk and LoRaWAN devices by using the AWS IoT Wireless API operations. The AWS IoT Wireless API that AWS IoT Core is built on is supported by the AWS SDK. For more information, see AWS SDKs and Toolkits.

You can use the AWS CLI to run commands for onboarding and managing your Sidewalk end devices. For more information, see AWS IoT Wireless CLI reference.

AWS IoT Core for Amazon Sidewalk Regions and endpoints

Amazon Sidewalk is only available in the us-east-1 AWS Region. AWS IoT Core for Amazon Sidewalk provides support for control plane and data plane API endpoints in this Region. The data plane API endpoints are specific to your AWS account. For more information, see see AWS IoT Wireless Service endpoints in the AWS General Reference.

AWS IoT Core for Amazon Sidewalk has quotas that apply to device data that is transmitted between the device and the AWS Cloud, and the maximum TPS for the AWS IoT Wireless API operations. For more information, see AWS IoT Wireless quotas in the AWS General Reference.

AWS IoT Core for Amazon Sidewalk pricing

When you sign up for AWS, you can get started with AWS IoT Core for Amazon Sidewalk for no charge by using the AWS Free Tier.

For more information about general product overview and pricing, see AWS IoT Core pricing.
What is AWS IoT Core for Amazon Sidewalk?

With AWS IoT Core for Amazon Sidewalk, you can onboard your Amazon Sidewalk end devices to AWS IoT and manage and monitor them. It also manages the destinations that send device data to other AWS services.

Features of AWS IoT Core for Amazon Sidewalk

Using AWS IoT Core for Amazon Sidewalk, you can:

- Onboard your Sidewalk end devices to AWS IoT using the AWS IoT console, AWS IoT Core for Amazon Sidewalk API operations, or AWS CLI commands.
- Leverage the capabilities offered by the AWS Cloud.
- Create a destination that uses AWS IoT rules to process incoming payload messages and to interact with other AWS services.
- Enable event notifications to receive messages about events such as when your Sidewalk end device has been provisioned or registered, or whether a downlink message has been successfully delivered to your device.
- Log and monitor your Sidewalk end devices in real time, obtain useful insights, and identify and troubleshoot errors.
- Associate your Sidewalk end devices with an AWS IoT thing, which helps you store a representation of your device on the cloud. Things in AWS IoT make it easier to search and manage your features, and access other AWS IoT Core features.

Topics

- What is Amazon Sidewalk? (p. 1342)
- How AWS IoT Core for Amazon Sidewalk works (p. 1343)

What is Amazon Sidewalk?

Amazon Sidewalk is a secure community network that uses Amazon Sidewalk Bridges, such as compatible Amazon Echo and Ring devices, to provide cloud connectivity for IoT devices. Amazon Sidewalk enables low-bandwidth and long-range connectivity at home and beyond using Bluetooth LE for short-distance communication and LoRa and FSK radio protocols at 900MHz frequencies to cover longer distances.

When Amazon Sidewalk is enabled, this network can support other Sidewalk end devices in your community, and can be used for applications such as sensing your environment. Amazon Sidewalk helps your devices get and stay connected.

Features of Amazon Sidewalk

The following are features of Amazon Sidewalk.

- Amazon Sidewalk creates a low-bandwidth network using Sidewalk gateways that include Ring and select Echo devices. Using gateways, you can share a portion of your internet bandwidth, which is then used to connect your end devices to the network.
- Amazon Sidewalk offers a secure networking mechanism with multiple layers of encryption and security.
- Amazon Sidewalk offers a simple mechanism to enable or disable participation in Sidewalk.
Amazon Sidewalk concepts

The following are some key concepts of Amazon Sidewalk.

Sidewalk gateways

Sidewalk gateways, or Amazon Sidewalk bridges, route data between your Sidewalk end devices and the cloud. Gateways are Amazon devices, such as the Echo device or the Ring Floodlight Cam, that support SubG-CSS (asynchronous, LDR), SubG-FSK (synchronous, HDR), or Bluetooth LE for Sidewalk communication. Sidewalk gateways share a portion of your internet bandwidth with the Sidewalk community to provide connectivity to a group of Sidewalk-enabled devices.

Sidewalk end devices

Sidewalk end devices roam on Amazon Sidewalk by connecting to Sidewalk gateways. The end devices are low-bandwidth, low-power smart products, such as Sidewalk-enabled lights or door locks.

Note
Certain Sidewalk gateways can also act as end devices.

Sidewalk Network Server

The Sidewalk Network Server, operated by Amazon, verifies the incoming packets and routes uplink and downlink messages to the desired destination, while keeping the Sidewalk network time-synchronized.

Learn more about Amazon Sidewalk

For more information about Amazon Sidewalk, see the following web pages:

- Amazon Sidewalk
- Amazon Sidewalk documentation
- AWS IoT Core for Amazon Sidewalk

How AWS IoT Core for Amazon Sidewalk works

With AWS IoT Core for Amazon Sidewalk, you can onboard your Amazon Sidewalk end devices to AWS IoT and manage and monitor them. It also manages the destinations that send device data to other AWS services.

AWS IoT Core for Amazon Sidewalk provides the cloud services that you can use to connect your Sidewalk end devices to the AWS Cloud and use other AWS services. You can also use AWS IoT Core for Amazon Sidewalk to manage your Sidewalk devices, and monitor and build applications on them.

Sidewalk end devices communicate with AWS IoT Core through Sidewalk gateways. AWS IoT Core for Amazon Sidewalk manages the service and device policies that AWS IoT Core requires to manage and communicate with the Sidewalk end devices and gateways. It also manages the destinations that send device data to other AWS services.
Get started using AWS IoT Core for Amazon Sidewalk

You can use the AWS IoT console, the AWS IoT Core for Amazon Sidewalk API, or the AWS CLI to create and onboard Sidewalk end devices and connect them to the Sidewalk network. For information about getting started with Amazon Sidewalk and onboarding end devices to AWS IoT, see the following topics.

- **Getting started with AWS IoT Core for Amazon Sidewalk (p. 1345)**
  This topic walks through the prerequisites for onboarding your Sidewalk end devices, illustrates the workflow using a sensor monitoring application, and provides an overview of how to onboard your device using AWS CLI commands.

- **Connecting Sidewalk devices to AWS IoT Core for Amazon Sidewalk (p. 1351)**
  This section describes the different steps in the onboarding workflow introduction, and walks through onboarding your end devices using the console, and the API operations. You'll also connect your device and view messages that are exchanged between your device and AWS IoT Core for Amazon Sidewalk.

- **Bulk provisioning devices with AWS IoT Core for Amazon Sidewalk (p. 1365)**
  This section provides a detailed step-by-step tutorial for bulk provisioning your Sidewalk end devices using AWS IoT Core for Amazon Sidewalk. You'll learn the bulk provisioning workflow, and how to onboard a large number of Sidewalk devices.

Learn more about AWS IoT Core for Amazon Sidewalk

For more information about AWS IoT Core for Amazon Sidewalk, see the following web pages:

- [Amazon Sidewalk](#)
- [Amazon Sidewalk documentation](#)
- [AWS IoT Core for Amazon Sidewalk](#)
Getting started with AWS IoT Core for Amazon Sidewalk

This section shows you how to get started with connecting your Sidewalk end devices to AWS IoT Core for Amazon Sidewalk. It explains how you can connect an end device to Amazon Sidewalk and pass messages between them. You’ll also learn about the Sidewalk sample application and an overview of how to perform sensor monitoring using AWS IoT Core for Amazon Sidewalk. The sample application provides you with a dashboard to view and monitor changes to the sensor temperature.

Try the sensor monitoring tutorial

This section provides you an overview of the Amazon Sidewalk sample application on GitHub that shows you how to monitor the temperature of a sensor. In this tutorial, you use scripts that programmatically create the required wireless resources, provision the end device and flash the binaries, and then connect your end device to the application. The scripts that use the AWS CLI and Python commands create an AWS CloudFormation stack and wireless resources, and then flash the binaries and deploy the application onto your hardware development kit (HDK).

The following diagram shows the steps are involved when you run the sample application and connect your Sidewalk end device to the application. For detailed instructions including pre-requisites and configuration for this tutorial, see the README document in GitHub.

The following are performed in this section:

Topics
- Setting up to use AWS IoT Core for Amazon Sidewalk (p. 1346)
- Describing your Sidewalk resources (p. 1347)
Setting up to use AWS IoT Core for Amazon Sidewalk

Before you connect your Sidewalk end device, you must set up your AWS account and configure the AWS CLI.

**Important**
To perform the entire onboarding workflow for provisioning and registering your Sidewalk end device, you must also set up your Sidewalk gateway and the HDK. For instructions, see Setting up the hardware development kit (HDK) and Setting up a Sidewalk gateway in the Amazon Sidewalk documentation.

**Topics**
- Install Python and Python3-pip (p. 1346)
- Setting up your account and AWS CLI (p. 1347)

**Install Python and Python3-pip**

To use the AWS CLI and boto3 as described in the next section, you must use a Python version 3.6 or later. If you want to onboard your end devices using the AWS IoT console, you can skip this section and continue to setting up your AWS account. To check whether you’ve already installed Python and Python3-pip, run the following commands. If running these commands return the version, it means that Python and Python3-pip have been installed correctly.

```bash
python3 -V
pip3 --version
```

If this command returns an error, it might be because Python is not installed, or your operating system calls the Python v3.x executable as Python3. In that case, replace all instances of python with python3 when you run the commands. If it still produces an error, either download and run the Python installer, or install Python depending on your operating system as described below.

**Windows**

On your Windows machine, download Python from the Python website and then run the installer to install Python on your machine.

**Linux**

On your Ubuntu machine, run the following sudo command to install Python.

```
sudo apt install python3
sudo apt install python3-pip
```

**macOS**

On your Mac machine, use Homebrew to install Python. Homebrew also installs pip, which then points to the installed Python3 version.

```
$ brew install python
```
Setting up your account and AWS CLI

The following steps show you how to configure your AWS account, AWS CLI, and boto3 (AWS SDK for Python).

1. **Set up your AWS account**
   
   To use AWS IoT Core for Amazon Sidewalk, sign up for an AWS account and create an administrative user. For instructions, see Set up your AWS account (p. 18).

2. **Install and configure the AWS CLI**
   
   You can use the AWS CLI to programmatically onboard your Sidewalk end devices to AWS IoT Core for Amazon Sidewalk. If you want to onboard your devices using the AWS IoT console, you can skip this section. Open the AWS IoT Core console and then continue to the next section to get started with connecting your devices to AWS IoT Core for Amazon Sidewalk. For instructions on configuring the AWS CLI, see Installing and configuring the AWS CLI.

3. **Install boto3 (AWS SDK for Python)**
   
   The following commands show you how to install boto3 (AWS SDK for Python) and the AWS CLI. You’ll also install botocore, which is required to run boto3. For detailed instructions, see Installing Boto3 in the Boto3 Documentation Guide.

   **Note**
   
   awscli version 1.26.6 requires PyYAML version that's 3.10 or later, but not later than 5.5.

   ```
   python3 -m pip install botocore-version-py3-none-any.whl
   python3 -m pip install boto3-version-py3-none-any.whl
   ```

4. **Configure your credentials and default Region**
   
   Configure your credentials and default Region in the ~/.aws/credentials and ~/.aws/config files. The boto3 library uses these credentials to identify your AWS account and authorize API calls. For configuration instructions, see:
   
   - Configuration in the Boto3 Documentation Guide
   - Configuration and credentials file settings in the AWS CLI Documentation Guide

Describing your Sidewalk resources

Before you get started and create resources, we recommend that you consider the naming convention of your resources. Your wireless resources can include Sidewalk end devices, device profiles, or destinations. AWS IoT Core for Amazon Sidewalk assigns a unique identifier to the resources that you create. However, you can give them more descriptive names, add a description, or add optional tags to help identify and manage them.

The following sections show the various Sidewalk resources and their length constraints.

**Topics**

- Resource names and description (p. 1347)
- Resource tags (p. 1348)

Resource names and description

Sidewalk resources can have a name of up to 256 characters. For Sidewalk end devices and profiles, the resource name is optional and can be changed after the resource has been created. For destinations,
provide a name that's unique to your AWS account and AWS Region. The destination name can't be changed after you create it. We recommend that you use short, meaningful names to help you identify your resource. For example, if your Sidewalk end device is used for object location, you can specify a name such as *Sidewalk_Object_Locator_Device*.

In the AWS IoT console, the name field appears in the resource hub list of resources. When selecting names for your resources, consider how you want them to be identified and displayed on the console. As space is limited in the console, only the first 15-30 characters might be visible.

### Sidewalk name field constraints

<table>
<thead>
<tr>
<th>Resource name</th>
<th>Name field constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Name is a unique ID and can't be changed.</td>
</tr>
<tr>
<td>Sidewalk end device</td>
<td>Name is an optional descriptor and can be changed after the resource has been created.</td>
</tr>
<tr>
<td>Device profile</td>
<td>Name is an optional descriptor and can be changed after the resource has been created.</td>
</tr>
</tbody>
</table>

Destinations, end devices, and profiles also support a description field, which can have up to 2,048 characters. While the description field can hold a lot of information, it appears only in the details page of your resource in the AWS IoT console, and might not be convenient for scanning in the context of multiple resources. To help you identify and manage your resources, we recommend that you provide a short, meaningful description. For example, if your destination republishes sensor data to an IoT topic, you can specify a description such as *Sidewalk destination to republish sensor data*.

### Resource tags

Tags are words or phrases that act as metadata that you can use to identify and organize your AWS resources. Tags can help you categorize your resources. You choose tag keys and their corresponding values.

Destinations and profiles can have up to 50 AWS tags attached to them. Sidewalk devices don't support tags. For example, you can define a set of tags for a group of profiles that are associated with a particular set of Sidewalk end devices. To more easily manage your resources, we recommend that you create a consistent set of tag keys that meets your needs for each kind of resource. The following table shows the supported tags for your Sidewalk resources.

### Sidewalk tag limits

<table>
<thead>
<tr>
<th>Resource name</th>
<th>Tag limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination</td>
<td>Up to 50 AWS tags can be added to each resource.</td>
</tr>
<tr>
<td>Sidewalk device</td>
<td>This resource doesn't support tags.</td>
</tr>
<tr>
<td>Device profile</td>
<td>Up to 50 AWS tags can be added to each resource.</td>
</tr>
</tbody>
</table>

You can think of the tag key as a category of information and the tag value as a specific value in that category. For example, you might have a tag value of *color* and then give some resources a value of *blue* for that tag and others a value of *red*. With that, you could use the Tag Editor in the AWS Management Console to find the resources with a color tag value of *blue*.

For more information about tagging and tagging strategies, see [Tag editor](#).
Introduction to onboarding your Sidewalk devices

This section shows you how to onboard your Sidewalk end devices to AWS IoT Core for Amazon Sidewalk. To onboard your devices, first add your Sidewalk device, then provision and register your device, and then connect your hardware to the cloud application. Before running this tutorial, review and complete Setting up to use AWS IoT Core for Amazon Sidewalk (p. 1346).

The following steps show you how to onboard and connect your Sidewalk end devices to AWS IoT Core for Amazon Sidewalk. If you want to onboard devices using the AWS CLI, you can refer to the sample commands provided in this section. For information about onboarding devices using the AWS IoT console, see Connecting Sidewalk devices to AWS IoT Core for Amazon Sidewalk (p. 1351).

Important
To perform the entire onboarding workflow, you also provision and register your end device, and connect your hardware development kit (HDK). For more information, see Provisioning and registering your end device in the Amazon Sidewalk documentation.

Topics
- Step 1: Add your Sidewalk device to AWS IoT Core for Amazon Sidewalk (p. 1349)
- Step 2: Create a destination for your Sidewalk end device (p. 1350)
- Step 3: Provision and register the end device (p. 1350)
- Step 4: Connect to Sidewalk end device and exchange messages (p. 1351)

Step 1: Add your Sidewalk device to AWS IoT Core for Amazon Sidewalk

Here's an overview of the steps that you'll perform to add your Sidewalk end device to AWS IoT Core for Amazon Sidewalk. Store the information you obtain about the device profile and the wireless device that you create. You'll use this information to provision and register the end device. For more information about these steps, see Add your device to AWS IoT Core for Amazon Sidewalk (p. 1352).

1. **Create a device profile**

   Create a device profile that contains the shared configurations for your Sidewalk devices. When creating the profile, specify a name for the profile as an alphanumeric string. To create a profile, either go to the Sidewalk tab of the Profiles hub in the AWS IoT console and choose Create profile, or use the CreateDeviceProfile API operation or the create-device-profile CLI command as shown in this example.

   ```
   // Add your device profile using a name and the sidewalk object.
   aws iotwireless create-device-profile --name sidewalk_profile --sidewalk {} 
   ```

2. **Create your Sidewalk end device**

   Create your Sidewalk end device with AWS IoT Core for Amazon Sidewalk. Specify a destination name and the ID of the device profile obtained from the previous step. To add a device, either go to the Sidewalk tab of the Devices hub in the AWS IoT console and choose Provision device, or use the CreateWirelessDevice API operation or the create-wireless-device CLI command as shown in this example.

   ```
   // Add your Sidewalk device by using the device profile ID. 
   ```
aws iotwireless create-wireless-device --type "Sidewalk" --name sidewalk_device
--destination-name SidewalkDestination
--sidewalk DeviceProfileId="12345678-234a-45bc-67de-e8901234f0a1"

3. Get device profile and wireless device information

Get the device profile and wireless device information as a JSON. The JSON will contain information about the device details, device certificates, private keys, DeviceTypeId, and the Sidewalk manufacturing serial number (SMSN).

- If you're using the AWS IoT console, you can use the Sidewalk tab of the Devices hub to download a combined JSON file for your Sidewalk end device.
- If you're using the API operations, store the responses obtained from the API operations GetDeviceProfile and GetWirelessDevice as separate JSON files, such as device_profile.json and wireless_device.json.

```java
// Store device profile information as a JSON file.
aws iotwireless get-device-profile
--id "12345678-a1b2-3c45-67d8-e90fa1b2c34d" > device_profile.json

// Store wireless device information as a JSON file.
aws iotwireless get-wireless-device --identifier-type WirelessDeviceId
--identifier "23456789-abcd-0123-bcde-fabc012345678" > wireless_device.json
```

**Step 2: Create a destination for your Sidewalk end device**

Here's an overview of the steps that you'll perform to add your destination to AWS IoT Core for Amazon Sidewalk. Using the AWS Management Console, or the AWS IoT Wireless API operations, or the AWS CLI, you run the following steps to create an AWS IoT rule and destination. You can then connect to the hardware platform, and view and exchange messages. For a sample IAM role and AWS IoT rule used for the AWS CLI examples in this section, see [Create an IAM role and IoT rule for your destination](p. 1361).

1. **Create IAM role**

Create an IAM role that grants AWS IoT Core for Amazon Sidewalk permission to send data to the AWS IoT rule. To create the role, use the CreateRole API operation or create-role CLI command. You can name the role as SidewalkRole.

```bash
aws iam create-role --role-name lambda-ex
--assume-role-policy-document file://lambda-trust-policy.json
```

2. **Create a rule for the destination**

Create an AWS IoT rule that will process the device's data and specify the topic to which messages are published. You'll observe messages on this topic after connecting to the hardware platform. Use the AWS IoT Core API operation, CreateTopicRule, or the AWS CLI command, create-topic-rule, to create a rule for the destination.

```bash
aws iot create-topic-rule --rule-name SidewalkRule
--topic-rule-payload file://myrule.json
```

3. **Create a destination**

Create a destination that associates your Sidewalk device with the IoT rule that processes it for use with other AWS services. You can add a destination using the Destinations hub of the AWS IoT console, or the CreateDestination API operation or the create-destination CLI command.
Step 3: Provision and register the end device

Using Python commands, you can provision and register your end device. The provisioning script uses the device JSON data that you obtained to generate a manufacturing binary image, which is then flashed on the hardware board. You then register your end device for connecting to the hardware platform. For more information, see Provisioning and registering your end device in the Amazon Sidewalk documentation.

Note
When registering your Sidewalk end device, your gateway must be opted in to Amazon Sidewalk, and your gateway and device must be in range of each other.

Step 4: Connect to Sidewalk end device and exchange messages

After you’ve registered your end device, you can then connect your end device and start exchanging messages and device data.

1. Connect your Sidewalk end device

   Connect the HDK to your computer and follow the instructions provided by the vendor documentation to connect to your HDK. For more information, see Provisioning and registering your end device in the Amazon Sidewalk documentation.

2. View and exchange messages

   Use the MQTT client to subscribe to the topic specified in the rule and view the message received. You can also use the SendDataToWirelessDevice API operation or the send-data-to-wireless-device CLI command to send a downlink message to your device and verify the connectivity status.

   (Optional) You can enable the message delivery status event to check whether the downlink message was successfully received.

Connecting Sidewalk devices to AWS IoT Core for Amazon Sidewalk

This section shows you how to onboard your Sidewalk end device and then connect your device to the Sidewalk network. It describes the steps that you perform in the onboarding tutorial, as mentioned in Introduction to onboarding your Sidewalk devices (p. 1349). You’ll learn how to onboard devices by using the AWS IoT console and the AWS IoT Core for Amazon Sidewalk API operations. You’ll also learn about the AWS CLI commands that perform these operations.
Prerequisites

To add your end device and destination to AWS IoT Core for Amazon Sidewalk, you must set up your AWS account. To perform these operations using the AWS IoT Wireless API or the AWS CLI commands, you must also set up the AWS CLI. For more information about the prerequisites and setting up, see Setting up to use AWS IoT Core for Amazon Sidewalk (p. 1346).

Note
To perform the entire onboarding workflow for provisioning and registering your end device, and connecting to your hardware development kit (HDK), you must also set up your Sidewalk gateway and HDK. For more information, see Setting up the hardware development kit (HDK) and Setting up a Sidewalk gateway in the Amazon Sidewalk documentation.

Describing your Sidewalk resources

Before you get started and create the resources, we recommend that you consider the naming convention of your Sidewalk end devices, device profiles, and destinations. AWS IoT Core for Amazon Sidewalk assigns a unique identifier to the resources that you create. However, you can give them more descriptive names, add a description, or add optional tags to help identify and manage them.

Note
The destination name can't be changed after it's created. Use a name that's unique to your AWS account and AWS Region.

For more information, see Describing your Sidewalk resources (p. 1347).

The following topics show you how to onboard your Sidewalk device to AWS IoT Core for Amazon Sidewalk

Topics

• Add your device to AWS IoT Core for Amazon Sidewalk (p. 1352)
• Add a destination for your Sidewalk end device (p. 1359)
• Connect your Sidewalk device and view uplink metadata format (p. 1364)

Add your device to AWS IoT Core for Amazon Sidewalk

Before creating a wireless device, first create a device profile. Device profiles define the device capabilities and other parameters for your Sidewalk devices. A single device profile can be associated with multiple devices.

After you create a device profile, when you retrieve information about the profile, it returns a DeviceTypeId. When you provision your end device, you'll use this ID, the device certificates, application server public key, and the Sidewalk manufacturing serial number (SMSN). The SMSN is a unique serial number for each Sidewalk device.

How to create and add your device

1. Create a device profile for your Sidewalk end devices. Specify a profile name to use for your Sidewalk devices as an alphanumeric string. The profile will help identify the devices to associate it with.
   • (Console) When adding your Sidewalk device, you can also create a new profile. This helps you quickly add your device to AWS IoT Core for Amazon Sidewalk and associate it with a profile.
   • (API) Use the CreateDeviceProfile API operation by specifying a profile name and the Sidewalk object, sidewalk {}. The API response will contain a profile ID and ARN (Amazon Resource Name).
2. Add your wireless device to AWS IoT Core for Amazon Sidewalk. Specify a destination name and choose the device profile that you created in the previous step.

   - (Console) When adding your Sidewalk device, enter a destination name, and choose the profile that you created.
   - (API) Use the CreateWirelessDevice API operation. Specify a destination name and the ID of the device profile obtained previously.

### Wireless device parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Destination name</td>
<td>The name of the destination that describes the AWS IoT rules for processing the device's data that other AWS services will use.</td>
<td>If you haven't already created a destination, you can provide any string value. AWS IoT Core for Amazon Sidewalk will create an empty destination when creating the device, which you can then update when adding your destination.</td>
</tr>
<tr>
<td>Device profile</td>
<td>The device profile that you previously created.</td>
<td>-</td>
</tr>
</tbody>
</table>

3. Obtain the JSON file that contains the required information for provisioning your end device.

   - (Console) Download this file from the details page of the Sidewalk device that you created.
   - (API) Use the GetDeviceProfile and GetWirelessDevice API operations to retrieve information about your device profile and wireless device. Store the API response information as JSON files, such as `device_profile.json` and `wireless_device.json`.

### Add your device profile and Sidewalk end device

This section shows how you can create a device profile. It also shows how you can use the AWS IoT console and the AWS CLI to add your Sidewalk end device to AWS IoT Core for Amazon Sidewalk.

### Add your Sidewalk device (console)

To add your Sidewalk device using the AWS IoT console, go to the Sidewalk tab of the Devices hub, choose Provision device, and then perform the following steps.

**How it works**

With AWS IoT Core for Sidewalk, you can add your Sidewalk device fleet to the AWS Cloud. Use the following steps to get started.

1. **Step 1. Add your Sidewalk device**
   First, create a device profile and retrieve the application server public key. Next, create your Sidewalk device and retrieve information about it, including device certificates and private keys.

2. **Step 2. Provision & register your Sidewalk device**
   Provision your hardware as a Sidewalk endpoint by flashing the device certificates and the application server public key that you have generated. Register your device so that it can connect to AWS IoT Core for Amazon Sidewalk.

3. **Step 3. Connect your Sidewalk endpoint to the cloud**
   Create a destination and use AWS IoT Rules to process and route data to other AWS services. Your endpoint can now exchange messages with your cloud application.
1. **Specify device details**

Specify the configuration information for your Sidewalk device. You can also create a new device profile, or choose an existing profile for your Sidewalk device.

   a. Specify a device name and optional description. The description can be up to 2,048 characters long. These fields can be edited after you create the device.
   
   b. Choose a device profile to associate with your Sidewalk device. If you have any existing device profiles, you can choose your profile. To create a new profile, choose **Create new profile**, and then enter a name for the profile.

   **Note**
   
   To attach tags to your device profile, after you create your profile, go to the [Profiles hub](#) and then edit your profile to add this information.
   
   c. Specify the name of your destination that will route messages from your device to other AWS services. If you haven't already created a destination, go to the [Destinations hub](#) to create your destination. You can then choose that destination for your Sidewalk device. For more information, see [Add a destination for your Sidewalk end device](p. 1359).
   
   d. Choose **Next** to continue adding your Sidewalk device.

2. **Associate Sidewalk device with AWS IoT thing (Optional)**

You can optionally associate your Sidewalk device to an AWS IoT thing. IoT things are entries in the AWS IoT device registry. Things make it easier to search and manage your devices. Associating a thing with your device lets your device access other AWS IoT Core features.

To associate your device with a thing, choose **Automatic thing registration**.

   a. Enter a unique name for the IoT thing that you want to associate your Sidewalk device. Thing names are case sensitive and must be unique in your AWS account and AWS Region.
   
   b. Provide any additional configurations for your IoT thing, such as using a thing type, or searchable attributes that can be used to filter from a list of things.
   
   c. Choose **Next** and verify the information about your Sidewalk device, and then choose **Create**.

### Add your Sidewalk device (CLI)

To add your Sidewalk device and download the JSON files that will be used to provision your Sidewalk device, perform the following API operations.

**Topics**

- [Step 1: Create a device profile (p. 1354)]
- [Step 2: Add your Sidewalk device (p. 1355)]

**Step 1: Create a device profile**

To create a device profile in your AWS account, use the [CreateDeviceProfile](#) API operation or the `create-device-profile` CLI command. When creating your device profile, specify the name and provide any optional tags as name-value pairs.

For example, the following command creates a device profile for your Sidewalk devices:

```bash
aws iotwireless create-device-profile \
   --name sidewalk_profile --sidewalk {} 
```

Running this command returns the Amazon Resource Name (ARN) and the ID of the device profile as output.
Step 2: Add your Sidewalk device

To add your Sidewalk device to your account for AWS IoT Core for Amazon Sidewalk, use the CreateWirelessDevice API operation or the create-wireless-device CLI command. When creating your device, specify the following parameters, in addition to an optional name and description for your Sidewalk device.

Note
If you want to associate your Sidewalk device with an AWS IoT thing, use the AssociateWirelessDeviceWithThing API operation or the associate-wireless-device-with-thing CLI command. For more information, see Associate Sidewalk end devices in your AWS account to an IoT thing (p. 1381).

The following command shows an example of creating a Sidewalk device:

```
aws iotwireless create-wireless-device
   --cli-input-json "file://device.json"
```

The following shows the contents of the file `device.json`.

Contents of device.json

```json
{
   "Type": "Sidewalk",
   "Name": "SidewalkDevice",
   "DestinationName": "SidewalkDestination",
   "Sidewalk": {
      "DeviceProfileId": "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
   }
}
```

Running this command returns the device ID and Amazon Resource Name (ARN) as output.

```json
{
   "Id": "23456789-abcd-0123-bcde-fabc01234567"
}
```

Obtain device JSON files for provisioning

After you've added your Sidewalk device to AWS IoT Core for Amazon Sidewalk, download the JSON file that contains the information required to provision your end device. You can retrieve this information using the AWS IoT console or the AWS CLI. For more information about how to provision the device, see Provisioning and registering your end device in the Amazon Sidewalk documentation.

Obtain JSON file (console)

To obtain the JSON file for provisioning your Sidewalk device:
AWS IoT Core Developer Guide
Add your Sidewalk device

1. Go to the Sidewalk devices hub.
2. Choose the device that you added to AWS IoT Core for Amazon Sidewalk to view its details.
3. Obtain the JSON file by choosing Download device JSON file in the details page of the device that you added.

A certificate.json file will be downloaded that contains the required information for provisioning your end device. The following shows a sample JSON file. It contains the device certificates, private keys, the Sidewalk manufacturing serial number (SMSN), and the DeviceTypeID.

```
{
    "p256R1": "grg8izXoVvQ86cPVm0GMyWuZYHEBbbH ... DANKk0KoNT3bUGz+/f/pyTE+MrdIUBZIbw==",
    "e025519": "grg8izXoVvQ86cPVm0GMyWuZYHEBbbHD ... UiZmntHiUr1GfkT0FMyqRB+Aw==",
    "metadata": {
        "devicetypeid": "fe98",
        "applicationDeviceArn": "arn:aws:iotwireless:us-east-1:123456789012:WirelessDevice/897ce6be-3ca2-4ed0-85a2-30b0666c4052",
        "applicationDeviceId": "897ce6be-3ca2-4ed0-85a2-30b0666c4052",
        "smsn": "82B83C85E856F43E9C3D59B418CC96896071016DB1C3B3E9501F03011AA",
        "devicePrivKeyP256R1": "3e704bf8d319b3a475179f1d68c60737b28c708f845d0198f2d0400c899e018",
        "devicePrivKeyEd25519": "17dacb3a46ad9a42d5c520ca5f47f0167f59ce54d740aa13918465fa533b8d0"
    },
    "applicationServerPublicKey": "5ce29b89c2e3ce6183b41e75fe54e45f61b8bb320efbdd2abd7aef3a5957a316b"
}
```

In the details page of your Sidewalk device, you'll also see information about:

- The device ID, its Amazon Resource Name (ARN), and details about any AWS IoT thing that the device is associated with.
- The device profile and destination details.
- The time at which the last uplink message was received from the device.
- The status that indicates whether your device has been provisioned or registered.

**Obtain JSON file (CLI)**

To obtain the JSON files for provisioning your Sidewalk end device using the AWS IoT Core for Amazon Sidewalk API or the AWS CLI, save the API response from retrieving information about your device profile and wireless device as JSON files, such as `wireless_device.json` and `device_profile.json` temporarily. You'll use them for provisioning your Sidewalk device.

The following shows how to retrieve the JSON files.

**Topics**

- **Step 1: Get device profile information as JSON file (p. 1356)**
- **Step 2: Get Sidewalk device information as JSON file (p. 1357)**

**Step 1: Get device profile information as JSON file**

Use the `GetDeviceProfile` API operation or the `get-device-profile` CLI command to get information about your device profile that you added to your account for AWS IoT Core for Amazon Sidewalk. To retrieve information about your device profile, specify the profile ID.
The API will then return information about the device profile matching the specified identifier and the device ID. You save this response information as a file, and give it a name such as `device_profile.json`.

The following shows an example CLI command:

```
aws iotwireless get-device-profile
   --id "12345678-a1b2-3c45-67d8-e90fa1b2c34d" > device_profile.json
```

Running this command returns the parameters of your device profile, the application server public key, and the DeviceTypeID. The following shows a JSON file that contains a sample response information from the API. For more information about the parameters in the API response, see `GetDeviceProfile`.

**GetDeviceProfile API response (Contents of `device_profile.json`)**

```json
{
   "Arn": "arn:aws:iotwireless:us-east-1:123456789012:DeviceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
   "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d",
   "Name": "Sidewalk_profile",
   "LoRaWAN": null,
   "Sidewalk": {
       "ApplicationServerPublicKey": "a123b45c6d78e9f012a34cd5e6a7890b12c3d45e6f78a1b234c56d7e890a1234",
       "DAKCertificateMetadata": [
           {
               "DeviceTypeId": "fe98",
               "CertificateId": "43564A6D2D50524F544F54595045",
               "FactorySupport": false,
               "MaxAllowedSignature": 1000
           }
       ],
       "QualificationStatus": false
   }
}
```

**Step 2: Get Sidewalk device information as JSON file**

Use the `GetWirelessDevice` API operation or the `get-wireless-device` CLI command to get information about your Sidewalk device that you added to your account for AWS IoT Core for Amazon Sidewalk. To get information about your end device, provide the identifier of the wireless device that you obtained when adding your device.

The API will then return information about the device matching the specified identifier and the device ID. Save this response information as a JSON file. Give the file a meaningful name, such as `wireless_device.json`.

The following shows an example of running the command using the CLI:

```
aws iotwireless get-wireless-device --identifier-type WirelessDeviceId
   --identifier "23456789-abcd-0123-bcde-fabc012345678" > wireless_device.json
```

Running this command returns the device details, device certificates, private keys, and the Sidewalk manufacturing serial number (SMSN). The following shows an example output of this command. For more information about the parameters in the API response, see `GetWirelessDevice`.

**GetWirelessDevice API response (Contents of `wireless_device.json`)**
Add your Sidewalk device

```json
{
   "Id": "23456789-0123-bcde-fabc0123456789",
   "DestinationName": "SidewalkDestination",
   "Type": "Sidewalk",
   "Sidewalk": {
      "CertificateId": "4C7438772D50524F544F54595045",
      "DeviceCertificates": [
         {
            "SigningAlg": "Ed25519",
            "Value": "hDdkJw9L2uMCORjImJHmqzNR6nYy6QKncs15GthQN17KNe4ounb5UMQ1ljmzn7OYUPqghCeVOLCBU1Qe2Z1MBEWil2od6X0tG8d+99wPwGy5KMQb/1hYm7263ot11fMMFz1B32X9rzt8zuzmAuFRz14MUqWFDnGFAKu3tUNW6U/
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+FXRup67kubg1hpz04j/09dxg8ULZmthH0r16fkgTFMYqR?f+Aw=="
         },
         {
            "SigningAlg": "P256r1",
            "Value": "hDdkJw9L2uMCORjImJHmqzNR6nYy6QKncs15GthQN17KNe4ounb5UMQ1ljmzn7OYUPqghCeVOLCBU1Qe2Z1MBEWil2od6X0tG8d+99wPwGy5KMQb/1hYm7263ot11fMMFz1B32X9rzt8zuzmAuFRz14MUqWFDnGFAKu3tUNW6U/
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+FXRup67kubg1hpz04j/09dxg8ULZmthH0r16fkgTFMYqR?f+Aw=="
         }
      ],
      "DeviceProfileId": "0ff5b0c6-f149-4498-af34-21993acd52a7",
      "PrivateKeys": [
         {
            "SigningAlg": "Ed25519",
            "Value": "2c24d4572327f23b9bef38097137c292294a9e979081b3d90124ac9dfe4a77934e"
         },
         {
            "SigningAlg": "P256r1",
            "Value": "38d526f29cfaf142f596deca187bd089ef71bc13435e2cc885b63bb825d63def"
         }
      ],
      "SidewalkManufacturingSn": "843764270F4BDAE3023918C89A3307AB3351EA7887A40A9DC4A5E46B6I40D9",
      "Status": "PROVISIONED"
   }
}
```

Next steps

Store the JSON files, `wireless_device.json` and `device_profile.json` temporarily, as you'll use them in the next step to provision and register your end device for connecting to the hardware.
platform. For more information, see Provisioning and registering your end device in the Amazon Sidewalk documentation.

Add a destination for your Sidewalk end device

Use AWS IoT rules to process the data and device messages and route it to other services. You can also define rules to process the binary messages received from a device and convert the messages to other formats that make other services easy to use them. Destinations associate your Sidewalk end device with the rule that processes the device data to send to other AWS services.

How to create and use a destination

1. Create an AWS IoT rule and an IAM role for the destination. The AWS IoT rule specifies the rules that will process the device's data and routes it for use by other AWS services and your applications. The IAM role grants permission to access the rule.

2. Create a destination for your Sidewalk devices using the CreateDestination API operation. Specify the destination name, rule name, role name, and any optional parameters. The API will return a unique identifier for the destination, which you can specify when adding your end device to AWS IoT Core for Amazon Sidewalk.

The following shows how to create a destination, and an AWS IoT rule and IAM role for the destination.

Topics
- Create a destination for your Sidewalk device (p. 1359)
- Create an IAM role and IoT rule for your destination (p. 1361)

Create a destination for your Sidewalk device

You can add a destination to your account for AWS IoT Core for Amazon Sidewalk either from the using the Destinations hub or using the CreateDestination. When creating your destination, specify:

- A unique name for the destination to use for your Sidewalk end device.

  Note
  If you already add your device using a destination name, you must use that name when creating your destination. For more information, see Step 2: Add your Sidewalk device (p. 1355).

- The name of the AWS IoT rule that will process the device's data, and the topic to which messages are published.

- An IAM role that grants the device's data permission to access the rule.

The following sections describe how to create the AWS IoT rule and IAM role for your destination.

Create a destination (console)

To create a destination using the AWS IoT console, go to the Destinations hub and choose Add destination.
To process a device's data, specify the following fields when creating a destination, and then choose Add destination.

**Destination details**

Enter a Destination name and an optional description for your destination.

**Rule name**

The AWS IoT rule that is configured to evaluate messages sent by your device and process the device's data. The rule name will be mapped to your destination. The destination requires the rule to process the messages that it receives. You can choose for the messages to be processed by either invoking an AWS IoT rule or by publishing to the AWS IoT message broker.

- If you choose Enter a rule name, enter a name, and then choose Copy to copy the rule name that you'll enter when creating the AWS IoT rule. You can either choose Create rule to create the rule now or navigate to the Rules Hub of the AWS IoT console and create a rule with that name.

  You can also enter a rule and use the Advanced setting to specify a topic name. The topic name is provided during rule invocation and is accessed by using the topic expression inside the rule. For more information about AWS IoT rules, see AWS IoT rules.

- If you choose Publish to AWS IoT message broker, enter a topic name. You can then copy the MQTT topic name and multiple subscribers can subscribe to this topic to receive messages published to that topic. For more information, see MQTT topics.

For more information about AWS IoT rules for destinations, see Create rules to process LoRaWAN device messages.

**Role name**

The IAM role that grants the device's data permission to access the rule named in Rule name. In the console, you can create a new service role or select an existing service role. If you're creating a new service role, you can either enter a role name (for example, SidewalkDestinationRole), or leave it blank for AWS IoT Core for LoRaWAN to generate a new role name. AWS IoT Core for LoRaWAN will then automatically create the IAM role with the appropriate permissions on your behalf.

### Create a destination (CLI)

To create a destination, use the CreateDestination API operation or the create-destination CLI command. For example, the following command creates a destination for your Sidewalk end device:

```bash
aws iotwireless create-destination --name SidewalkDestination \
  --expression-type RuleName --expression SidewalkRule \
  --role-arn arn:aws:iam::123456789012:role/SidewalkRole
```

Running this command returns the destination details, which include the Amazon Resource Name (ARN) and the destination name.

```json
{
  "Arn": "arn:aws:iotwireless:us-east-1:123456789012:Destination/SidewalkDestination",
  "Name": "SidewalkDestination"
}
```

For more information about creating a destination, see Create rules to process LoRaWAN device messages.
Create an IAM role and IoT rule for your destination

AWS IoT rules send device messages to other services. AWS IoT rules can also process the binary messages received from a Sidewalk end device for other services to use. AWS IoT Core for Amazon Sidewalk destinations associate a wireless device with the rule that processes the device's message data to send to other services. The rule acts on the device's data as soon as AWS IoT Core for Amazon Sidewalk receives it. For all devices that send their data to the same service, you can create a destination that can be shared by all devices. You must also create an IAM role that grants permission to send data to the rule.

Create an IAM role for your destination

Create an IAM role that grants AWS IoT Core for Amazon Sidewalk permission to send data to the AWS IoT rule. To create the role, use the CreateRole API operation or create-role CLI command. You can name the role as SidewalkRole.

```
aws iam create-role --role-name SidewalkRole \
```

You can also define the trust policy for the role using a JSON file.

```
aws iam create-role --role-name SidewalkRole \
   --assume-role-policy-document file://trust-policy.json
```

The following shows the contents of the JSON file.

**Contents of trust-policy.json**

```
{
   "Version": "2012-10-17",
   "Statement": [
      {
         "Effect": "Allow",
         "Principal": {
            "Service": "lambda.amazonaws.com"
         },
         "Action": "sts:AssumeRole"
      }
   ]
}
```

Create a rule for your destination

Use the AWS IoT Core API operation, CreateTopicRule, or the AWS CLI command, create-topic-rule, to create a rule. The topic rule will be used by your destination to route the data received from your Sidewalk end device to other AWS services. For example, you can create a rule action that sends a message to a Lambda function. You can define the Lambda function such that it receives the application data from your device and uses base64 to decode the payload data so that it can be used by other applications.

The following steps show how you create the Lambda function and then a topic rule that sends a message to this function.

1. **Create execution role and policy**

   Create an IAM role that grants your function permission to access AWS resources. You can also define the trust policy for the role using a JSON file.
aws iam create-role --role-name lambda-ex \
--assume-role-policy-document file://lambda-trust-policy.json

The following shows the contents of the JSON file.

Contents of lambda-trust-policy.json

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Principal": {
                "Service": "lambda.amazonaws.com"
            },
            "Action": "sts:AssumeRole"
        }
    ]
}
```

2. Create and test Lambda function

Perform the following steps to create a AWS Lambda function that base64 decodes the payload data.

a. Write the code for decoding the payload data. For example, you can use the following sample Python code. Specify a name for the script, such as base64_decode.py.

Contents of base64_decode.py

```
// -----------------------------------------------------------
// ----- Python script to decode incoming binary payload ----- 
// -----------------------------------------------------------
import json
import base64

def lambda_handler(event, context):
    message = json.dumps(event)
    print (message)
    payload_data = base64.b64decode(event['PayloadData'])
    print(payload_data)
    print(int(payload_data,16))
```

b. Create a deployment package as a zip file that contains the Python file and name it as base64_decode.zip. Use the CreateFunction API or the create-function CLI command to create a Lambda function for the sample code, base64_decode.py.

c. aws lambda create-function --function-name my-function \
--zip-file fileb://base64_decode.zip --handler index.handler \
--runtime python3.9 --role arn:aws:iam::123456789012:role/lambda-ex

You should see the following output. You'll use the Amazon Resource Name (ARN) value from the output, FunctionArn, when creating the topic rule.

```
{
    "FunctionName": "my-function",
    "FunctionArn": "arn:aws:lambda:us-east-1:123456789012:function:my-function",
```
d. To get logs for an invocation from the command line, use the --log-type option with the invoke command. The response includes a LogResult field that contains up to 4 KB of base64-encoded logs from the invocation.

```
aws lambda invoke --function-name my-function out --log-type Tail
```

You should receive a response with a StatusCode of 200. For more information about creating and using Lambda functions from the AWS CLI, see Using Lambda with the AWS CLI.

3. Create a topic rule

Use the CreateTopicRule API or the create-topic-rule CLI command to create a topic rule that sends a message to this Lambda function. You can also add a second rule action that republishes to an AWS IoT topic. Name this topic rule as Sidewalkrule.

```
aws iot create-topic-rule --rule-name Sidewalkrule \  
--topic-rule-payload file://myrule.json
```

You can use the myrule.json file to specify more details about the rule. For example, the following JSON file shows how to republish to an AWS IoT topic and send a message to a Lambda function.

```json
{
  "sql": "SELECT * ",
  "actions": [
    // You obtained this functionArn when creating the Lambda function using
    // create-function command.
    "lambda": {
      "functionArn": "arn:aws:lambda:us-east-1:123456789012:function:my-function"
    },
  ],
  // This topic can be used to observe messages exchanged between the device and
  // AWS IoT Core for Amazon Sidewalk after the device is connected.
  "republish": {
    "roleArn": "arn:aws:iam::123456789012:role/service-role/SidewalkRepublishRole",
    "topic": "project/sensor/observed"
  }
}
```
Connect your Sidewalk device and view uplink metadata format

In this tutorial, you'll use the MQTT test client to test the connectivity and see messages exchanged between your end device and the AWS Cloud. To receive messages, in the MQTT test client, subscribe to the topic specified when creating the IoT rule for your destination. You can also send a downlink message from AWS IoT Core for Amazon Sidewalk to your device using the `SendDataToWirelessDevice` API operation. You can verify that the message was delivered by enabling the message delivery status event notification.

**Note**
For information about connecting your hardware platform and setting it up, see Provisioning and registering your end device and Setting up the hardware development kit (HDK) in the Amazon Sidewalk documentation.

Send downlink messages to your end device

Use the `SendDataToWirelessDevice` API operation or the `send-data-to-wireless-device` CLI command to send downlink messages from AWS IoT Core for Amazon Sidewalk to your Sidewalk end device. Following shows an example of how to run this command. The payload data is the binary to be sent, encoded in base64.

```bash
aws iotwireless send-data-to-wireless-device \
   --id "<Wireless_Device_ID>" \
   --payload-data "SGVsbG8gVG8gRGV2c2lt" \
   --wireless-metadata Sidewalk={Seq=1,AckModeRetryDurationSecs=10}
```

Following shows a sample output of running this command, which is an ID of the downlink message sent to the device.

```
{
    "MessageId": "6011dd36-0043d6eb-0072-0008"
}
```

**Note**
The `SendDataToWirelessDevice` API can return a message ID but the message might not be successfully delivered. To check the status of the message that was sent to the device, you can enable message delivery status events for your Sidewalk accounts and devices. For information about how to enable this event, see Enable events for Sidewalk devices (p. 1388). For more information about this event type, see Message delivery events.

View format of uplink messages from the device

After you've connected your device, you can subscribe to the topic (for example, `project/sensor/observed`) that you specified when creating the destination rule, and observe uplink messages from the device.

If you specified a topic name when creating your destination, you can subscribe to the topic to monitor uplink messages from your end device. Go to the MQTT test client on the Test page of the AWS IoT console, enter the topic name (for example, `project/sensor/observed`), and then choose Subscribe.

The following example shows the format of the uplink messages that are sent from Sidewalk devices to AWS IoT. The WirelessMetadata contains metadata about the message request.

```json
{
    "MessageId": "6011dd36-0043d6eb-0072-0008",
    "PayloadData": "ZjRlNjY1ZWNlNw==",
}
```
The following table shows a definition of the different parameters in the uplink metadata. The \textit{device-id} is the ID of the wireless device, such as \texttt{ABCDEF1234} and the \textit{messageType} is the type of uplink message that's received from the device.

### Sidewalk uplink metadata parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Type</th>
<th>Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>PayloadData</td>
<td>The message payload that is sent from the wireless device.</td>
<td>String</td>
<td>Yes</td>
</tr>
<tr>
<td>WirelessDeviceID</td>
<td>The identifier of the wireless device that's sending the data</td>
<td>String</td>
<td>Yes</td>
</tr>
<tr>
<td>Sidewalk.CmdExStatus</td>
<td>Command runtime status. Response-type messages shall include the status code, \texttt{COMMAND_EXEC_STATUS_SUCCESS}. However, notifications might not include the status code.</td>
<td>Enumeration</td>
<td>No</td>
</tr>
<tr>
<td>Sidewalk.NackExStatus</td>
<td>Response nack status, which can be \texttt{RADIO_TX_ERROR} or \texttt{MEMORY_ERROR}.</td>
<td>Array of strings</td>
<td>No</td>
</tr>
</tbody>
</table>

**Bulk provisioning devices with AWS IoT Core for Amazon Sidewalk**

You can use bulk provisioning to onboard a large number of end devices to AWS IoT Core for Amazon Sidewalk in bulk. Bulk provisioning is useful especially when you manufacture a large number of devices in a factory and want to onboard these devices to AWS IoT. For more information about manufacturing devices, see [Manufacturing Amazon Sidewalk devices](#) in the Amazon Sidewalk documentation.

The following topics show you how bulk provisioning works.

- **Amazon Sidewalk bulk provisioning workflow (p. 1366)**
  This topic shows you some key concepts of bulk provisioning and how it works. It also shows the steps that must be performed so that your Sidewalk devices can be imported to AWS IoT Core for Amazon Sidewalk.

- **Creating device profiles with factory support (p. 1369)**
  This topic explains how to create a device profile and obtain factory support for it. You'll also learn how to retrieve the YubiHSM key and send it to your manufacturer for obtaining the control log after the devices are manufactured.

- **Provisioning Sidewalk devices using import tasks (p. 1372)**
This topic shows you how to bulk provision your Sidewalk devices by creating and using import tasks. You'll also learn how to update or delete your import tasks, and view the status of the import task and devices in the task.

Topics
- Amazon Sidewalk bulk provisioning workflow (p. 1366)
- Creating device profiles with factory support (p. 1369)
- Provisioning Sidewalk devices using import tasks (p. 1372)

Amazon Sidewalk bulk provisioning workflow

The following sections show you key concepts of bulk provisioning and how it works. The steps that are involved in bulk provisioning include:

1. Create a device profile using AWS IoT Core for Amazon Sidewalk.
2. Request the Amazon Sidewalk team for a YubiHSM key and to update your device profile with factory support.
3. Send the YubiHSM key to your manufacturer so that AWS IoT Core for Amazon Sidewalk can obtain the control log after the devices are manufactured.
4. Create an import task and provide the serial numbers (SMSN) of the devices to be onboarded to AWS IoT Core for Amazon Sidewalk.

Components of bulk provisioning

The following concepts show you some key components of bulk provisioning and how to use them as part of bulk provisioning your Sidewalk devices.

YubiHSM key

Amazon creates one or more HSMs (hardware security modules) for each of your Sidewalk products. Each HSM has a unique serial number, called YubiHSM key, that's printed on the hardware module. This key can be purchased from the Yubico webpage.

The key is unique to each HSM and tied to each device profile that you create with AWS IoT Core for Amazon Sidewalk. To obtain the YubiHSM key, contact the Amazon Sidewalk team. If you send the YubiHSM key to the manufacturer, after the Sidewalk devices are manufactured in the factory, AWS IoT Core for Amazon Sidewalk will receive a control log file that contains the serial numbers of the devices. It then compares this information with your input CSV file for onboarding the devices to AWS IoT.

Device attestation key (DAK)

When a Sidewalk end device joins the Sidewalk network, it must be provisioned with a Sidewalk device certificate. The certificates that are used for setting up your device include a private device-specific certificate, and the public device certificates, which correspond to the Sidewalk certificate chain. When your Sidewalk devices are manufactured, the YubiHSM signs the device certificates.

The following shows a sample JSON file that contains the device certificates and the private keys. For more information, see Obtain device JSON files for provisioning (p. 1355).

```json
{
    "p256R1": "grg8izXoVvQ86cPvm0GMywzyHE8bbH ... DANKk0gNt3b6Gz+/f/pyTe+xMrdUBZI8w==",
    "eD25519": "grg8izXoVvQ86cPvm0GMywzyHE8bbHd ... U12mntHi1UgkT0FMyQrB+Aw==",
    "metadata": {}
}
```
The device attestation key (DAK) is a private key that you obtain when creating your device profile. It corresponds to the product certificate, which is a unique certificate that’s issued to each Sidewalk product. When you contact the Amazon Sidewalk team, you’ll receive the Sidewalk certificate chain, the YubiHSM key, and an HSM provisioned with the product device attestation key (DAK).

Your device profile is also updated with the new device attestation key (DAK), and with factory support enabled. The DAK metadata information of the device profile provides details such as the DAK name, the certificate ID, the ApId (Advertised Product ID), whether factory support is enabled, and the maximum number of signatures that the DAK can sign.

Advertised product ID (ApId)

The ApId parameter is an alphanumeric string that identifies the advertised product. This field must be specified when you want to use a given device profile for Sidewalk devices that you bulk provision. AWS IoT Core for Amazon Sidewalk then generates the DAK, and provides it to you through the YubiHSM key. The related DAK information will be presented in the device profile.

To obtain the ApId, after you retrieve information about the device profile that you created, contact the Amazon Sidewalk Support team. You can obtain the device profile information from the AWS IoT console, or using the GetDeviceProfile API operation, or the get-device-profile CLI command.

How bulk provisioning works

This flowchart shows how bulk provisioning works with AWS IoT Core for Amazon Sidewalk.

The following procedure illustrates the different steps in the bulk provisioning process.
1. **Create device profile for Sidewalk device**

   Before you take your end device to the factory, first create a device profile. You can use this profile to provision individual devices as described in Add your device profile and Sidewalk end device (p. 1353).

2. **Request factory support for your profile**

   When you’re ready to take your end device to factory, ask the Amazon Sidewalk team for the YubiHSM key and for factory support for your device profile.

3. **Obtain DAK and factory supported profile**

   The Amazon Sidewalk Support team will then update your device profile with the product device attestation key (DAK) and factory support. Your device profile will be updated automatically with an advertised product ID (ApID), and a new DAK and certificate information, such as the certificate ID. Sidewalk devices that use this profile are qualified for use with bulk provisioning.

4. **Send YubiHSM key to manufacturer (CM)**

   Your end device is now qualified, so you can send your YubiHSM key to the contract manufacturer (CM) to start the manufacturing process. For more information, see Manufacturing Amazon Sidewalk devices in the Amazon Sidewalk documentation.

5. **Manufacture devices and send control logs and serial numbers**

   The CM manufactures the devices and generates control logs. The CM also provides you a CSV file that contains a list of devices to be manufactured and their Sidewalk manufacturing serial numbers (SMSN). The following code shows a sample control log. It contains the serial numbers of the device, the APID, and the public device certificates.

   ```json
   { 
   "controlLogs": [ 
   { 
   "version": "4-0-1", 
   "device": {
   "serialNumber": "device1", 
   "productIdentifier": {
   "advertisedProductId": "abCD" 
   },
   "sidewalkData": {
   "SidewalkED25519CertificateChain": "...", 
   "SidewalkP256R1CertificateChain": "..." 
   }
   }
   ]
   }
   ```

6. **Pass control log information to AWS IoT Core for Amazon Sidewalk**

   The Amazon Sidewalk cloud retrieves the control log information from the manufacturer and passes this information to AWS IoT Core for Amazon Sidewalk. The devices can then be created along with their serial numbers.

7. **Check serial number match and start bulk provisioning**

   When you use the AWS IoT console or the AWS IoT Core for Amazon Sidewalk API operation StartWirelessDeviceImportTask, AWS IoT Core for Amazon Sidewalk compares the Sidewalk manufacturing serial number (SMSN) of each devices obtained from Amazon Sidewalk with the corresponding serial numbers in your CSV file. If this information matches, it starts the bulk provisioning process and creates the devices to be imported to AWS IoT Core for Amazon Sidewalk.
Creating device profiles with factory support

Before you can bulk provision your Amazon Sidewalk devices, you must create a device profile and then contact the Amazon Sidewalk support team to request factory support for it. The Amazon Sidewalk team will then update your device profile with a new device attestation key (DAK) and add factory support to it. Sidewalk devices that use this profile are then qualified to be used with AWS IoT Core for Amazon Sidewalk, and can be onboarded for bulk provisioning.

The following steps show you how to create a factory-supported device profile.

1. Create a device profile

   First create a device profile. When you create a profile, specify a name and optional tags as name-value pairs. For more information about the parameters required, and creating and using profiles, see How to create and add your device (p. 1352).

2. Obtain factory support for the profile

   Then obtain factory support for your device profile so that devices that use this profile can be qualified. For qualification, create a ticket with the Amazon Sidewalk team. Once confirmed by the team, you'll receive an AplId (advertised product ID), and your profile will be updated with a factory-issued DAK. Sidewalk end devices that use this profile will be qualified.

You can create a device profile either using the AWS IoT console, the AWS IoT Core for Amazon Sidewalk API operations, or the AWS CLI.

Topics
- Create a profile (console) (p. 1369)
- Create a profile (CLI) (p. 1370)
- Next steps (p. 1371)

Create a profile (console)

To create a device profile using the AWS IoT console, go to the Sidewalk tab of the Profiles hub and choose Create profile.

To create a profile, specify the following fields, and then choose Submit.

- Name
  
  Enter a Name for your profile.
- Tags
Enter optional tags as name-value pairs to help you more easily identify your profile. Tags also make it easier to track billing charges.

View profile information and qualify profiles

You'll see the profile that you created in the Profiles hub. Choose the profile to view its details. You'll see information about:

- The device profile name and unique identifier, and any optional tags you specified as name value pairs.
- The application server public key and device type ID of the profile.
- The qualification status, which indicates that you're using a device profile that is not factory supported. To qualify your device profile so that it's factory supported, contact Amazon Sidewalk Support.
- The device attestation key (DAK) information. Once your device profile is qualified, a new DAK will be issued and your profile will be updated automatically with the new DAK information.

Create a profile (CLI)

To create a device profile, use the CreateDeviceProfile API operation or the create-device-profile CLI command. For example, the following command creates a profile for your Sidewalk end device.

```sh
aws iotwireless create-device-profile \\
   --name sidewalk_device_profile --sidewalk {}
```

Running this command returns the profile details, which include the Amazon Resource Name (ARN) and the ID of the profile.

```
{
   "DeviceProfileArn": "arn:aws:iotwireless:us-east-1:123456789012:DeviceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
   "DeviceProfileId": "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
}
```

View profile information and qualify profiles

Use the GetDeviceProfile API operation or the get-device-profile CLI command to get information about your device profile that you added to your account for AWS IoT Core for Amazon Sidewalk. To retrieve information about your device profile, specify the profile ID. The API will then return information about the device profile matching the specified identifier.

The following shows an example CLI command:

```sh
aws iotwireless get-device-profile \\
   --id "12345678-234a-45bc-67de-e8901234f0a1" > device_profile.json
```

Running this command returns the parameters of your device profile, the application server public key, the DeviceTypeId, ApId, qualification status, and the DAKCertificate information.

In this example, the qualification status and DAK information indicate that your device profile is not qualified. To qualify your profile, contact Amazon Sidewalk Support, and your profile will be issued a new DAK with no device limit.
Once the Amazon Sidewalk Support team confirms this information, you'll receive the APID and a factory-supported DAK, as shown in the following example.

**Note**
The `MaxAllowedSignature` of `-1` indicates that the DAK doesn't have any device limit. For information about the DAK parameters, see [DAKCertificateMetadata](#).

```json
{
   "Arn": "arn:aws:iotwireless:us-east-1:123456789012:DeviceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d",
   "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d",
   "Name": "Sidewalk_profile",
   "LoRaWAN": null,
   "Sidewalk":
   {
      "ApplicationServerPublicKey": "a123b45c6d78e9f012a34cd5e6a7890b12c3d45e6f78a1b234c56d7e890a1234",
      "DAKCertificateMetadata": [
         {
            "DeviceTypeId": "fe98",
            "CertificateId": "43564A6D2D50524F544F54595045",
            "FactorySupport": false,
            "MaxAllowedSignature": 1000
         }
      ],
      "QualificationStatus": false
   }
}
```

Next steps

Now that you've created a device profile which has a factory-supported DAK, provide the YubiHSM key that you obtain from the team to your manufacturer. Your devices will then be manufactured in the factory and a control log information will then be passed to Amazon Sidewalk, which contains the serial numbers (SMSN) of the devices. For more information about this workflow, see [Manufacturing Amazon Sidewalk devices](#) in the Amazon Sidewalk documentation.

You can then bulk provision your Sidewalk devices by providing AWS IoT Core for Amazon Sidewalk the serial numbers of the devices to be onboarded. When AWS IoT Core for Amazon Sidewalk receives the
control log, it compares the serial numbers in the control log with the serial numbers that you provided. If the serial numbers match, the import task starts onboarding your devices to AWS IoT Core for Amazon Sidewalk. For more information, see Provisioning Sidewalk devices using import tasks (p. 1372).

Provisioning Sidewalk devices using import tasks

This section shows how you can provision Sidewalk devices in bulk using the AWS IoT console, or the AWS IoT Core for Amazon Sidewalk API operations, or the AWS CLI. The following sections explain how to bulk provision your Sidewalk devices.

Topics

- How Sidewalk bulk provisioning works (p. 1372)
- Key considerations for Sidewalk bulk provisioning (p. 1372)
- CSV file format (p. 1373)
- How to use Sidewalk bulk provisioning (p. 1373)
- Provision Sidewalk devices in bulk (p. 1374)
- View import task and device onboarding status (p. 1378)

How Sidewalk bulk provisioning works

The following steps illustrate how bulk provisioning works.

1. Starting wireless device import task

   To provision Sidewalk devices in bulk, you must create an import task and provide the Sidewalk manufacturing serial number (SMSN) of the devices to be onboarded to AWS IoT Core for Amazon Sidewalk. You obtained the Sidewalk manufacturing serial number (SMSN) of the devices as a CSV file in your email after the manufacturer uploaded the control logs to Amazon Sidewalk. For more information about the workflow and how you obtain the control log, see Manufacturing Amazon Sidewalk devices in the Amazon Sidewalk documentation.

2. Running import process in background

   When AWS IoT Core for Amazon Sidewalk receives the import task request, it starts setting things up and starts a background process that polls the system frequently. Once the background process receives the import task instruction, it starts reading the CSV file. AWS IoT Core for Amazon Sidewalk simultaneously checks whether the control logs have been received from Amazon Sidewalk.

3. Creating wireless device records

   When the control log is received from Amazon Sidewalk, AWS IoT Core for Amazon Sidewalk checks whether the serial numbers in the control log match the SMSN values in the CSV file. If the serial numbers match, AWS IoT Core for Amazon Sidewalk will start creating wireless device records for the Sidewalk devices that correspond to these serial numbers. Once all the devices have been onboarded, the import task is marked as Completed.

Key considerations for Sidewalk bulk provisioning

When provisioning your Sidewalk devices in bulk to AWS IoT Core for Amazon Sidewalk, following are some key considerations.

- You must perform bulk provisioning using the AWS IoT console or the AWS IoT Core for Amazon Sidewalk API operations in the same AWS account where you created the device profile.
Before you bulk provision your Sidewalk devices, your device profile must already contain DAK information that indicates factory support. Otherwise, bulk provisioning using the AWS IoT console, or the bulk provisioning API operations can fail.

After you start an import task, it can take at least 10 minutes or longer to process the CSV file, import the wireless devices, and onboard them to AWS IoT Core for Amazon Sidewalk.

The wireless device import task will run for 90 days, once started. During this time, it checks whether the control logs have been received from Amazon Sidewalk. If the control log is not received from Amazon Sidewalk before 90 days, the task will be marked as Completed with a message indicating that it has expired when you view the task details. The onboarding status of the devices in the import task that were waiting for the control log will be marked as Failed.

When you attempt to update an import task that you’ve already created, you can only add additional devices to the task. You can add new devices anytime after creating an import task and before the task has started on devices that were already added to the import task. If the update file contains serial numbers of devices that already exist in the original import task, these serial numbers will be ignored.

When you request an update operation, the same IAM role as the one you used when creating the import task will be assumed to access the CSV file in the Amazon S3 bucket.

An import task can be deleted only if the task has already completed successfully or if the task failed to update. A task might fail to update in cases such as when an incorrect IAM role was provided or when an Amazon S3 bucket file wasn’t found. An import task cannot be updated or deleted if it is in the PENDING state.

The CSV file that you import to the task must use the format described in the following section.

CSV file format

The CSV file that’s contained in an Amazon S3 bucket that you specify for the import task must use the following format:

• Row 1 must use the keyword smsn, which indicates that the CSV file being imported contains the SMSN of the devices to be imported.
• Rows 2 and after must contain the SMSN of the devices to be onboarded. The device SMSN must be in the 64 hex character format.

This JSON file shows a sample CSV file format.

```
smrn
1c1a10b0ac0a200c012bbac2cbb1b21c1b12c0ca2ac1c1bb22caa01c1b0b01122
b122cb21b121baca2221001ac1b2202a1ec11112c11c2a100c1c2b012a1100c10
0b2b22c110b0a210b0a0c2c112ccac21c1c0b0a1221ab0122a22cc11b1b1122
cc02c1a1c111ccab1221c0021c1c2aaa0a1a201add0cbacca2a0112022a
0cb22c01bbc2ca2c001100121acb2abb0bb0121c2a01c012cc2b0c011ac0
```

How to use Sidewalk bulk provisioning

The following steps show you how to use Amazon Sidewalk bulk provisioning.

1. **Provide device serial numbers**

   To provision your Sidewalk devices, you must provide the serial numbers of the devices to be onboarded. You can provision your devices using either of the following methods.
   
   • Provision each device individually using their Sidewalk manufacturing serial number (SMSN). This method is useful when you want to test the workflow and onboard your device faster without having to upload a CSV file with the appropriate IAM role, or waiting for the devices to be ready to be onboarded to the task.
• Provision devices in bulk by providing an Amazon S3 bucket URL that contains the SMSN of the devices to be provisioned in a CSV file. This method is especially useful when you have a large number of devices to be onboarded. In this case, onboarding each device individually can be tedious. Instead, you only need to provide the path to the CSV file that has been uploaded to an Amazon S3 bucket, and the IAM role to access the file.

2. Obtain import task and device onboarding status

For each import task that you create, you can retrieve information about the task onboarding status and the onboarding status of devices added to the task. You can also see additional status information, such as a reason as to why a task or device onboarding failed. For more information, see

3. (Optional) Update or delete import task

You can update or delete an import task that you've already created.

• You can update an import task and add additional devices to the task anytime before the task has started on devices that have already been added. AWS IoT Core for Amazon Sidewalk assumes the same IAM role as the one that you used when creating the import task. When you create the task, specify the new CSV file that contains the serial numbers of devices that you want to add to the task.

  Note
  When you're updating an existing import task, you can only add devices to the task. AWS IoT Core for Amazon Sidewalk performs a union operation between the devices that are already in the import task and the devices that you're attempting to add to the task. If the new file contains serial numbers of devices that already exist in the import task, these serial numbers will be ignored.

• You can delete an import task that has already completed successfully, or an import task that failed to update in cases such as when the IAM role information is incorrect, or when an S3 bucket file isn't available when creating or updating a task.

Topics
• Provision Sidewalk devices in bulk (p. 1374)
• View import task and device onboarding status (p. 1378)

Provision Sidewalk devices in bulk

This section shows how you can provision Sidewalk devices in bulk to AWS IoT Core for Amazon Sidewalk using the AWS IoT console and the AWS CLI.

Provision Sidewalk devices in bulk (console)

To add your Sidewalk device using the AWS IoT console, go to the Sidewalk tab of the Devices hub, choose Bulk provision devices, and then perform the following steps.
Choose import method

Specify how you want to import the devices to be onboarded in bulk to AWS IoT Core for Amazon Sidewalk.

- To provision individual devices using their SMSN, choose **Provision individual factory supported device**.
- To provision devices in bulk by providing a CSV file that contains a list of devices and their SMS, choose **Use S3 bucket**.

Specify devices to be onboarded

Depending on the method that you chose to onboard your devices, add the device information and their serial numbers.

a. If you chose **Provision individual factory supported device**, specify the following information:

   i. A **Name** for each device to be onboarded. The name must be unique in your AWS account and AWS Region.
   
   ii. Their Sidewalk manufacturing serial number (SMSN) in the **Enter SMSN** field.
   
   iii. A **Destination** that describes the IoT rule to route messages from the device to other AWS services.

b. If you chose **Use S3 bucket**:

   i. **Provide the S3 Bucket destination** information, which consists of the S3 URL information. To provide your CSV file, choose **Browse S3**, and then choose the CSV file you want to use.

   AWS IoT Core for Amazon Sidewalk automatically populates the S3 URL, which is the path to your CSV file in the S3 bucket. The format of the path is s3://bucket_name/file_name. To view the file in the Amazon Simple Storage Service console, choose **View**.
ii. Provide the **S3 Provisioning role**, which allows AWS IoT Core for Amazon Sidewalk to access the CSV file in the S3 bucket on your behalf. You can either create a new service role or choose an existing role.

To create a new role, you can either provide a **Role name** or leave it blank to generate a random name automatically.

iii. Provide a **Destination** that describes the IoT rule to route messages from the device to other AWS services.

3. **Start import task**

Provide any optional tags as name-value pairs and choose **Submit** to start your wireless device import task.

**Provision Sidewalk devices in bulk (CLI)**

To onboard your Sidewalk devices to your account for AWS IoT Core for Amazon Sidewalk, use any of the following API operations depending on whether you want to add devices individually or by providing the CSV file contained in an S3 bucket.

- **Upload devices in bulk using an S3 CSV file**

To upload devices in bulk by providing the CSV file in an S3 bucket, use the `StartWirelessDeviceImportTask` API operation, or the `start-wireless-device-import-task` AWS CLI command. When creating the task, specify the path to the CSV file in the Amazon S3 bucket and the IAM role that grants AWS IoT Core for Amazon Sidewalk permissions to access the CSV file.

Once the task starts to run, AWS IoT Core for Amazon Sidewalk will start reading the CSV file and compare the serial numbers (SMSN) in the file with the corresponding information in the control log received from Amazon Sidewalk. When the serial numbers match, it will start creating wireless device records corresponding to these serial numbers.

The following command shows an example of creating an import task:

```bash
aws iotwireless start-wireless-device-import-task \
  --cli-input-json "file://task.json"
```

The following shows the contents of the file `task.json`.

**Contents of task.json**

```json
{
  "DestinationName": "Sidewalk_Destination",
  "Sidewalk": {
    "DeviceCreationFile": "s3://import_task_bucket/import_file1",
    "Role": "arn:aws:iam::123456789012:role/service-role/ACF1zBEI"
  }
}
```

Running this command returns an ID and ARN for the import task.

```json
{
  "Arn": "arn:aws:iotwireless:us-east-1:123456789012:ImportTask/a1b234c5-67ef-21a2-a1b2-3cd4e5f6789a"
  "Id": "a1b234c5-67ef-21a2-a1b2-3cd4e5f6789a"
}
```
Provisioning Sidewalk devices using import tasks

- **Provision devices individually using their SMSN**

To provision devices individually using their SMSN, use the `StartSingleWirelessDeviceImportTask` API operation, or the `start-single-wireless-device-import-task` AWS CLI command. When creating the task, specify the Sidewalk destination and the serial number of the device that you want to onboard.

When the serial number matches the corresponding information in the control log received from Amazon Sidewalk, the task will run and create the wireless device record.

The following command shows an example of creating an import task:

```bash
aws iotwireless start-single-wireless-device-import-task \
   --destination-name sidewalk_destination \
   --sidewalk '{"SidewalkManufacturingSn": "82B83CBB35E856F43CE9C3D59B418CC968996071016DB1C3BE5901F0F3071A4A"}'
```

Running this command returns an ID and ARN for the import task.

```json
{
   "Arn": "arn:aws:iotwireless:us-east-1:123456789012:ImportTask/e2a5995e-743b-41f2-a1e4-3ca6a5c5249f",
   "Id": "e2a5995e-743b-41f2-a1e4-3ca6a5c5249f"
}
```

### Update or delete import tasks

If you want to add additional devices to an import task, you can update the task. You can also delete a task if you no longer require the task or if it failed. For information about when to update or delete a task, see [How to use Sidewalk bulk provisioning](p. 1373).

**Warning**

Deletion actions are permanent and can’t be undone. Deleting an import task that has already completed successfully will not remove the end devices that have already been onboarded using the task.

To update or delete import tasks:

- **Using the AWS IoT console**

  The following steps explain how to update or delete your import tasks using the AWS IoT console.

  **To update an import task:**

  1. Go to the [Sidewalk devices hub](#) of the AWS IoT console.
  2. Choose the import task that you want to update and then choose **Edit**.
  3. Provide another S3 file that contains the serial numbers of devices that you want to add to the task and then choose **Submit**.

  **To delete an import task:**

  1. Go to the [Sidewalk devices hub](#) of the AWS IoT console.
  2. Choose the task that you want to delete and then choose **Delete**.

- **Using the AWS IoT Wireless API or AWS CLI**
Use the following AWS IoT Wireless API operations or CLI commands to update or delete your import task.

- **UpdateWirelessDeviceImportTask** API or `update-wireless-device-import-task` CLI
  
  This API operation appends the contents of an Amazon S3 CSV file to an existing import task. You can only add serial numbers of devices that were not previously included in the task. For more information, see [Add devices to import task](#).

- **DeleteWirelessDeviceImportTask** API or `delete-wireless-device-import-task` CLI
  
  This API operation deletes the import task that was marked for deletion using the import task ID. For more information, see [Delete import tasks from your AWS account](#).

### View import task and device onboarding status

Your wireless device import tasks and Sidewalk devices that you’ve added to the task can have one of the following status messages. You’ll see these messages displayed in the AWS IoT console, or when you use any of the AWS IoT Wireless API operations or AWS CLI commands to retrieve information about these tasks and their devices.

#### View import task status information

After you’ve created an import task, you can view the import task that you created and the onboarding status of devices added to the task. The onboarding status indicates the number of devices that are pending onboarding, the number of devices that have been onboarded successfully, and the number of devices that failed to onboard.

When an import task has just been created, the **Pending count** will display a value that corresponds to the number of devices that were added. Once the task starts and reads the CSV file to create the wireless device records, the **Pending count** will decrease, and the **Success count** will increase as the devices are onboarded successfully. If any device fails to onboard, the **Failed count** will increase.

To view the import task and device onboarding status:

- **Using the AWS IoT console**
  
  In the [Sidewalk devices hub](#) of the AWS IoT console, you can see the import tasks that you created and a count of the summary of the onboarding status information of your devices. If you view the details of any of the import tasks that you created, you can see additional information about the device onboarding status.

- **Using the AWS IoT Wireless API or AWS CLI**
  
  To view the device onboarding status, use any of the following AWS IoT Wireless API operations or the corresponding AWS CLI command. For more information and examples that show how to use them, see [AWS IoT Core for Amazon Sidewalk API operations for bulk provisioning](#).

- **ListWirelessDeviceImportTasks** API or `list-wireless-device-import-tasks` CLI
  
  This API operation returns information about all the import tasks that have been added to your account for AWS IoT Wireless and their status. It also returns a count of the summary of onboarding status of Sidewalk devices in these tasks.

- **ListDevicesForWirelessDeviceImportTask** API or `list-devices-for-wireless-device-import-task` CLI
  
  This API operation returns information about the specified import task and its status, and information about all Sidewalk devices that have been added to the import task and their onboarding status information.

- **GetWirelessDeviceImportTask** API or `get-wireless-device-import-task` CLI
This API operation returns information about the specified import task and its status, and a count of the summary of onboarding status of Sidewalk devices in that task.

Import task status

The import tasks that you have created in your AWS account can have one of the following status messages. The status indicates whether your import task has started processing, or has completed, or failed. You can also use the AWS IoT console or the StatusReason parameter of any of the AWS IoT Wireless API operations to retrieve additional status details.

- **INITIALIZING**
  
  AWS IoT Core for Amazon Sidewalk has received the wireless device import task request and is in the process of setting up the task.

- **INITIALIZED**
  
  AWS IoT Core for Amazon Sidewalk has completed setting up the import task and is waiting for the control log to arrive so that it can import the devices using their serial numbers (SMSN) and continue processing the task.

- **PENDING**
  
  The import task is waiting in the queue to be processed. AWS IoT Core for Amazon Sidewalk is evaluating other tasks that are in the processing queue.

- **COMPLETE**
  
  The import task has been processed and completed.

- **FAILED**
  
  The import task or device task failed. You can use the StatusReason parameter to identify why the import task failed, such as a validation exception.

- **DELETING**
  
  The import task has been marked for deletion and is in the process of being deleted.

Device onboarding status

The Sidewalk devices that you added to your import task can have one of the following status messages. The status indicates whether your devices are ready to be onboarded, or has onboarded, or failed to onboard. You can also use the AWS IoT console or the OnboardingStatusReason parameter of the AWS IoT Wireless API operation, ListDevicesForWirelessDeviceImportTask, to retrieve additional status details.

- **INITIALIZED**
  
  AWS IoT Core for Amazon Sidewalk has completed setting up the import task and is waiting for the control log to arrive so that it can import the devices using their serial numbers (SMSN) and continue processing the task.

- **PENDING**
  
  The import task is waiting in the queue to be processed and to start onboarding your devices to the task. AWS IoT Core for Amazon Sidewalk is evaluating other tasks that are in the processing queue.

- **ONBOARDED**
  
  The Sidewalk device has been successfully onboarded to the import task.
AWS IoT Core for Amazon Sidewalk API operations

You can perform the following additional API operations when onboarding your Sidewalk end devices, or when creating an import task for provisioning Sidewalk end devices in bulk.

The following sections contain additional information about these API operations.

Topics

- AWS IoT Core for Amazon Sidewalk API operations for device profiles (p. 1380)
- AWS IoT Core for Amazon Sidewalk API operations for Sidewalk end devices (p. 1381)
- AWS IoT Core for Amazon Sidewalk API operations for destinations for Sidewalk end devices (p. 1383)
- AWS IoT Core for Amazon Sidewalk API operations for bulk provisioning (p. 1384)

AWS IoT Core for Amazon Sidewalk API operations for device profiles

You can perform the following API operations for your Sidewalk device profiles:

- CreateDeviceProfile API or the create-device-profile CLI
- GetDeviceProfile API or the get-device-profile CLI
- ListDeviceProfiles API or the list-device-profiles CLI
- DeleteDeviceProfile API or the delete-device-profile CLI

The following sections show you how to list and delete profiles. For information about creating and retrieving device profiles, see Step 1: Create a device profile (p. 1354).

List device profiles in your AWS account

You can use the ListDeviceProfiles API operation to list device profiles in your AWS account that you added to AWS IoT Core for Amazon Sidewalk. You can use this information to identify the devices that you want to associate this profile to.

To filter the list to display only Sidewalk device profiles, set Type to Sidewalk when running the API. Following shows an example CLI command:

```bash
aws iotwireless list-device-profiles --wireless-device-type "Sidewalk"
```

Running this command returns a list of device profiles that you added, including their profile identifier and Amazon Resource Name (ARN). To retrieve additional details about a specific profile, use the GetDeviceProfile API.
"DeviceProfileList": [
  {
    "Name": "SidewalkDeviceProfile1",
    "Id": "12345678-a1b2-3c45-67d8-e90fa1b2c34d",
    "Arn": "arn:aws:iotwireless:us-east-1:123456789012:DeviceProfile/12345678-a1b2-3c45-67d8-e90fa1b2c34d"
  },
  {
    "Name": "SidewalkDeviceProfile2",
    "Id": "a1b2c3d4-5678-90ab-cdef-12ab345c67de",
    "Arn": "arn:aws:iotwireless:us-east-1:123456789012:DeviceProfile/a1b2c3d4-5678-90ab-cdef-12ab345c67de"
  }
]

Delete device profiles from your AWS account

You can delete your device profiles using the DeleteDeviceProfile API operation. The following shows an example CLI command:

**Warning**
Deletion actions can't be undone. The device profile will be permanently removed from your AWS account.

```
aws iotwireless delete-device-profile --name "SidewalkProfile"
```

This command doesn't produce any output. You can use the GetDeviceProfile API or the ListDeviceProfiles API operation to verify that the profile has been removed from your account.

AWS IoT Core for Amazon Sidewalk API operations for Sidewalk end devices

You can perform the following API operations for your Sidewalk devices:

- **CreateWirelessDevice** API or the `create-wireless-device` CLI
- **GetWirelessDevice** API or the `get-wireless-device` CLI
- **ListWirelessDevices** API or the `list-wireless-devices` CLI
- **DeleteWirelessDevice** API or the `delete-wireless-device` CLI
- **UpdateWirelessDevice** API or the `update-wireless-device` CLI
- **AssociateWirelessDeviceWithThing** API or the `associate-wireless-device-with-thing` CLI
- **DisassociateWirelessDeviceFromThing** API or the `disassociate-wireless-device-from-thing` CLI

The following sections show you how to list and delete devices. For information about creating Sidewalk end devices and retrieving device information, see [Step 2: Add your Sidewalk device (p. 1355)](#)

Associate Sidewalk end devices in your AWS account to an IoT thing

To associate your Sidewalk device with an AWS IoT thing, use the **AssociateWirelessDeviceWithThing** API operation.
Things in AWS IoT make it easier to search and manage your devices. Associating a thing with your device lets the device access other AWS IoT Core features. For more information about using this API, see the API reference documentation.

The following shows an example of running this command. Running this command doesn't produce any output.

```bash
aws iotwireless associate-wireless-device-with-thing
   --id "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
   --thing-arn "arn:aws:iot:us-east-1:123456789012:thing/MySidewalkThing"
```

To disassociate your Sidewalk device from an AWS IoT thing, use the `DisassociateWirelessDeviceFromThing` API operation, as shown in the following example.

```bash
aws iotwireless disassociate-wireless-device-from-thing
   --id "12345678-a1b2-3c45-67d8-e90fa1b2c34d"
```

**List Sidewalk end devices in your AWS account**

To list Sidewalk devices in your AWS account that you added to AWS IoT Core for Amazon Sidewalk, use the `ListWirelessDevices` API operation. To filter the list to return only Sidewalk devices, set the `WirelessDeviceType` to `Sidewalk`.

The following shows an example of running this command:

```bash
aws iotwireless list-wireless-devices --wireless-device-type Sidewalk
```

Running this command returns a list of devices that you added, including their profile identifier and the Amazon Resource Name (ARN). To retrieve additional details about a specific device, use the `GetWirelessDevice` API operation.

```json
{
   "WirelessDeviceList": [
      {
         "Name": "mySidewalkDevice",
         "DestinationName": "SidewalkDestination",
         "Id": "1ffd32c8-8130-4194-96df-622f072a315f",
         "Type": "Sidewalk",
         "Sidewalk": {
            "SidewalkId": "1234567890123456"
         },
         "Arn": "arn:aws:iotwireless:us-east-1:123456789012:WirelessDevice/1ffd32c8-8130-4194-96df-622f072a315f"
      }
   ]
}
```

**Delete Sidewalk devices from your AWS account**

To delete your Sidewalk devices, pass the `WirelessDeviceID` of the devices you want to delete to the `DeleteWirelessDevice` API operation.

The following shows an example command:

```bash
aws iotwireless delete-wireless-device --id "23456789-abcd-0123-bcde-fabc012345678"
```
This command doesn't produce any output. You can use the GetWirelessDevice API or the ListWirelessDevices API operation to verify that the device has been removed from your account.

AWS IoT Core for Amazon Sidewalk API operations for destinations for Sidewalk end devices

You can perform the following API operations for destinations for your Sidewalk end devices:

- [CreateDestination](#) API or the `create-destination` CLI
- [GetDestination](#) API or the `get-destination` CLI
- [UpdateDestination](#) API or the `update-destination` CLI
- [ListDestinations](#) API or the `list-destinations` CLI
- [DeleteDestination](#) API or the `delete-destination` CLI

The following sections show you how to get, list, update, and delete destinations. For information about creating destinations, see Add a destination for your Sidewalk end device (p. 1359).

Get information about your destination

You can use the GetDestination API operation to get information about the destination that you added to your account for AWS IoT Core for Amazon Sidewalk. Provide the destination name as input to the API. The API will return information about the destination matching the specified identifier.

The following shows an example CLI command:

```bash
aws iotwireless get-destination --name SidewalkDestination
```

Running this command returns the parameters of your destination.

```
{
  "Arn": "arn:aws:iotwireless:us-east-1:123456789012:Destination/IoTWirelessDestination",
  "Name": "SidewalkDestination",
  "Expression": "IoTWirelessRule",
  "ExpressionType": "RuleName",
  "RoleArn": "arn:aws:iam::123456789012:role/IoTWirelessDestinationRole"
}
```

Update properties of your destination

Use the UpdateDestination API operation to update properties of your destination that you added to your account for AWS IoT Core for Amazon Sidewalk. The following shows an example CLI command that updates the description property:

```bash
aws iotwireless update-destination --name SidewalkDestination \[--description "Destination for messages processed using IoTWirelessRule"
```

List destinations in your AWS account

Use the ListDestinations API operation to list destinations in your AWS account that you added to AWS IoT Core for Amazon Sidewalk. To filter the list to return only destinations for Sidewalk end devices, use the WirelessDeviceType parameter.
The following shows an example CLI command:

```
aws iotwireless list-destinations --wireless-device-type "Sidewalk"
```

Running this command returns a list of destinations that you added, including their Amazon Resource Name (ARN). To retrieve additional details about a specific destination, use the `GetDestination` API.

```
{
  "DestinationList": [
    {
      "Arn": "arn:aws:iotwireless:us-east-1:123456789012:Destination/IoTWirelessDestination",
      "Name": "IoTWirelessDestination",
      "Expression": "IoTWirelessRule",
      "Description": "Destination for messages processed using IoTWirelessRule",
      "RoleArn": "arn:aws:iam::123456789012:role/IoTWirelessDestinationRole"
    },
    {
      "Arn": "arn:aws:iotwireless:us-east-1:123456789012:Destination/IoTWirelessDestination2",
      "Name": "IoTWirelessDestination2",
      "Expression": "IoTWirelessRule2",
      "RoleArn": "arn:aws:iam::123456789012:role/IoTWirelessDestinationRole"
    }
  ]
}
```

Delete destinations from your AWS account

To delete your destination, pass the name of the destination to be deleted as input to the `DeleteDestination` API operation. The following shows an example CLI command:

```
Warning
Deletion actions can't be undone. The destination will be permanently removed from your AWS account.
```

```
aws iotwireless delete-destination --name "SidewalkDestination"
```

This command doesn't produce any output. You can use the `GetDestination` API or the `ListDestinations` API operation to verify that the destination has been removed from your account.

**AWS IoT Core for Amazon Sidewalk API operations for bulk provisioning**

You can perform the following API operations for bulk provisioning your Sidewalk end devices:

- `StartWirelessDeviceImportTask` API or the `start-wireless-device-import-task` CLI
- `StartSingleWirelessDeviceImportTask` API or the `start-single-wireless-device-import-task` CLI
- `ListWirelessDeviceImportTasks` API or the `list-wireless-device-import-tasks` CLI
- `ListDevicesForWirelessDeviceImportTask` API or the `list-devices-for-wireless-device-import-task` CLI
- `GetWirelessDeviceImportTask` API or the `get-wireless-device-import-task` CLI
- `UpdateWirelessDeviceImportTask` API or the `update-wireless-device-import-task` CLI
The following sections show you how to get, list, update, and delete import tasks. For information about creating import tasks, see AWS IoT Core for Amazon Sidewalk API operations for bulk provisioning (p. 1384).

Get information about your import task

You can use the ListDevicesForWirelessDeviceImportTask API operation to retrieve information about a particular import task and the onboarding status of devices in that task. As input to the API operation, specify the import task ID that you obtained from either the StartWirelessDeviceImportTask or StartSingleWirelessDeviceImportTask API operations. The API will then return information about the import task matching the specified identifier.

The following shows an example CLI command:

```bash
aws iotwireless list-devices-for-wireless-device-import-task --id e2a5995e-743b-41f2-a1e4-3ca6a5c5249f
```

Running this command returns your import task information and device onboarding status.

```
{
   "DestinationName": "SidewalkDestination",
   "ImportedWirelessDeviceList": [
     {
       "Sidewalk": {
         "OnboardingStatus": "ONBOARDED",
         "LastUpdateTime": "2023-02021T06:11:09.151Z",
         "SidewalkManufacturingSn": "82B83C8B3E856F43CE9C3D59B418CC96B996071016DB1C385901F0F3071A4A"
       },
       "Sidewalk": {
         "OnboardingStatus": "PENDING",
         "LastUpdateTime": "2023-02021T06:22:12.061Z",
         "SidewalkManufacturingSn": "12345ABCDE6789FABDE5BDEF123456789012345FEABC0123679AFEBC01234EF"
       }
     }
   ]
}
```

Get import task device summary

To get a count of summary information of the onboarding status of devices that you added to a particular import task, use the GetWirelessDeviceImportTask API operation. The following shows an example CLI command.

```bash
aws iotwireless get-wireless-device-import-task --Id "e2a5995e-743b-41f2-a1e4-3ca6a5c5249f"
```

The following code shows a sample response from the command.

```
{
   "NumberOfFailedImportedDevices": 2,
   "NumberOfOnboardedImportedDevices": 4,
   "NumberOfPendingImportedDevices": 1
}
```
Add devices to import task

Use the UpdateWirelessDeviceImportTask API operation to add devices to an existing import task that you added. You can use this API operation to add the serial numbers (SMSN) of devices that were not previously included in the task that you created using the StartWirelessDeviceImportTask API operation.

To append devices to the import task, as part of the API request, specify a new CSV file in an Amazon S3 bucket that contains the serial numbers of devices to be added. The request will be accepted only if the onboarding process hasn't already started for devices that are currently in the import task. If the onboarding process has already started, then the UpdateWirelessDeviceImportTask API request will fail.

If you still want to append devices to the import task, you can perform the UpdateWirelessDeviceImportTask API operation a second time. Before you perform this API operation, the first UpdateWirelessDeviceImportTask API request must have completed processing the CSV file in the S3 bucket.

Note
When you perform a ListImportedWirelessDeviceTasks API request, the S3 URL of the new CSV file specified using the UpdateWirelessDeviceImportTask API operation is currently not returned. Instead, the API operation returns the S3 URL of the request sent originally using the StartWirelessDeviceImportTask API request.

The following shows an example CLI command.

```
aws iotwireless update-wireless-device-import task \
--Id "e2a5995e-743b-41f2-a1e4-3ca6a5c5249f" \
--sidewalk '{"FileForCreateDevices": "s3://import_task_bucket/import_file3"}'
```

List import tasks in your AWS account

Use the ListWirelessDeviceImportTasks API or the list-imported-wireless-device-tasks CLI command to list import tasks in your AWS account. The following shows an example CLI command.

```
aws iotwireless list-wireless-device-import-tasks
```

Running this command returns a list of import tasks that you created. The list includes their Amazon S3 CSV files and the IAM role that was specified, the import task ID, and summary information of the device onboarding status.

```json
{
  "ImportWirelessDeviceTaskList": [
    {
      "FileForCreateDevices": "s3://import_task_bucket/import_file1",
      "ImportTaskId": "e2a5995e-743b-41f2-a1e4-3ca6a5c5249f",
      "NumberOfFailedImportedDevices": 1,
      "NumberOfOnboardedImportedDevices": 3,
      "NumberOfPendingImportedDevices": 2,
      "Role": "arn:aws:iam::123456789012:role/service-role/ACF1zBEI",
      "TimeStamp": "1012202218:23:55"
    },
    {
      "FileForCreateDevices": "s3://import_task_bucket/import_file2",
      "ImportTaskId": "a1b234c5-67ef-21a2-a1b2-3cd4e5f6789a",
      "NumberOfFailedImportedDevices": 2,
      "NumberOfOnboardedImportedDevices": 4,
      "NumberOfPendingImportedDevices": 1,
      "Role": "arn:aws:iam::123456789012:role/service-role/CDEFaBC1"
    }
  ]
}
```
Delete import tasks from your AWS account

To delete an import task, pass the import task ID to the DeleteWirelessDeviceImportTask API operation or the delete-wireless-device-import-task CLI command.

**Warning**
Deletion actions can't be undone. The import task will be permanently removed from your AWS account.

When you perform the DeleteWirelessDeviceImportTask API request, a background process starts deleting the import task. When the request is in progress, the serial numbers (SMSN) of devices in the import tasks are in the process of deletion. Only after the deletion has completed, you'll be able to see this information using the ListImportedWirelessDeviceTasks or the GetImportedWirelessDeviceTasks API operations.

If an import task still contains devices that are waiting to be onboarded, the DeleteWirelessDeviceImportTask API request will be processed only after all the devices in the import task have either onboarded or failed to onboard. An import task expires after 90 days, and once the task has expired, it can be deleted from your account. However, devices that were onboarded successfully using the import task will not be deleted.

**Note**
If you attempt to create another import task that includes the serial number of a device that's pending deletion using the DeleteWirelessDeviceImportTask API request, then the StartWirelessDeviceImportTask API operation will return an error.

The following shows an example CLI command:

```
aws iotwireless delete-import-task --Id "e2a5995e-743b-41f2-a1e4-3ca6a5c5249f"
```

This command doesn't produce any output. After the task has been deleted, to verify that the import task has been removed from your account, you can use the GetWirelessDeviceImportTask API operation or the ListWirelessDeviceImportTasks API operation.

Monitoring and events for AWS IoT Core for Amazon Sidewalk

You can configure events and use CloudWatch Logs to monitor your Sidewalk devices and troubleshoot any issues.

**Events for Sidewalk devices**

Use AWS IoT Core for Amazon Sidewalk to publish messages that notify you of events such as when the Sidewalk devices in your account have been provisioned or registered. The events are published over MQTT with a JSON payload whose content depends on the type of event.

**Event types for Sidewalk devices**

Events for Sidewalk resources include:
• **Device registration state events**

These events publish notifications when there's a change in the device registration state, such as when a Sidewalk device has been provisioned or registered.

• **Proximity events**

These events publish notifications when a beacon is received from your Sidewalk device. Beacons are sent at regular intervals when your Sidewalk device approaches Amazon Sidewalk.

• **Message delivery status events**

These events publish notifications about the status of messages that are exchanged between AWS IoT Core for Amazon Sidewalk and the Sidewalk device. For example, it will publish an event to indicate when a message failed to deliver even though the `SendDataToWirelessDevice` API returns a message ID.

### Enable events for Sidewalk devices

To receive events, your device must use an appropriate policy that allows it to connect to the AWS IoT device gateway and subscribe to MQTT event topics, as shown in the following example.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "iot:Subscribe",
        "iot:Receive"
      ],
      "Resource": [
        "arn:aws:iotwireless:region:account:/aws/iotwireless/events/join/*",
        "arn:aws:iotwireless:region:account:/aws/iotwireless/events/connection_status/*",
        "arn:aws:iotwireless:region:account:/aws/iotwireless/events/device_registration_state/*",
        "arn:aws:iotwireless:region:account:/aws/iotwireless/events/proximity/*",
        "arn:aws:iotwireless:region:account:/aws/iotwireless/events/message_delivery_status/*"
      ]
    }
  ]
}
```

You can enable events using the AWS IoT Core for Amazon Sidewalk API, AWS CLI, or the AWS Management Console. To configure events for all Sidewalk devices, use the `UpdateEventConfigurationByResourceTypes` API or the `update-event-configuration-by-resource-types` CLI command.

```
aws iotwireless update-event-configuration-by-resource-types \
  --device-registration-state Sidewalk={WirelessDeviceEventTopic="Enabled"}
```

To configure events for individual devices, use the `UpdateResourceEventConfiguration` API or the `update-resource-event-configuration` CLI command.

```
aws iotwireless update-resource-event-configuration --identifier-type WirelessDeviceID \
  --identifier "1ffd32c8-8130-4194-96df-622f072a315f" \
  --message-delivery-status Sidewalk={WirelessDeviceIdEventTopic="Enabled"}
```

For more information about configuring events, see [Sidewalk events](#).
Monitoring of Sidewalk devices

You can monitor your Sidewalk devices and applications that run in real time by using Amazon CloudWatch. Use CloudWatch to collect and track metrics, view logs that contain information about the status of your Sidewalk devices, filter the logs to view only errors, or obtain useful insights.

When using Amazon CloudWatch, first configure a logging role and then use log metrics or CloudWatch Insights to monitor your devices. Any error that occurs will be logged and sent to your CloudWatch log group. You can then learn more about the error and troubleshoot issues to resolve them.

The following steps show you how to log and monitor your Sidewalk devices:

1. Create a logging role to log your Sidewalk devices, as shown in the following example policy. For more information, see Create logging role and policy for AWS IoT Wireless.

   ```json
   {
   "Version": "2012-10-17",
   "Statement": [
   {
   "Effect": "Allow",
   "Principal": {
   "Service": "iotwireless.amazonaws.com"
   },
   "Action": "sts:AssumeRole",
   "Condition": {}
   }
   ]
   }
   ```

2. To obtain less verbose logs such as to view only error information, configure logging to logs. For more information, see Configure logging for AWS IoT Wireless resources.

3. Monitor your Sidewalk devices by viewing the logs in the CloudWatch Logs console and create simple filters and view log entries in the Logs groups. For more information, see View CloudWatch AWS IoT Wireless log entries.

4. Create advanced filter expressions depending on the logging information that you want to obtain, and go to CloudWatch Insights to filter the log queries and obtain additional insights. For more information, see View CloudWatch Insights to filter logs for AWS IoT Wireless.

For detailed instructions, see Monitoring and logging for AWS IoT Wireless.
Monitoring and logging for AWS IoT Wireless using Amazon CloudWatch

You can monitor your AWS IoT Wireless resources and applications that run in real time by using Amazon CloudWatch. You can monitor the status of your LoRaWAN and Sidewalk devices that you've onboarded using Amazon CloudWatch.

- For information about onboarding LoRaWAN devices, see [Connecting gateways and devices to AWS IoT Core for LoRaWAN (p. 1228)](#).
- For information about onboarding Amazon Sidewalk devices to AWS IoT Core, see [Getting started with AWS IoT Core for Amazon Sidewalk (p. 1345)](#).

Use CloudWatch to collect and track metrics, which are variables that you can measure for your resources and applications. For more information about the benefits of using monitoring, see [Monitoring AWS IoT (p. 439)](#).

If you want to obtain more real-time log information from your LoRaWAN devices, use the network analyzer. For more information, see [Monitoring your wireless resource fleet in real time using network analyzer (p. 1318)](#).

**How to monitor your wireless resources**

To log and monitor your wireless resources, perform the following steps.

1. Create a logging role to log your AWS IoT Wireless resources, as described in [Create logging role and policy for AWS IoT Wireless (p. 1391)](#).
2. Log messages in the CloudWatch Logs console have a default log level of ERROR, which is less verbose and contains only error information. If you want to view more verbose messages, we recommend that you use the CLI to configure logging first, as described in [Configure logging for AWS IoT Wireless resources (p. 1393)](#).
3. Next, you can monitor your resources by viewing the log entries in the CloudWatch Logs console. For more information, see [View CloudWatch AWS IoT Wireless log entries (p. 1401)](#).
4. You can create filter expressions by using [Logs groups] but we recommend that you first create simple filters and view log entries in the log groups, and then go to CloudWatch Insights to create queries to filter the log entries depending on the resource or event you're monitoring. For more information, see [Use CloudWatch Insights to filter logs for AWS IoT Wireless (p. 1407)](#).

The following topics show how to configure logging for AWS IoT Wireless and to collect metrics from CloudWatch. In addition to LoRaWAN devices, you can use these topics to configure logging for any Sidewalk devices that you've added to your account and monitor them. For information about how to add these devices, see [AWS IoT Core for Amazon Sidewalk (p. 1341)](#).

**Topics**
- [Configure Logging for AWS IoT Wireless (p. 1390)](#)
- [Monitor AWS IoT Wireless using CloudWatch Logs (p. 1401)](#)

**Configure Logging for AWS IoT Wireless**

Before you can monitor and log AWS IoT activity, first enable logging for AWS IoT Wireless resources by using either the CLI or API.
When considering how to configure your AWS IoT Wireless logging, the default logging configuration determines how AWS IoT activity will be logged unless you specify otherwise. Starting out, you might want to obtain detailed logs with a default log level of INFO.

After reviewing the initial logs, you can change the default log level to ERROR, which is less verbose, and set a more verbose, resource-specific log level on resources that might need more attention. Log levels can be changed whenever you want.

The following topics show how to configure logging for AWS IoT Wireless resources.

Topics
- Create logging role and policy for AWS IoT Wireless (p. 1391)
- Configure logging for AWS IoT Wireless resources (p. 1393)

Create logging role and policy for AWS IoT Wireless

The following shows how to create a logging role for only AWS IoT Wireless resources. If you want to also create a logging role for AWS IoT Core, see Create a logging role (p. 440).

Create a logging role for AWS IoT Wireless

Before you can enable logging, you must create an IAM role and a policy that gives AWS permission to monitor AWS IoT Wireless activity on your behalf.

Create IAM role for logging

To create a logging role for AWS IoT Wireless, open the Roles hub of the IAM console and choose Create role.

1. Under Select type of trusted entity, choose Another AWS account.
2. In Account ID, enter your AWS account ID, and then choose Next: Permissions.
3. In the search box, enter AWSIoTWirelessLogging.
4. Select the box next to the policy named AWSIoTWirelessLogging, and then choose Next: Tags.
5. Choose Next: Review.
6. In Role name, enter IoTWirelessLogsRole, and then choose Create role.

Edit trust relationship of the IAM role

In the confirmation message displayed after you ran the previous step, choose the name of the role you created, IoTWirelessLogsRole. Next, you'll edit the role to add the following trust relationship.

1. In the Summary section of the role IoTWirelessLogsRole, choose the Trust relationships tab, and then choose Edit trust relationship.
2. In Policy Document, change the Principal property to look like this example.

```json
"Principal": {
    "Service": "iotwireless.amazonaws.com"
},
```

After you change the Principal property, the complete policy document should look like this example.

```json
{
    "Version": "2012-10-17",
    "Statement": [
```
3. To save your changes and exit, choose Update Trust Policy.

Logging policy for AWS IoT Wireless

The following policy document provides the role policy and trust policy that allows AWS IoT Wireless to submit log entries to CloudWatch on your behalf.

**Note**

This AWS managed policy document was automatically created for you when you created the logging role, *IoTWirelessLogsRole*.

**Role policy**

The following shows the role policy document.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": [
        "logs:CreateLogGroup",
        "logs:CreateLogStream",
        "logs:DescribeLogGroups",
        "logs:DescribeLogStreams",
        "logs:PutLogEvents"
      ],
      "Resource": "arn:aws:logs:*:*:log-group:/aws/iotwireless*"
    }
  ]
}
```

**Trust policy to log only AWS IoT Wireless activity**

The following shows the trust policy for logging only AWS IoT Wireless activity.

```json
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Sid": "",
      "Effect": "Allow",
      "Principal": {
        "Service": ["iotwireless.amazonaws.com"]
      },
      "Action": "sts:AssumeRole"
    }
  ]
}
```
If you created the IAM role to also log AWS IoT Core activity, then the policy documents allow you to log both activities. For information about creating a logging role for AWS IoT Core, see Create a logging role (p. 440).

Next steps

You've learned how to create a logging role to log your AWS IoT Wireless resources. By default, logs have a log level of ERROR, so if you want to see only error information, go to View CloudWatch AWS IoT Wireless log entries (p. 1401) to monitor your wireless resources by viewing the log entries.

If you want more information in the log entries, you can configure the default log level for your resources or for different event types, such as setting the log level to INFO. For information about configuring logging for your resources, see Configure logging for AWS IoT Wireless resources (p. 1393).

Configure logging for AWS IoT Wireless resources

To configure logging for AWS IoT Wireless resources, you can use either the API or the CLI. When starting to monitor AWS IoT Wireless resources, you can use the default configuration. To do this, you can skip this topic and proceed to Monitor AWS IoT Wireless using CloudWatch Logs (p. 1401) to monitor your logs.

After you start monitoring the logs, you can use the CLI to change the log levels to a more verbose option, such as providing INFO and ERROR information and enabling logging for more resources.

AWS IoT Wireless resources and log levels

Before you use the API or CLI, use the following table to learn about the different log levels and the resources that you can configure logging for. The table shows parameters that you see in the CloudWatch logs when you monitor the resources. How you configure the logging for your resources will determine the logs you see in the console.

For information about what a sample CloudWatch logs looks like and how you can use these parameters to log useful information about the AWS IoT Wireless resources, see View CloudWatch AWS IoT Wireless log entries (p. 1401).

Log levels and resources

<table>
<thead>
<tr>
<th>Name</th>
<th>Possible values</th>
<th>Description</th>
</tr>
</thead>
</table>
| logLevel       | INFO, ERROR, or DISABLED         | • ERROR: Displays any error that causes an operation to fail. Logs include only ERROR information.  
 |                |                                  | • INFO: Provides high-level information about the flow of things. Logs include INFO and ERROR information.  
 |                |                                  | • DISABLED: Disables all logging.                                             |
| resource       | WirelessGateway or WirelessDevice| The type of the resource, which can be WirelessGateway or WirelessDevice.    |
| wirelessGatewayType | LoRaWAN                        | The type of the wireless gateway, when resource is WirelessGateway, which is always LoRaWAN. |
| wirelessDeviceType | LoRaWAN or Sidewalk            | The type of the wireless device, when resource is WirelessDevice, which can be LoRaWAN or Sidewalk. |
Configure logging for AWS IoT Wireless resources

<table>
<thead>
<tr>
<th>Name</th>
<th>Possible values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>wirelessGatewayId</td>
<td>-</td>
<td>The identifier of the wireless gateway, when resource is WirelessGateway.</td>
</tr>
<tr>
<td>wirelessDeviceId</td>
<td>-</td>
<td>The identifier of the wireless device, when resource is WirelessDevice.</td>
</tr>
<tr>
<td>event</td>
<td>Join, Rejoin, Registration, Uplink_data, Downlink_data, CUPS_Request, and Certificate</td>
<td>The type of event being logged, which depends on whether the resource that you're logging is a wireless device or a wireless gateway. For more information, see View CloudWatch AWS IoT Wireless log entries (p. 1401).</td>
</tr>
</tbody>
</table>

AWS IoT Wireless logging API

You can use the following API actions to configure logging of resources. The table also shows a sample IAM policy that you must create for using the API actions. The following section describes how you can use the APIs to configure log levels of your resources.

Logging API actions

<table>
<thead>
<tr>
<th>API name</th>
<th>Description</th>
<th>Sample IAM policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>GetLogLevelsByResourceTypes</td>
<td>Returns current default log levels, or log levels by resource types, which can include log options for wireless devices or wireless gateways.</td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Version&quot;: &quot;2012-10-17&quot;,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Statement&quot;: [</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Effect&quot;: &quot;Allow&quot;,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Action&quot;: [</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;iotwireless:GetLogLevelsByResourceTypes&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>],</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Resource&quot;: [</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;*&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>GetResourceLogLevel</td>
<td>Returns the log-level override for a given resource identifier and resource type. The resource can be a wireless device or a wireless gateway.</td>
<td>{</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Version&quot;: &quot;2012-10-17&quot;,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Statement&quot;: [</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Effect&quot;: &quot;Allow&quot;,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;Action&quot;: [</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&quot;iotwireless:GetResourceLogLevel&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>}</td>
</tr>
<tr>
<td>API name</td>
<td>Description</td>
<td>Sample IAM policy</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| **PutResourceLogLevel** | Sets the log-level override for a given resource identifier and resource type. The resource can be a wireless gateway or a wireless device. | ```json
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["iotwireless:PutResourceLogLevel"]
        }
    ],
    "Resource": [
        "arn:aws:iotwireless:us-east-1:123456789012:WirelessDevice/012bc5ab12-cd3a-d00e-1f0e20c1204a",
        "arn:aws:iotwireless:us-east-1:123456789012:WirelessDevice/012bc5ab12-cd3a-d00e-1f0e20c1204a"
    ]
}
``` |

**Note**
This API has a limit of 200 log-level overrides per account.
## Configure logging for AWS IoT Wireless resources

<table>
<thead>
<tr>
<th>API name</th>
<th>Description</th>
<th>Sample IAM policy</th>
</tr>
</thead>
</table>
| **ResetAllResourceLogLevels** | Removes the log-level overrides for all resources, which includes both wireless gateways and wireless devices. | {
| **ResetResourceLogLevel**     | Removes the log-level override for a given resource identifier and resource type. The resource can be a wireless gateway or a wireless device. | {
|                               |                                                                                           | } |
Configure log levels of resources using the CLI

This section describes how to configure log levels for AWS IoT Wireless resources by using the API or AWS CLI.

Before you use the CLI:

- Make sure you created the IAM policy for the API for which you want to run the CLI command, as described previously.
- You need the Amazon Resource Name (ARN) of the role you want to use. If you need to create a role to use for logging, see Create logging role and policy for AWS IoT Wireless (p. 1391).

Why use the AWS CLI

By default, if you create the IAM role, IoTWirelessLogsRole, as described in Create logging role and policy for AWS IoT Wireless (p. 1391), you'll see CloudWatch logs in the AWS Management Console that have a default log level of ERROR. To change the default log level for all your resources or for specific resources, use the AWS IoT Wireless logging API or CLI.

How to use the AWS CLI

The API actions can be categorized into the following types depending on whether you want to configure log levels for all resources or for specific resources:

- API actions GetLogLevelsByResourceTypes and UpdateLogLevelsByResourceTypes can retrieve and update the log levels for all resources in your account that are of a specific type, such as a wireless gateway, or a LoRaWAN or Sidewalk device.
- API actions GetResourceLogLevel, PutResourceLogLevel, and ResetResourceLogLevel can retrieve, update, and reset log levels of individual resources that you specify using a resource identifier.
- API action ResetAllResourceLogLevelOverride resets the log-level override to null for all resources for which you specified a log-level override using the PutResourceLogLevel API.
To use the CLI to configure resource-specific logging for AWS IoT

**Note**
You can also perform this procedure with the API by using the methods in the AWS API that correspond to the CLI commands shown here.

1. By default, all resources have log level set to ERROR. To set the default log levels, or log levels by resource types for all resources in your account, use the `update-log-levels-by-resource-types` command. The following example shows how you can create a JSON file, `Input.json`, and provide it as an input to the CLI command. You can use this command to selectively disable logging or override the default log level for specific types of resources and events.

```json
{
   "DefaultLogLevel": "INFO",
   "WirelessDeviceLogOptions": [
      {
         "Type": "Sidewalk",
         "LogLevel": "INFO",
         "Events": [
            {
               "Event": "Registration",
               "LogLevel": "DISABLED"
            }
         ]
      },
      {
         "Type": "LoRaWAN",
         "LogLevel": "INFO",
         "Events": [
            {
               "Event": "Join",
               "LogLevel": "DISABLED"
            },
            {
               "Event": "Rejoin",
               "LogLevel": "ERROR"
            }
         ]
      }
   ],
   "WirelessGatewayLogOptions": [
      {
         "Type": "LoRaWAN",
         "LogLevel": "INFO",
         "Events": [
            {
               "Event": "CUPS_Request",
               "LogLevel": "DISABLED"
            },
            {
               "Event": "Certificate",
               "LogLevel": "ERROR"
            }
         ]
      }
   ]
}
```
where:

**WirelessDeviceLogOptions**

The list of log options for a wireless device. Each log option includes the wireless device type (Sidewalk or LoRaWAN), and a list of wireless device event log options. Each wireless device event log option can optionally include the event type and its log level.

**WirelessGatewayLogOptions**

The list of log options for a wireless gateway. Each log option includes the wireless gateway type (LoRaWAN), and a list of wireless gateway event log options. Each wireless gateway event log option can optionally include the event type and its log level.

**DefaultLogLevel**

The log level to use for all your resources. Valid values are: ERROR, INFO, and DISABLED. The default value is INFO.

**LogLevel**

The log level you want to use for individual resource types and events. These log levels override the default log level, such as the log level INFO for the LoRaWAN gateway, and log levels DISABLED and ERROR for the two event types.

Run the following command to provide the `Input.json` file as input to the command. This command doesn't produce any output.

```
aws iotwireless update-log-levels-by-resource-types \
   --cli-input-json file://input.json
```

If you want to remove the log options for both wireless devices and wireless gateways, run the following command.

```
{
   "DefaultLogLevel": "DISABLED",
   "WirelessDeviceLogOptions": [],
   "WirelessGatewayLogOptions": []
}
```

2. The `update-log-levels-by-resource-types` command doesn't return any output. Use the `get-log-levels-by-resource-types` command to retrieve resource-specific logging information. The command returns the default log level, and the wireless device and wireless gateway log options.

   **Note**
   The `get-log-levels-by-resource-types` command can't directly retrieve the log levels in the CloudWatch console. You can use the `get-log-levels-by-resource-types` command to get the latest log-level information that you've specified for your resources using the `update-log-levels-by-resource-types` command.

```
aws iotwireless get-log-levels-by-resource-types
```

When you run the following command, it returns the latest logging information you specified with `update-log-levels-by-resource-types`. For example, if you remove the wireless device log options, then running the `get-log-levels-by-resource-types` will return this value as `null`.

```
{
   "DefaultLogLevel": "INFO",
```
3. To control log levels for individual wireless gateways or wireless device resources, use the following CLI commands:

- **put-resource-log-level**
- **get-resource-log-level**
- **reset-resource-log-level**

For an example for when to use these CLIs, say that you have a large number of wireless devices or gateways in your account that are being logged. If you want to troubleshoot errors for only some of your wireless devices, you can disable logging for all wireless devices by setting the DefaultLogLevel to DISABLED, and use the **put-resource-log-level** to set the LogLevel to ERROR for only those devices in your account.

```bash
aws iotwireless put-resource-log-level
    --resource-identifier
    --resource-type WirelessDevice
    --log-level ERROR
```

In this example, the command sets the log level to ERROR only for the specified wireless device resource and the logs for all other resources are disabled. This command doesn't produce any output. To retrieve this information and verify that the log levels were set, use the **get-resource-log-level** command.

4. In the previous step, after you've debugged the issue and resolved the error, you can run the **reset-resource-log-level** command to reset the log level for that resource to null. If you used the **put-resource-log-level** command to set the log-level override for more than one wireless device or gateway resource, such as for troubleshooting errors for multiple devices, you can reset the log-level overrides back to null for all those resources using the **reset-all-resource-log-levels** command.

```bash
aws iotwireless reset-all-resource-log-levels
```

This command doesn't produce any output. To retrieve the logging information for the resources, run the **get-resource-log-level** command.
Next Steps

You've learned how to create the logging role and use the AWS IoT Wireless API to configure logging for your AWS IoT Wireless resources. Next, to learn about monitoring your log entries, go to Monitor AWS IoT Wireless using CloudWatch Logs (p. 1401).

Monitor AWS IoT Wireless using CloudWatch Logs

AWS IoT Wireless has more than 50 CloudWatch log entries that are enabled by default. Each log entry describes the event type, log level, and the resource type. For more information, see AWS IoT Wireless resources and log levels (p. 1393).

How to monitor your AWS IoT Wireless resources

When logging is enabled for AWS IoT Wireless, AWS IoT Wireless sends progress events about each message as it passes from your devices through AWS IoT and back. By default, AWS IoT Wireless log entries have a default log level of error. When you enable logging as described in Create logging role and policy for AWS IoT Wireless (p. 1391), you’ll see messages in the CloudWatch console that have a default log level of ERROR. By using this log level, the messages will show only error information for all wireless devices and gateway resources that you’re using.

If you want the logs to show additional information, such as those that have a log level of INFO, or disable logs for some of your devices and show log messages for only some of your devices, you can use the AWS IoT Wireless logging API. For more information, see Configure log levels of resources using the CLI (p. 1397).

You can also create filter expressions to display only the required messages.

Before you can view AWS IoT Wireless logs in the console

To make the /aws/iotwireless log group appear in the CloudWatch console, you must have done the following.

• Enabled logging in AWS IoT Wireless. For more information about how to enable logging in AWS IoT Wireless, see Configure Logging for AWS IoT Wireless (p. 1390).
• Written some log entries by performing AWS IoT Wireless operations.

To create and use filter expressions more effectively, we recommend that you try using CloudWatch insights as described in the following topics. We also recommend that you follow the topics in the order they're presented here. This will help you use CloudWatch Log groups first to learn about the different types of resources, its event types, and log levels that you can use to view log entries in the console. You can then learn how to create filter expressions by using CloudWatch Insights to get more helpful information from your resources.

Topics

• View CloudWatch AWS IoT Wireless log entries (p. 1401)
• Use CloudWatch Insights to filter logs for AWS IoT Wireless (p. 1407)

View CloudWatch AWS IoT Wireless log entries

After you've configured logging for AWS IoT Wireless as described in Create logging role and policy for AWS IoT Wireless (p. 1391) and written some log entries, you can view the log entries in the CloudWatch console by performing the following steps.
Viewing AWS IoT logs in the CloudWatch Log groups console

In the CloudWatch console, CloudWatch logs appear in a log group named /aws/iotwireless. For more information about CloudWatch Logs, see CloudWatch Logs.

To view your AWS IoT logs in the CloudWatch console

Navigate to the CloudWatch console and choose Log groups in the navigation pane.

1. In the Filter text box, enter /aws/iotwireless, and then choose the /aws/iotwireless Log group.
2. To see a complete list of the AWS IoT Wireless logs generated for your account, choose Search all. To look at an individual log stream, choose the expand icon.
3. To filter the log streams, you can also enter a query in the Filter events text box. Here are some queries to try:
   - `{ $.logLevel = "ERROR" }`  
     Use this filter to find all logs that have a log level of ERROR and you can expand the individual error streams to read the error messages, which will help you resolve them.
   - `{ $.resource = "WirelessGateway" }`  
     Find all logs for the WirelessGateway resource regardless of the log level.
   - `{ $.event = "CUPS_Request" && $.logLevel = "ERROR" }`  
     Find all logs that have an event type of CUPS_Request and a log level of ERROR.

Events and resource types

The following table shows the different types of events for which you’ll see log entries. The event types also depend on whether the resource type is a wireless device or a wireless gateway. You can use the default log level for the resources and event types or override the default log level by specifying a log level for each of them.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Resource type</th>
<th>Event type</th>
</tr>
</thead>
</table>
| Wireless gateway  | LoRaWAN       | • CUPS_Request  
                   |                             | • Certificate               |
| Wireless device   | LoRaWAN       | • Join                      
                   |                             | • Rejoin                    
                   |                             | • Uplink_Data               
                   |                             | • Downlink_Data             |
| Wireless device   | Sidewalk      | • Registration              
                   |                             | • Uplink_Data               
                   |                             | • Downlink_Data             |

The following topic contains more information about these event types and the log entries for wireless gateways and wireless devices.

Topics
Log entries for wireless gateways and wireless device resources (p. 1403)

Log entries for wireless gateways and wireless device resources

After you've enabled logging, you can view log entries for your wireless gateways and wireless devices. The following section describes the various kinds of log entries based on your resource and event types.

Wireless gateway log entries

This section shows some of the sample log entries for your wireless gateway resources that you'll see in the CloudWatch console. These log messages can have event type as CUPS_Request or Certificate, and can be configured to display a log level of INFO, ERROR, or DISABLED at the resource level or the event level. If you want to see only error information, set the log level to ERROR. The message in the ERROR log entry will contain information about why it failed.

The log entries for your wireless gateway resource can be classified based on the following event types:

• CUPS_Request

The LoRa Basics Station running on your gateway periodically sends a request to the Configuration and Update Server (CUPS) for updates. For this event type, if you set log level to INFO when configuring the CLI for your wireless gateway resource, then in the logs:

• If the event is successful, you'll see log messages that have a logLevel of INFO. The messages will include details about the CUPS response sent to your gateway and the gateway details. Following shows an example of this log entry. For more information about the logLevel and other fields in the log entry, see AWS IoT Wireless resources and log levels (p. 1393).

{
    "timestamp": "2021-05-13T16:56:08.853Z",
    "resource": "WirelessGateway",
    "wirelessGatewayId": "5da85cc8-3361-4c79-8be3-3360fb87abda",
    "wirelessGatewayType": "LoRaWAN",
    "gatewayEui": "feffff00000000e2",
    "event": "CUPS_Request",
    "logLevel": "INFO",
    "message": "Sending CUPS response of total length 3213 to GatewayEui: feffff00000000e2 with TC Credentials,"
}

• If there is an error, you'll see log entries that have a logLevel of ERROR, and the messages will include details about the error. Examples of when an error can occur for the CUPS_Request event include: missing CUPS CRC, mismatch in the gateway's TC Uri with AWS IoT Wireless, missing IoTWirelessGatewayCertManagerRole, or not able to obtain wireless gateway record. Following example shows a missing CRC log entry. To resolve the error, check your gateway setup to verify that you've entered the correct CUPS CRC.

{
    "timestamp": "2021-05-13T16:56:08.853Z",
    "resource": "WirelessGateway",
    "wirelessGatewayId": "5da85cc8-3361-4c79-8be3-3360fb87abda",
    "wirelessGatewayType": "LoRaWAN",
    "gatewayEui": "feffff00000000e2",
    "event": "CUPS_Request",
    "logLevel": "ERROR",
    "message": "The CUPS CRC is missing from the request. Check your gateway setup and enter the CUPS CRC,"
}

• Certificate
These log entries will help you check whether your wireless gateway presented the correct certificate for authenticating connection to AWS IoT. For this event type, if you set log level to INFO when configuring the CLI for your wireless gateway resource, then in the logs:

- If the event is successful, you'll see log messages that have a logLevel of INFO. The messages will include details about the Certificate ID and the Wireless gateway identifier. Following shows an example of this log entry. For more information about the logLevel and other fields in the log entry, see [AWS IoT Wireless resources and log levels](p. 1393).

```json
{
    "resource": "WirelessGateway",
    "wirelessGatewayId": "5da85cc8-3361-4c79-8be3-3360fb87abda",
    "wirelessGatewayType": "LoRaWAN",
    "event": "Certificate",
    "logLevel": "INFO",
    "message": "Gateway connection authenticated. (CertificateId: b5942a7aee97eda24314e41e889227a5e0aa5ed87e6eb89239a83f515de17c, WireGatewaysId: 5da85cc8-3361-4c79-8be3-3360fb87abda)"
}
```

- If there is an error, you'll see log entries that have a logLevel of ERROR, and the messages will include details about the error. Examples of when an error can occur for the Certificate event include an invalid Certificate ID, wireless gateway identifier, or a mismatch between the wireless gateway identifier and the Certificate ID. Following example shows an ERROR due to invalid wireless gateway identifier. To resolve the error, check the gateway identifiers.

```json
{
    "resource": "WirelessGateway",
    "wirelessGatewayId": "5da85cc8-3361-4c79-8be3-3360fb87abda",
    "wirelessGatewayType": "LoRaWAN",
    "event": "Certificate",
    "logLevel": "INFO",
    "message": "The gateway connection couldn't be authenticated because a provisioned gateway associated with the certificate couldn't be found. (CertificateId: 729828e264810f6fc7134daf68056e8f8d8beebf416d709d9e)"
}
```

### Wireless device log entries

This section shows some of the sample log entries for your wireless device resources that you'll see in the CloudWatch console. The event type for these log messages depend on whether you're using a LoRaWAN or a Sidewalk device. Each wireless device resource or event type can be configured to display a log level of INFO, ERROR, or DISABLED.

**Note**

Your request must not contain both LoRaWAN and Sidewalk wireless metadata at the same time. To avoid an ERROR log entry for this scenario, specify either LoRaWAN or Sidewalk wireless data.

#### LoRaWAN device log entries

The log entries for your LoRaWAN wireless device can be classified based on the following event types:

- **Join and Rejoin**

  When you add a LoRaWAN device and connect it to AWS IoT Wireless, before your device can send uplink data, you must complete a process called activation or join procedure. For more information, see [Add your wireless device to AWS IoT Core for LoRaWAN](p. 1239).
For this event type, if you set log level to INFO when configuring the CLI for your wireless gateway resource, then in the logs:

- If the event is successful, you'll see log messages that have a `logLevel` of INFO. The messages will include details about the status of your join or rejoin request. Following shows an example of this log entry. For more information about the `logLevel` and other fields in the log entry, see AWS IoT Wireless resources and log levels (p. 1393).

  ```json
  {  
      "timestamp": "2021-05-13T16:56:08.853Z",
      "resource": "WirelessDevice",
      "wirelessDeviceType": "LoRaWAN",
      "WirelessDeviceId": "5da85cc8-3361-4c79-8be3-3360fb87abda",
      "devEui": "feffff00000000e2",
      "event": "Rejoin",
      "logLevel": "INFO",
      "message": "Rejoin succeeded"
  }
  ```

- If there is an error, you'll see log entries that have a `logLevel` of ERROR, and the messages will include details about the error. Examples of when an error can occur for the Join and Rejoin events include invalid LoRaWAN region setting, or invalid Message Integrity Code (MIC) check. Following example shows a join error due to MIC check. To resolve the error, check whether you've entered the correct root keys.

  ```json
  {  
      "timestamp": "2020-11-24T01:46:50.883481989Z",
      "resource": "WirelessDevice",
      "wirelessDeviceType": "LoRaWAN",
      "WirelessDeviceId": "cb4c087c-1be5-4990-8654-ccf543ee9fff",
      "devEui": "58a0cb000020255c",
      "event": "Join",
      "logLevel": "ERROR",
      "message": "invalid MIC. It's most likely caused by wrong root keys."
  }
  ```

- **Uplink_Data and Downlink_Data**

  The event type Uplink_Data is used for messages that are generated by AWS IoT Wireless when the payload is sent from the wireless device to AWS IoT. The event type Downlink_Data is used for messages that are related to downlink messages that are sent from AWS IoT to the wireless device.

  **Note**

  Events Uplink_Data and Downlink_Data apply to both LoRaWAN and Sidewalk devices.

  For this event type, if you set log level to INFO when configuring the CLI for your wireless devices, then in the logs, you'll see:

  - If the event is successful, you'll see log messages that have a `logLevel` of INFO. The messages will include details about the status of the uplink or downlink message that was sent and the wireless device identifier. Following shows an example of this log entry for a Sidewalk device. For more information about the `logLevel` and other fields in the log entry, see AWS IoT Wireless resources and log levels (p. 1393).

    ```json
    {  
        "resource": "WirelessDevice",
        "wirelessDeviceId": "5371db88-d63d-481a-868a-e54b6431845d",
        "wirelessDeviceType": "Sidewalk",
        "event": "Downlink_Data",
        "logLevel": "INFO",
        "messageId": "8da04fa8-037d-4ae9-bf67-35c4bb33da71",
    }
    ```
If there is an error, you'll see log entries that have a `logLevel` of `ERROR`, and the messages will include details about the error, which will help you resolve it. Examples of when an error can occur for the `Registration` event include: authentication issues, invalid or too many requests, unable to encrypt or decrypt the payload, or unable to find the wireless device using the specified ID. Following example shows a permission error encountered while processing a message.

```
{
"resource": "WirelessDevice",
"wirelessDeviceId": "cb4c087c-1be5-4990-8654-ccf543ee9fff",
"wirelessDeviceType": "LoRaWAN",
"event": "Uplink_Data",
"logLevel": "ERROR",
}
```

**Sidewalk device log entries**

The log entries for your Sidewalk device can be classified based on the following event types:

- **Registration**

  These log entries will help you monitor the status of any Sidewalk devices that you're registering with AWS IoT Wireless. For this event type, if you set log level to `INFO` when configuring the CLI for your wireless device resource, then in the logs, you'll see log messages that have a `logLevel` of `INFO` and `ERROR`. The messages will include details about the registration progress from start to completion. `ERROR` log messages will contain information about how to troubleshoot issues with registering your device.

  Following shows an example for a log message with log level of `INFO`. For more information about the `logLevel` and other fields in the log entry, see [AWS IoT Wireless resources and log levels](p. 1393).

```
{
"resource": "WirelessDevice",
"wirelessDeviceId": "8d0b2775-e19b-4b2a-a351-cb8a2734a504",
"wirelessDeviceType": "Sidewalk",
"event": "Registration",
"logLevel": "INFO",
"message": "Successfully completed device registration. Amazon SidewalkId = 2000000002"
}
```

- **Uplink_Data and Downlink_Data**

  The event types `Uplink_Data` and `Downlink_Data` for Sidewalk devices are similar to the corresponding event types for LoRaWAN devices. For more information, refer to the [Uplink_Data and Downlink_Data](p. 1393) section described previously for LoRaWAN device log entries.
Next steps

You've learned how to view log entries for your resources and the different log entries that you can view in the CloudWatch console after enabling logging for AWS IoT Wireless. While you can create filter streams using Log groups, we recommend that you use CloudWatch Insights to create and use filter streams. For more information, see Use CloudWatch Insights to filter logs for AWS IoT Wireless (p. 1407).

Use CloudWatch Insights to filter logs for AWS IoT Wireless

While you can use CloudWatch Logs to create filter expressions, we recommend that you use CloudWatch insights to more effectively create and use filter expressions depending on your application.

We recommend that you first use CloudWatch Log groups to learn about the different types of resources, its event types, and log levels that you can use to view log entries in the console. You can then use the examples of some filter expressions on this page as a reference to create your own filters for your AWS IoT Wireless resources.

Viewing AWS IoT logs in the CloudWatch Logs insights console

In the CloudWatch console, CloudWatch logs appear in a log group named /aws/iotwireless. For more information about CloudWatch Logs, see CloudWatch Logs.

To view your AWS IoT logs in the CloudWatch console

Navigate to the CloudWatch console and choose Logs Insights in the navigation pane.

1. In the Filter text box, enter /aws/iotwireless, and then choose the /aws/iotwireless Logs Insights.
2. To see a complete list of log groups, choose Select log group(s). To look at log groups for AWS IoT Wireless, choose /aws/iotwireless.

You can now start entering queries to filter the log groups. The following sections contain some useful queries that'll help you gain insights about your resource metrics.

Create useful queries to filter and gain insights for AWS IoT Wireless

You can use filter expressions to show additional helpful log information with CloudWatch Insights. Following shows some sample queries:

Show only logs for specific resource types

You can create a query that'll help you show logs for only specific resource types, such as a LoRaWAN gateway or a Sidewalk device. For example, to filter logs to show only messages for Sidewalk devices, you can enter the following query and choose Run query. To save this query, choose Save.

```
fields @message
| filter @message like /Sidewalk/
```

After the query runs, you'll see the results in the Logs tab, which shows the timestamps for logs related to Sidewalk devices in your account. You'll also see a bar graph, which will show the time at which the events occurred, if there were such events that occurred previously related to your Sidewalk device.

Following shows an example if you expand one of the results in the Logs tab. Alternatively, if you want
to troubleshoot errors related to Sidewalk devices, you can add another filter that sets the log level to ERROR and show only error information.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>@ingestionTime</td>
<td>1623894967640</td>
</tr>
<tr>
<td>@log</td>
<td>9543149292104:/aws/iotwireless</td>
</tr>
<tr>
<td>@logStream</td>
<td>WirelessDevice-Downlink_Data-715adccfb34170214ec2f6667ddfa13cb5af2c3ddfc52fbeee0e554a2e780bed</td>
</tr>
<tr>
<td>@message</td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>&quot;resource&quot;: &quot;WirelessDevice&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;wirelessDeviceId&quot;: &quot;3b058d05-4e84-4e1a-b026-4932bdff978d&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;wirelessDeviceType&quot;: &quot;Sidewalk&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;devEui&quot;: &quot;feffff000000011a&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;event&quot;: &quot;Downlink_Data&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;logLevel&quot;: &quot;INFO&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;messageId&quot;: &quot;7e752a10-28f5-45a5-923f-6fa7133fedda&quot;,</td>
</tr>
<tr>
<td>@timestamp</td>
<td>1623894967640</td>
</tr>
<tr>
<td>devEui</td>
<td>feffff0000000011a</td>
</tr>
<tr>
<td>event</td>
<td>Downlink_Data</td>
</tr>
<tr>
<td>logLevel</td>
<td>INFO</td>
</tr>
<tr>
<td>message</td>
<td>Successfully sent downlink message. Amazon SidewalkId = 2000000006,</td>
</tr>
<tr>
<td></td>
<td>Sequence number = 0</td>
</tr>
<tr>
<td>messageId</td>
<td>7e752a10-28f5-45a5-923f-6fa7133fedda</td>
</tr>
<tr>
<td>resource</td>
<td>WirelessDevice</td>
</tr>
<tr>
<td>wirelessDeviceId</td>
<td>3b058d05-4e84-4e1a-b026-4932bdff978d</td>
</tr>
<tr>
<td>wirelessDeviceType</td>
<td>Sidewalk</td>
</tr>
</tbody>
</table>

**Show specific messages or events**

You can create a query that'll help you show specific messages and observe when the events occurred. For example, if you want to see when your downlink message was sent from your LoRaWAN wireless device, you can enter the following query and choose **Run query**. To save this query, choose **Save**.

```
filter @message like /Downlink message sent/
```

After the query runs, you'll see the results in the **Logs** tab, which shows the timestamps when the downlink message was successfully sent to your wireless device. You'll also see a bar graph, which will show the time at which a downlink message was sent, if there were downlink messages were previously sent to your wireless device. Following shows an example if you expand one of the results in the **Logs** tab. Alternatively, if a downlink message wasn't sent, you can modify the query to display only results for when the message wasn't sent so that you can debug the issue.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>@ingestionTime</td>
<td>1623884043676</td>
</tr>
<tr>
<td>@log</td>
<td>954314929104:/aws/iotwireless</td>
</tr>
<tr>
<td>@logStream</td>
<td>WirelessDevice-Downlink_Data-42d0e609ba4d7015f4e9756fcdc616d401cd85fe3ac19854d9fbd866153c872</td>
</tr>
<tr>
<td>@message</td>
<td>{</td>
</tr>
<tr>
<td></td>
<td>&quot;timestamp&quot;: &quot;2021-06-16T22:54:00.770493863Z&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;resource&quot;: &quot;WirelessDevice&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;wirelessDeviceId&quot;: &quot;3b058d05-4e84-4e1a-b026-4932bdff978d&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;wirelessDeviceType&quot;: &quot;LoRaWAN&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;devEui&quot;: &quot;feffff0000000011a&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;event&quot;: &quot;Downlink_Data&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;logLevel&quot;: &quot;INFO&quot;,</td>
</tr>
<tr>
<td></td>
<td>&quot;messageId&quot;: &quot;7e752a10-28f5-45a5-923f-6fa7133fedda&quot;,</td>
</tr>
<tr>
<td>@timestamp</td>
<td>1623884043676</td>
</tr>
<tr>
<td>devEui</td>
<td>feffff0000000011a</td>
</tr>
<tr>
<td>event</td>
<td>Downlink_Data</td>
</tr>
<tr>
<td>logLevel</td>
<td>INFO</td>
</tr>
<tr>
<td>messageId</td>
<td>7e752a10-28f5-45a5-923f-6fa7133fedda</td>
</tr>
<tr>
<td>resource</td>
<td>WirelessDevice</td>
</tr>
<tr>
<td>wirelessDeviceId</td>
<td>3b058d05-4e84-4e1a-b026-4932bdff978d</td>
</tr>
<tr>
<td>wirelessDeviceType</td>
<td>Sidewalk</td>
</tr>
</tbody>
</table>
Next steps

You've learned how to use CloudWatch Insights to gain more helpful information by creating queries to filter log messages. You can combine some of the filters described previously and design your own filters depending on the resource you're monitoring. For more information about using CloudWatch Insights, see Analyzing log data with CloudWatch Insights.

After you've created queries with CloudWatch Insights, if you've saved them, you can load and run the saved queries as needed. Alternatively, if you click the History button in the CloudWatch Logs Insights console, you can view the previously run queries and rerun them as needed, or further modify them by creating additional queries.
Event notifications for AWS IoT Wireless

AWS IoT Wireless can publish messages to notify you of events for LoRaWAN and Sidewalk devices that you onboard to AWS IoT Core. For example, you can be notified of events such as when the Sidewalk devices in your account have been provisioned or registered.

How your resources can be notified of events

Event notifications are published when certain events occur. For example, events are generated when your Sidewalk device is provisioned. Each event causes a single event notification to be sent. Event notifications are published over MQTT with a JSON payload. The content of the payload depends on the type of event.

**Note**
Event notifications are published at least once. It's possible for them to be published more than once. The ordering of event notifications is not guaranteed.

Events and resource types

The following table shows the different types of events for which you'll receive notifications. The event types depend on whether the resource type is a wireless device, a wireless gateway, or a Sidewalk account. You can also enable events for your resources at the resource level, which applies to all resources of a particular type, or for select resources, as described in the following section. For more information about the different event types, see [Event notifications for LoRaWAN resources](#) and [Event notifications for Sidewalk resources](#).

<table>
<thead>
<tr>
<th>Resource</th>
<th>Resource type</th>
<th>Event type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wireless device</td>
<td>LoRaWAN</td>
<td>Join</td>
</tr>
<tr>
<td></td>
<td>Sidewalk</td>
<td>• Device registration state</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Proximity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Message delivery status</td>
</tr>
<tr>
<td>Wireless gateway</td>
<td>LoRaWAN</td>
<td>Connection status</td>
</tr>
<tr>
<td>Sidewalk account</td>
<td>Sidewalk</td>
<td>• Device registration state</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Proximity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Message delivery status</td>
</tr>
</tbody>
</table>

Policy for receiving wireless event notifications

To receive event notifications, your IAM role or user must use an appropriate policy that allows it to connect to the AWS IoT device gateway and subscribe to MQTT event topics. You must also subscribe to the appropriate topic filters.
The following is an example of the policy required for receiving notifications for the various wireless events.

```json
{
    "Version":"2012-10-17",
    "Statement":[
        {
            "Effect":"Allow",
            "Action":"iot:Subscribe",
            "Resource":[
                "arn:aws:iot:region:account:topicfilter/$aws/iotwireless/events/join/**",
                "arn:aws:iot:region:account:topicfilter/$aws/iotwireless/events/connection_status/**",
                "arn:aws:iot:region:account:topicfilter/$aws/iotwireless/events/device_registration_state/**",
                "arn:aws:iot:region:account:topicfilter/$aws/iotwireless/events/proximity/**",
            ]
        },
        {
            "Effect":"Allow",
            "Action":"iot:Receive",
            "Resource":[
                "arn:aws:iot:region:account:topic/$aws/iotwireless/events/join/**",
                "arn:aws:iot:region:account:topic/$aws/iotwireless/events/connection_status/**",
                "arn:aws:iot:region:account:topic/$aws/iotwireless/events/device_registration_state/**",
                "arn:aws:iot:region:account:topic/$aws/iotwireless/events/proximity/**",
            ]
        }
    ]
}
```

**Format of MQTT topics for wireless events**

To send you notifications of events for your wireless resources, AWS IoT uses MQTT reserved topics that begin with a dollar sign ($). You can publish and subscribe to these reserved topics. However, you can't create new topics that begin with a dollar sign.

**Note**

MQTT topics are specific to your AWS account and use the format arn:aws:iotwireless:aws-region:AWS-account-ID:topic/Topic. For more information, see [MQTT topics](p. 109).

Reserved MQTT topics for wireless devices use the following format:

- **Resource-level topics**
  
  These topics apply to all resources of a particular type in your AWS account that you've onboarded to AWS IoT Wireless.

  $aws/iotwireless/events/{eventName}/{eventType}/{resourceType}/resources

- **Identifier-level topics**
  
  These topics apply to select resources of a particular type in your AWS account that you've onboarded to AWS IoT Wireless, specified by the resource identifier.

  $aws/iotwireless/events/{eventName}/{eventType}/{resourceType}/
  {resourceIdentifierType}/{resourceID}/{id}
For more information about topics at resource and identifier levels, see *Event configurations (p. 1413)*.

The following table shows examples of MQTT topics for the various events:

### Events and MQTT topics

<table>
<thead>
<tr>
<th>Event</th>
<th>MQTT topic</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Sidewalk device registration state         | • **Resource-level topic** $aws/iotwireless/events/device_registration_state/{eventType}/sidewalk/wireless_devices  
                                          |                                                                            | • **Identifier-level topic** $aws/iotwireless/events/device_registration_state/{eventType}/sidewalk/{resourceType}/{resourceID}/id  
                                          |                                                                            | • {eventType} can be registered or provisioned  
                                          |                                                                            | • {resourceType} can be sidewalk_accounts or wireless_devices  
                                          |                                                                            | • {resourceID} is the amazon_id for sidewalk_accounts and wireless_device_id for wireless_devices |
| Sidewalk proximity                         | • **Resource-level topic** $aws/iotwireless/events/proximity/{eventType}/sidewalk/wireless_devices  
                                          |                                                                            | • **Identifier-level topic** $aws/iotwireless/events/proximity/{eventType}/sidewalk/{resourceType}/{resourceID}/id  
                                          |                                                                            | • {eventType} can be beacon_discovered or beacon_lost  
                                          |                                                                            | • {resourceType} can be sidewalk_accounts or wireless_devices  
                                          |                                                                            | • {resourceID} is the amazon_id for sidewalk_accounts and wireless_device_id for wireless_devices |
| Sidewalk message delivery status           | • **Resource-level topic** $aws/iotwireless/events/message_delivery_status/{eventType}/sidewalk/wireless_devices  
                                          |                                                                            | • **Identifier-level topic** $aws/iotwireless/events/message_delivery_status/{eventType}/sidewalk/ 
                                          |                                                                            | • {eventType} can be success or error  
                                          |                                                                            | • {resourceType} can be sidewalk_accounts or wireless_devices  
                                          |                                                                            | • {resourceID} is the amazon_id for sidewalk_accounts and wireless_device_id for wireless_devices |
### Event

<table>
<thead>
<tr>
<th>Event</th>
<th>MQTT topic</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>{resourceType}/</td>
<td>{resourceID}/id</td>
<td></td>
</tr>
<tr>
<td>LoRaWAN join</td>
<td><strong>Resource-level topic</strong></td>
<td>{eventType} can be join_req_0_received or join_req_2_received or join_accepted</td>
</tr>
<tr>
<td></td>
<td>$aws/iotwireless/events/join/</td>
<td>{resourceID} can be wireless_device_id or dev_eui</td>
</tr>
<tr>
<td></td>
<td>{eventType}/lorawan/wireless_devices</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Identifier-level topic</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$aws/iotwireless/events/join/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>{eventType}/lorawan/wireless_devices/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>{resourceID}/id</td>
<td></td>
</tr>
<tr>
<td>LoRaWAN gateway connection status</td>
<td><strong>Resource-level topic</strong></td>
<td>{eventType} can be connected or disconnected</td>
</tr>
<tr>
<td></td>
<td>$aws/iotwireless/events/join/</td>
<td>{resourceID} can be wireless_gateway_id or gateway_eui</td>
</tr>
<tr>
<td></td>
<td>{eventType}/lorawan/wireless_gateways</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Identifier-level topic</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$aws/iotwireless/events/join/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>{eventType}/lorawan/wireless_gateways/</td>
<td></td>
</tr>
<tr>
<td></td>
<td>{resourceID}/id</td>
<td></td>
</tr>
</tbody>
</table>

For more information about the different events, see [Event notifications for LoRaWAN resources](#) and [Event notifications for Sidewalk resources](#).

If you've subscribed to these topics, you'll be notified when a message is published to one of the event notification topics. For more information, see [Reserved topics](#).

### Pricing for wireless events

For information about pricing for subscribing to events and for receiving notifications, see [AWS IoT Core pricing](#).

### Enable events for wireless resources

Before subscribers to the reserved topics can receive messages, you must enable event notifications. To do this, you can use the AWS Management Console, or the AWS IoT Wireless API or AWS CLI.

### Event configurations

You can configure events to send notifications to either all resources that belong to a particular type, or for individual wireless resources. The resource type can be a wireless gateway, Sidewalk partner account,
or a wireless device, which can be a LoRaWAN or Sidewalk device. For information about the type of events that you can enable for your wireless devices, see Event types for LoRaWAN resources (p. 1417) and Event types for Sidewalk resources (p. 1421).

All resources

You can enable events such that all resources in your AWS account that belong to a particular resource type receives notifications. For example, you can enable an event that notifies you of changes to connection status for all LoRaWAN gateways that you've onboarded with AWS IoT Core for LoRaWAN. Monitoring these events will help you get notified in cases such as when certain LoRaWAN gateways in your resource fleet get disconnected or if a beacon is lost for a number of Sidewalk devices in your AWS account.

Individual resources

You can also add individual LoRaWAN and Sidewalk resources to your event configuration and enable notifications for them. This will help you monitor individual resources of a particular type. For example, you can add select LoRaWAN and Sidewalk devices to your configuration and receive notifications for join or device registration state events for these resources.

Prerequisites

Your LoRaWAN or Sidewalk resource must have an appropriate policy that allows it to receive event notifications. For more information, see Policy for receiving wireless event notifications (p. 1410).

Enable notifications using the AWS Management Console

To enable event messages from the console, go to the Settings tab of the AWS IoT console, and then go to the LoRaWAN and Sidewalk event notification section.

To enable notifications for all resources

1. In the LoRaWAN and Sidewalk event notification section, go to the All resources tab, choose Action, and then choose Manage events.
2. Enable the events that you want to monitor, and then choose Update events. If you no longer want to monitor certain events, choose Action and choose Manage events, and then disable those events.

To enable notifications for individual resources

1. In the LoRaWAN and Sidewalk event notification section, choose Action, and then choose Add resources.
2. Select the resources and events for which you want to receive notifications:
   a. Choose whether you want to monitor events for your LoRaWAN resources or Sidewalk resources.
   b. Depending on the resource type, you can choose the events you want to enable for the resources. You can then subscribe to these events and receive notifications. If you choose:
• **LoRaWAN resources**: You can enable join events for your LoRaWAN devices or connection status events for your LoRaWAN gateways.

• **Sidewalk resources**: You can enable device registration state or proximity events or both for your Sidewalk partner accounts and Sidewalk devices.

  **Note**
  The Sidewalk message delivery status event configuration isn’t available in the console. It can be enabled only using the AWS IoT Wireless API or the AWS CLI.

3. Depending on the resource type and events that you chose, select the wireless devices or gateways that you want to monitor. You can select up to 250 resources for all resources combined.

4. Choose **Submit** to add your resources.

The resources that you add will appear with their MQTT topics in the tab for your resource type in the **LoRaWAN and Sidewalk event notification** section of the console.

• **LoRaWAN join** events and events for your Sidewalk devices will appear in the **Wireless devices** section of the console.

• **Connection status** events for your LoRaWAN gateways will appear in the **Wireless gateways** section.

• **Device registration state** and **proximity** events for your Sidewalk accounts will appear in the **Sidewalk accounts** tab.

**Subscribe to topics using MQTT client**

Depending on whether you enabled events for all resources or for individual resource types, the events that you enabled will appear in the console with their MQTT topics on the **All resources** tab or the tab for the specified resource type.

• If you choose one of the MQTT topics, you can go to the MQTT client to subscribe to these topics and receive messages.

• If you've added multiple events, you can subscribe to multiple event topics and receive notifications for them. To subscribe to multiple topics, choose your topics, and choose **Action** and then choose **Subscribe**.

---

**Enable notifications using the AWS CLI**

You can configure events and add resources to your configuration by using the AWS IoT Wireless API or the AWS CLI.

**Enable notifications for all resources**

You can enable notifications for all resources in your AWS account that belong to a particular resource type and monitor them by using the `UpdateEventConfigurationByResourceTypes` API or the `update-event-configuration-by-resource-types` CLI command. For example:

```
aws iotwireless update-event-configuration-by-resource-types \ 
  --cli-input-json input.json
```

**Contents of input.json**

```json
{
  "DeviceRegistrationState": {
    "Sidewalk": {
      "AmazonIdEventTopic": "Enabled"
    }
  }
}```
Enable notifications using the AWS CLI

```
{
    "ConnectionStatus": {
        "LoRaWAN": {
            "WirelessGatewayEventTopic": "Enabled"
        }
    }
}
```

**Note**

All quotation marks ("") are escaped with a backslash (\).

You can get the current event configuration by calling the `GetEventConfigurationByResourceTypes` API or by using the `get-event-configuration-by-resource-types` CLI command. For example:

```
aws iotwireless get-event-configuration-by-resource-types
```

**Enable notifications for individual resources**

To add individual resources to your event configuration and control which events are published by using the API or CLI, call the `UpdateResourceEventConfiguration` API or use the `update-resource-event-configuration` CLI command. For example:

```
aws iotwireless update-resource-event-configuration \
  --identifier 1ffd32c8-8130-4194-96df-622f072a315f \
  --identifier-type WirelessDeviceId \
  --cli-input-json input.json
```

**Contents of input.json**

```
{
    "Join": {
        "LoRaWAN": {
            "DevEuiEventTopic": "Disabled",
            "WirelessDeviceIdEventTopic": "Enabled"
        }
    }
}
```

**Note**

All quotation marks ("") are escaped with a backslash (\).

You can get the current event configuration by calling the `GetResourceEventConfiguration` API or by using the `get-resource-event-configuration` CLI command. For example:

```
aws iotwireless get-resource-event-configuration \
  --identifier-type WirelessDeviceId \
  --identifier 1ffd32c8-8130-4194-96df-622f072a315f
```

**List event configurations**

You can also use the AWS IoT Wireless API or the AWS CLI to list event configurations where at least one event topic has been enabled. To list configurations, use the `ListEventConfigurations` API operation or by using the `list-event-configurations` CLI command. For example:

```
aws iotwireless list-event-configurations --resource-type WirelessDevice
```
Event notifications for LoRaWAN resources

You can use the AWS Management Console or AWS IoT Wireless API operations to notify you of events for your LoRaWAN devices and gateways. For information about event notifications and how to enable them, see Event notifications for AWS IoT Wireless (p. 1410) and Enable events for wireless resources (p. 1413).

Event types for LoRaWAN resources

Events that you can enable for your LoRaWAN resources include:

- Join events that notify you of join events for your LoRaWAN device. You'll receive notifications when a device joins with AWS IoT Core for LoRaWAN, or when a rejoin request of type 0 or type 2 is received.
- Connection status events that notify you when the connection status of your LoRaWAN gateway changes to connected or disconnected.

The following sections contain more information about the events for your LoRaWAN resources:

Topics

- LoRaWAN join events (p. 1417)
- Connection status events (p. 1419)

LoRaWAN join events

AWS IoT Core for LoRaWAN can publish messages to notify you of join events for LoRaWAN devices that you onboard to AWS IoT. Join events notify you when a join or rejoin request of type 0 or type 2 is received, and the device has joined with AWS IoT Core for LoRaWAN.

How join events work

When you onboard your LoRaWAN devices with AWS IoT Core for LoRaWAN, AWS IoT Core for LoRaWAN performs a join procedure for your device with AWS IoT Core for LoRaWAN. Your device then becomes activated for use and can send an uplink message to indicate that it's available. After the device has joined, uplink and downlink messages can be exchanged between your device and AWS IoT Core for LoRaWAN. For more information about onboarding your device, see Onboard your devices to AWS IoT Core for LoRaWAN (p. 1238).

You can enable events to notify you when your device has joined with AWS IoT Core for LoRaWAN. You'll also be notified if the join event fails and when a rejoin request of type 0 or type 2 is received, and when it's accepted.

Enable LoRaWAN join events

Before subscribers to the LoRaWAN join reserved topics can receive messages, you must enable event notifications for them from the AWS Management Console, or by using the API or CLI. You can enable these events for all LoRaWAN resources in your AWS account or for select resources. For information about how to enable these events, see Enable events for wireless resources (p. 1413).

Format of MQTT topics for LoRaWAN events

Reserved MQTT topics for LoRaWAN devices use the following format. If you've subscribed to these topics, then all LoRaWAN devices that are registered to your AWS account can receive the notification:
• **Resource-level topics**
  $aws/iotwireless/events/{eventName}/{eventType}/lorawan/wireless_devices

• **Identifier topics**
  $aws/iotwireless/events/{eventName}/{eventType}/lorawan/wireless_devices/
  {resourceID}/{id}

Where:

{eventName}
  {eventName} must be `join`.

eventType
  {eventType} can be:
  • `join_req_received`
  • `rejoin_req_0_received`
  • `rejoin_req_2_received`
  • `join_accepted`

(resourceID)
  {resourceID} can be `dev_eui` or `wireless_device_id`.

For example, you can subscribe to the following topics to receive an event notification when AWS IoT Core for LoRaWAN has accepted a join request from your devices.

$aws/iotwireless/events/join/join_accepted/lorawan/wireless_devices/
wireless_device_id/{id}

You can also use the `+` wildcard character to subscribe to multiple topics at the same time. The `+` wildcard character matches any string in the level that contains the character, such as the following topic:

$aws/iotwireless/events/join/join_req_received/lorawan/wireless_devices/
wireless_device_id/+  

**Note**
You can’t use the wildcard character `#` to subscribe to the reserved topics. For more information about topic filters, see [Topic filters](p. 110).

For more information about using the `+` wildcard when subscribing to topics, see [Topic filters](p. 110).

**Message payload for LoRaWAN join event**

The following shows the message payload for the LoRaWAN join event.

```json
{
  // General fields
  "eventId": "string",
  "eventType": "{join_req_received|rejoin_req_0_received|rejoin_req_2_received|join_accepted}
  "WirelessDeviceId": "string",
  "timestamp": "timestamp",

  // Event-specific fields
  "LoRaWAN": {
```
Connection status events

AWS IoT Core for LoRaWAN can publish messages to notify you of connection status events for LoRaWAN gateways that you onboard to AWS IoT. Connection status events notify you when the connection status of a LoRaWAN gateway changes to connected or disconnected.

How connection status events work

After you've onboarded your gateway to AWS IoT Core for LoRaWAN, you can connect your gateway to AWS IoT Core for LoRaWAN and verify its connection status. This event notifies you when your gateway connection status changes to connected or disconnected. For more information about onboarding and connecting your gateway to AWS IoT Core for LoRaWAN, see Onboard your gateways to AWS IoT Core for LoRaWAN (p. 1230) and Connect your LoRaWAN gateway and verify its connection status (p. 1237).

Format of MQTT topics for LoRaWAN gateways

Reserved MQTT topics for LoRaWAN gateways use the following format. If you've subscribed to these topics, then all LoRaWAN gateways that are registered to your AWS account can receive the notification:

- For resource-level topics:
  
  $aws/iotwireless/events/{eventName}/{eventType}/lorawan/wireless_gateways

The payload contains the following attributes:

**eventId**

A unique event ID that's generated by AWS IoT Core for LoRaWAN (string).

**eventType**

The type of event that occurred. Can be one of the following values:

- `join_req_received`: This field will show the EUI parameters `JoinEui` or `AppEui`
- `rejoin_req_0_received`
- `rejoin_req_2_received`
- `join_accepted`: This field will show the `NetId` and `DevAddr`.

**wirelessDeviceId**

The ID of the LoRaWAN device.

**timestamp**

The Unix timestamp of when the event occurred.

**DevEui**

The unique identifier of the device found on the device label or device documentation.

**DevAddr and EUIs (optional)**

These fields are the optional device address and the EUI parameters `JoinEUI` or `AppEUI`.
• For identifier topics:

$aws/iotwireless/events/{eventName}/{eventType}/lorawan/wireless_gateways/
{resourceID}/{id}

Where:

(eventName)

(eventName) must be connection_status.

(eventType)

(eventType) can be connected or disconnected.

(resourceID)

(resourceID) can be gateway_eui or wireless_gateway_id.

For example, you can subscribe to the following topics to receive an event notification when all your
gateways have connected to AWS IoT Core for LoRaWAN:

$aws/iotwireless/events/connection_status/connected/lorawan/wireless_gateways/
wireless_gateway_id/{id}

You can also use the + wildcard character to subscribe to multiple topics at the same time. The +
wildcard character matches any string in the level that contains the character, such as the following
topic:

$aws/iotwireless/events/connection_status/connected/lorawan/wireless_gateways/
wireless_gateway_id/+  

Note
You can't use the wildcard character # to subscribe to the reserved topics. For more information
about topic filters, see Topic filters (p. 110).

For more information about using the + wildcard when subscribing to topics, see Topic filters (p. 110).

Message payload for connection status events

The following shows the message payload for the connection status event.

```
{
  // General fields
  "eventId": "string",
  "eventType": "connected|disconnected",
  "WirelessGatewayId": "string",
  "timestamp": "timestamp",

  // Event-specific fields
  "LoRaWAN": {
    "GatewayEui": "string"
  }
}
```

The payload contains the following attributes:

eventId

A unique event ID that's generated by AWS IoT Core for LoRaWAN (string).
Event notifications for Sidewalk resources

You can use the AWS Management Console or AWS IoT Wireless API operations to notify you of events for your Sidewalk devices and partner accounts. For information about event notifications and how to enable them, see Event notifications for AWS IoT Wireless (p. 1410) and Enable events for wireless resources (p. 1413).

Event types for Sidewalk resources

Events that you can enable for your Sidewalk resources include:

- Device events that notify you of changes to the state of your Sidewalk device, such as when the device has been registered and is ready to use.
- Proximity events that notify you when AWS IoT Wireless receives a notification from Amazon Sidewalk that a beacon has been discovered or lost.

The following sections contain more information about the events for your Sidewalk resources:

Topics

- Device registration state events (p. 1421)
- Proximity events (p. 1423)
- Message delivery status events (p. 1425)

Device registration state events

Device registration state events publish event notifications when there is a change in the device registration state, such as when a Sidewalk device has been provisioned or registered. The events provide you information about the different states that the device goes through from when it's provisioned to when it has been registered.

How device registration state events work

When you onboard your Sidewalk device with Amazon Sidewalk and AWS IoT Wireless, AWS IoT Wireless performs a create operation and adds your Sidewalk device to your AWS account. Your device then enters the provisioned state and the eventType becomes provisioned. For more information about onboarding your device, see Getting started with AWS IoT Core for Amazon Sidewalk (p. 1345).

After the device has been provisioned, Amazon Sidewalk performs a register operation to register your Sidewalk device with AWS IoT Wireless. The registration process starts, where the encryption
and session keys are set up with AWS IoT. When the device is registered, the eventType becomes registered, and your device is ready to use.

After the device has been registered, Sidewalk can send a request to deregister your device. AWS IoT Wireless then fulfills the request and changes the device state back to provisioned. For more information about the device states, see DeviceState.

**Enable notifications for device registration state events**

Before subscribers to the device registration state reserved topics can receive messages, you must enable event notifications for them from the AWS Management Console, or by using the API or CLI. You can enable these events for all Sidewalk resources in your AWS account or for select resources. For information about how to enable these events, see Enable events for wireless resources (p. 1413).

**Format of MQTT topics for device registration state events**

To notify you of device registration state events, you can subscribe to MQTT reserved topics that begin with a dollar ($) sign. For more information, see MQTT topics (p. 109).

Reserved MQTT topics for Sidewalk device registration state events use the following format:

- For resource-level topics:
  
  $aws/iotwireless/events/{eventName}/{eventType}/sidewalk/wireless_devices

- For identifier topics:
  
  $aws/iotwireless/events/{eventName}/{eventType}/sidewalk/{resourceType}/
  {resourceID}/{id}

Where:

(eventName)

{eventName} must be device_registration_state.

(eventType)

{eventType} can be provisioned or registered.

(resourceType)

{resourceType} can be sidewalk_accounts or wireless_devices.

(resourceID)

{resourceID} is amazon_id for {resourceType} of sidewalk_accounts and wireless_device_id for {resourceType} of wireless_devices.

You can also use the + wildcard character to subscribe to multiple topics at the same time. The + wildcard character matches any string in the level that contains the character. For example, if you want to be notified of all possible event types (provisioned and registered) and for all devices registered to a particular Amazon ID, you can use the following topic filter:

$aws/iotwireless/events/device_registration_state/+/sidewalk/sidewalk_accounts/
amazon_id/+  

**Note**

You can't use the wildcard character # to subscribe to the reserved topics. For more information about topic filters, see Topic filters (p. 110).
Message payload for device registration state events

After you enable notifications for device registration state events, event notifications are published over MQTT with a JSON payload. These events contain the following example payload:

```json
{
    "eventId": "string",
    "eventType": "provisioned|registered",
    "WirelessDeviceId": "string",
    "timestamp": "timestamp",

    // Event-specific fields
    "operation": "create|deregister|register",
    "Sidewalk": {
        "AmazonId": "string",
        "SidewalkManufacturingSn": "string"
    }
}
```

The payload contains the following attributes:

- **eventId**: A unique event ID (string).
- **eventType**: The type of event that occurred. Can be `provisioned` or `registered`.
- **wirelessDeviceId**: The identifier of the wireless device.
- **timestamp**: The Unix timestamp of when the event occurred.
- **operation**: The operation that triggered the event. Valid values are `create`, `register`, and `deregister`.
- **sidewalk**: The Sidewalk Amazon ID or `SidewalkManufacturingSn` for which you want to receive event notifications.

Proximity events

Proximity events publish event notifications when AWS IoT receives a beacon from the Sidewalk device. When your Sidewalk device approaches Amazon Sidewalk, beacons that are sent from your device are filtered by Amazon Sidewalk at regular intervals and received by AWS IoT Wireless. AWS IoT Wireless then notifies you of these events when a beacon is received.

How proximity events work

Proximity events notify you when AWS IoT receives a beacon. Your Sidewalk devices can emit beacons any time. When your device is near Amazon Sidewalk, Sidewalk receives the beacons and forwards them to AWS IoT Wireless at regular time intervals. Amazon Sidewalk has configured this time interval as 10 minutes. When AWS IoT Wireless receives the beacon from Sidewalk, you'll be notified of the event.

Proximity events will notify you when a beacon is discovered or when a beacon is lost. You can configure the intervals at which you're notified of the proximity event.
Enable notifications for proximity events

Before subscribers to the Sidewalk proximity reserved topics can receive messages, you must enable event notifications for them from the AWS Management Console, or by using the API or CLI. You can enable these events for all Sidewalk resources in your AWS account or for select resources. For information about how to enable these events, see Enable events for wireless resources (p. 1413).

Format of MQTT topics for proximity events

To notify you of proximity events, you can subscribe to MQTT reserved topics that begin with a dollar ($) sign. For more information, see MQTT topics (p. 109).

Reserved MQTT topics for Sidewalk proximity events use the format:

- For resource-level topics:
  
  \$aws/iotwireless/events/{eventName}/{eventType}/sidewalk/wireless_devices

- For identifier topics:
  
  \$aws/iotwireless/events/{eventName}/{eventType}/sidewalk/{resourceType}/
  {resourceID}/{id}

Where:

{eventName}

{eventName} must be proximity.

{eventType}

{eventType} can be beacon_discovered or beacon_lost.

{resourceType}

{resourceType} can be sidewalk_accounts or wireless_devices.

{resourceID}

{resourceID} is amazon_id for {resourceType} of sidewalk_accounts and wireless_device_id for {resourceType} of wireless_devices.

You can also use the + wildcard character to subscribe to multiple topics at the same time. The + wildcard character matches any string in the level that contains the character. For example, if you want to be notified of all possible event types (beacon_discovered and beacon_lost) and for all devices registered to a particular Amazon ID, you can use the following topic filter:

\$aws/iotwireless/events/proximity/+/sidewalk/sidewalk_accounts/amazon_id/+  

Note

You can't use the wildcard character # to subscribe to the reserved topics. For more information about topic filters, see Topic filters (p. 110).

Message payload for proximity events

After you enable notifications for proximity events, event messages are published over MQTT with a JSON payload. These events contain the following example payload:

```json
{
    "eventId": "string",
```
The payload contains the following attributes:

**eventId**
A unique event ID, which is a string.

**eventType**
The type of event that occurred. Can be `beacon_discovered` or `beacon_lost`.

**WirelessDeviceId**
The identifier of the wireless device.

**timestamp**
The Unix timestamp of when the event occurred.

**sidewalk**
The Sidewalk Amazon ID or `SidewalkManufacturingSn` for which you want to receive event notifications.

---

**Message delivery status events**

Message delivery status events publish event notifications about the status of messages that are exchanged between your Sidewalk devices and AWS IoT Wireless. Event notifications are published for both downlink messages that are sent from AWS IoT Wireless to the Sidewalk device, and uplink messages that are sent from your device to AWS IoT Wireless.

**How message delivery status events work**

After you’ve onboarded your Sidewalk device to AWS IoT Wireless and connected your device, messages can be exchanged between your device and AWS IoT Wireless. The events publish notifications about the message delivery status that indicate whether these messages were successfully delivered to your device or to AWS IoT Wireless.

For example, if an uplink message is received from the device with an acknowledge (ACK) flag, a notification is published indicating that the message was delivered successfully. When you send downlink messages from AWS IoT Wireless to the Sidewalk device, the `SendDataToWirelessDevice` API returns a `MessageId` for the downlink message even if packets have dropped or the message wasn’t delivered. In this case, the message delivery status events return an error indicating that the message failed to deliver to the device.

**Enable notifications for message delivery status events**

Before subscribers to the Sidewalk message delivery status reserved topics can receive messages, you must enable event notifications for them using the AWS IoT Wireless API or the AWS CLI. You can enable these events for all Sidewalk resources in your AWS account or for select resources.
Note

The Sidewalk message delivery status event configuration isn't available in the console.

For information about how to enable these events, see Enable notifications using the AWS CLI (p. 1415).

Format of MQTT topics for message delivery status events

To receive notifications about message delivery status events, you can subscribe to MQTT reserved topics
that begin with a dollar ($) sign. For more information, see MQTT topics (p. 109).

Reserved MQTT topics for Sidewalk proximity events use the format:

- For resource-level topics:
  $aws/iotwireless/events/{eventName}/{eventType}/sidewalk/wireless_devices
- For identifier topics:
  $aws/iotwireless/events/{eventName}/{eventType}/sidewalk/{resourceType}/
  {resourceID}/{id}

Where:

{eventName}
  {eventName} must be message_delivery_status.

{eventType}
  {eventType} can be success or error.

{resourceType}
  {resourceType} can be sidewalk_accounts or wireless_devices.

{resourceID}
  {resourceID} is amazon_id for {resourceType} of sidewalk_accounts and wireless_device_id
  for {resourceType} of wireless_devices.

You can also use the + wildcard character to subscribe to multiple topics at the same time. The +
wildcard character matches any string in the level that contains the character. For example, if you
want to be notified of all possible event types (success and error) and for all devices registered to a
particular Amazon ID, you can use the following topic filter:

$aws/iotwireless/events/message_delivery_status/+/sidewalk/sidewalk_accounts/
amazon_id/+  

Note
  You can't use the wildcard character # to subscribe to the reserved topics. For more information
about topic filters, see Topic filters (p. 110).

Message payload for message delivery status events

After you enable notifications for message delivery status events, event messages are published over
MQTT with a JSON payload. These events contain the following example payload depending on whether
the event is a success, indicating that the device successfully received the message, or an error.

Success events

The following shows the payload format when the event is a success.
Message delivery status events

The payload contains the following attributes:

**eventId**
A unique event ID, which is a string.

**eventType**
The type of event that occurred. Can be **success** or **error**. In this case, the eventType is **error**.

**WirelessDeviceId**
The identifier of the wireless device.

**timestamp**
The Unix timestamp of when the event occurred.

**sidewalk**
The Sidewalk wrapper that contains the status code for success messages, sequence number of message, and the message type.

**Error events**
The following shows the payload format when the event indicates that an error occurred.

```json
{
  "eventId": "string",
  "eventType": "error",
  "WirelessDeviceId": "string",
  "timestamp": "timestamp",
  "Sidewalk": {
    "Seq": "Integer",
    "Status": "DeviceNotReachable" | "RADIO_TX_ERROR" | "MEMORY_ERROR"
  }
}
```

The payload contains similar attributes as when the eventType is a success. Following are some differences or additional attributes:

**eventType**
The type of event that occurred. In this case, the eventType is an **error**.

**sidewalk**
The Sidewalk wrapper that contains the sequence number and the status code that indicates why the downlink message wasn't sent successfully.
AWS IoT Device SDKs, Mobile SDKs, and AWS IoT Device Client

This page summarizes the AWS IoT Device SDKs, open-source libraries, developer guides, sample apps, and porting guides to help you build innovative IoT solutions with AWS IoT and your choice of hardware platforms.

These SDKs are for use on your IoT device. If you're developing an IoT app for use on a mobile device, see the AWS Mobile SDKs (p. 1430). If you're developing an IoT app or server-side program, see the AWS SDKs (p. 76).

AWS IoT Device SDKs

The AWS IoT Device SDKs include open-source libraries, developer guides with samples, and porting guides so that you can build innovative IoT products or solutions on your choice of hardware platforms.

Note
The AWS IoT Device SDKs don't support using TLS 1.3 on macOS.

These SDKs help you connect your IoT devices to AWS IoT using the MQTT and WSS protocols.

C++

AWS IoT C++ Device SDK

The AWS IoT C++ Device SDK allows developers to build connected applications using AWS and the AWS IoT APIs. Specifically, this SDK was designed for devices that are not resource constrained and require advanced features such as message queuing, multi-threading support, and the latest language features. For more information, see the following:

- AWS IoT Device SDK C++ v2 on GitHub
- AWS IoT Device SDK C++ v2 Readme
- AWS IoT Device SDK C++ v2 Samples
- AWS IoT Device SDK C++ v2 API documentation

Python

AWS IoT Device SDK for Python

The AWS IoT Device SDK for Python makes it possible for developers to write Python scripts to use their devices to access the AWS IoT platform through MQTT or MQTT over the WebSocket protocol. By connecting their devices to AWS IoT, users can securely work with the message broker, rules, and shadows provided by AWS IoT and with other AWS services like AWS Lambda, Kinesis, and Amazon S3, and more.

- AWS IoT Device SDK for Python v2 on GitHub
- AWS IoT Device SDK for Python v2 Readme
JavaScript

**AWS IoT Device SDK for JavaScript**

The aws-iot-device-sdk.js package makes it possible for developers to write JavaScript applications that access AWS IoT using MQTT or MQTT over the WebSocket protocol. It can be used in Node.js environments and browser applications. For more information, see the following:

- [AWS IoT Device SDK for JavaScript v2 on GitHub](#)
- [AWS IoT Device SDK for JavaScript v2 Readme](#)
- [AWS IoT Device SDK for JavaScript v2 Samples](#)
- [AWS IoT Device SDK for JavaScript v2 API documentation](#)

Java

**AWS IoT Device SDK for Java**

The AWS IoT Device SDK for Java makes it possible for Java developers to access the AWS IoT platform through MQTT or MQTT over the WebSocket protocol. The SDK is built with shadow support. You can access shadows by using HTTP methods, including GET, UPDATE, and DELETE. The SDK also supports a simplified shadow access model, which allows developers to exchange data with shadows by just using getter and setter methods, without having to serialize or deserialize any JSON documents. For more information, see the following:

- [AWS IoT Device SDK for Java v2 on GitHub](#)
- [AWS IoT Device SDK for Java v2 Readme](#)
- [AWS IoT Device SDK for Java v2 Samples](#)
- [AWS IoT Device SDK for Java v2 API documentation](#)

**AWS IoT Device SDK for Embedded C**

**Note**

This SDK is intended for use by experienced embedded-software developers.

The AWS IoT Device SDK for Embedded C (C-SDK) is a collection of C source files under the MIT open source license that can be used in embedded applications to securely connect IoT devices to AWS IoT Core. It includes an MQTT client, JSON Parser, and AWS IoT Device Shadow, AWS IoT Jobs, AWS IoT Fleet Provisioning, and AWS IoT Device Defender libraries. This SDK is distributed in source form and can be built into customer firmware along with application code, other libraries, and an operating system (OS) of your choice.

The AWS IoT Device SDK for Embedded C is generally targeted at resource constrained devices that require an optimized C language runtime. You can use the SDK on any operating system and host it on any processor type (for example, MCUs and MPUs).

For more information, see the following:

- [AWS IoT Device SDK for Embedded C on GitHub](#)
- [AWS IoT Device SDK for Embedded C Readme](#)
- [AWS IoT Device SDK for Embedded C Samples](#)
Earlier AWS IoT Device SDKs versions

These are earlier versions of AWS IoT Device SDKs that have been replaced by the newer versions listed above. These SDKs are receiving only maintenance and security updates. They will not be updated to include new features and should not be used on new projects.

- AWS IoT C++ Device SDK on GitHub
- AWS IoT C++ Device SDK Readme
- AWS IoT Device SDK for Python v1 on GitHub
- AWS IoT Device SDK for Python v1 Readme
- AWS IoT Device SDK for Java on GitHub
- AWS IoT Device SDK for Java Readme
- AWS IoT Device SDK for JavaScript on GitHub
- AWS IoT Device SDK for JavaScript Readme
- Arduino Yún SDK on GitHub
- Arduino Yún SDK Readme

AWS Mobile SDKs

The AWS Mobile SDKs provide mobile app developers platform-specific support for the APIs of the AWS IoT Core services, IoT device communication using MQTT, and the APIs of other AWS services.

Android

AWS Mobile SDK for Android

The AWS Mobile SDK for Android contains a library, samples, and documentation for developers to build connected mobile applications using AWS. This SDK also includes support for MQTT device communications and calling the APIs of the AWS IoT Core services. For more information, see the following:

- AWS Mobile SDK for Android on GitHub
- AWS Mobile SDK for Android Readme
- AWS Mobile SDK for Android Samples
- AWS Mobile SDK for Android API reference
- AWSIoTClient Class reference documentation

iOS

AWS Mobile SDK for iOS

The AWS Mobile SDK for iOS is an open-source software development kit, distributed under an Apache Open Source license. The AWS Mobile SDK for iOS provides a library, code samples, and documentation to help developers build connected mobile applications using AWS. This SDK also includes support for MQTT device communications and calling the APIs of the AWS IoT Core services. For more information, see the following:

- AWS Mobile SDK for iOS on GitHub
- AWS Mobile SDK for iOS Readme
- AWS Mobile SDK for iOS Samples
- AWSIoT Class reference docs in the AWS Mobile SDK for iOS
AWS IoT Device Client

The AWS IoT Device Client provides code to help your device connect to AWS IoT, perform fleet provisioning tasks, support device security policies, connect using secure tunneling, and process jobs on your device. You can install this software on your device to handle these routine device tasks so you can focus on your specific solution.

**Note**
The AWS IoT Device Client works with microprocessor-based IoT devices with x86_64 or ARM processors and common Linux operating systems.

C++

**AWS IoT Device Client**

For more information about the AWS IoT Device Client in C++, see the following:

- [AWS IoT Device Client in C++ source code on GitHub](#)
- [AWS IoT Device Client in C++ Readme](#)
Troubleshooting AWS IoT

The following information might help you troubleshoot common issues in AWS IoT.

**Tasks**
- AWS IoT Core troubleshooting guide (p. 1432)
- AWS IoT Device Defender troubleshooting guide (p. 1439)
- AWS IoT Device Advisor troubleshooting guide (p. 1442)
- AWS IoT Device Management troubleshooting guide (p. 1444)
- AWS IoT errors (p. 1448)

### AWS IoT Core troubleshooting guide

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This is the troubleshooting section for AWS IoT Core.

**Topics**
- Diagnosing connectivity issues (p. 1432)
- Diagnosing rules issues (p. 1435)
- Diagnosing problems with shadows (p. 1436)
- Diagnosing Salesforce IoT input stream action issues (p. 1437)
- Diagnosing Stream Limits (p. 1438)
- Troubleshooting device fleet disconnects (p. 1438)

### Diagnosing connectivity issues

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A successful connection to AWS IoT requires:

- A valid connection
- A valid and active certificate
- A policy that allows the desired connection and operation

**Connection**

How do I find the correct endpoint?

- The endpointAddress returned by `aws iot describe-endpoint --endpoint-type iot:Data-ATS`

or
• The domainName returned by `aws iot describe-domain-configuration` --domain-configuration-name "domain_configuration_name"

How do I find the correct Server Name Indication (SNI) value?

The correct SNI value is the endpointAddress returned by the `describe-endpoint` or the domainName returned by the `describe-domain-configuration` commands. It's the same address as the endpoint in the previous step. When connecting devices to AWS IoT Core, clients can send the Server Name Indication (SNI) extension, which is not required but highly recommended. To use features such as multi-account registration, custom domains, and VPC endpoints, you must use the SNI extension. For more information, see Transport Security in AWS IoT.

How do I solve a connectivity issue that persists?

You can use AWS Device Advisor to help troubleshoot. Device Advisor's pre-built tests help you validate your device software against best practices for usage of TLS, MQTT, AWS IoT Device Shadow, and AWS IoT Jobs.

Here is a link to the existing Device Advisor content.

**Authentication**

Devices must be authenticated (p. 300) to connect to AWS IoT endpoints. For devices that use X.509 client certificates (p. 300) for authentication, the certificates must be registered with AWS IoT and be active.

How do my devices authenticate AWS IoT endpoints?

Add the AWS IoT CA certificate to your client's trust store. Refer to the documentation on Server Authentication in AWS IoT Core and then follow the links to download the appropriate CA certificate.

What is checked when a device connects to AWS IoT?

When a device attempts to connect to AWS IoT:

1. AWS IoT checks for a valid certificate and Server Name Indication (SNI) value.
2. AWS IoT checks to see that the certificate used is registered with the AWS IoT Account and that it has been activated.
3. When a device attempts to perform any action in AWS IoT, such as to subscribe to or publish a message, the policy attached to the certificate it used to connect is checked to confirm that the device is authorized to perform that action.

How can I validate a correctly configured certificate?

Use the OpenSSL s_client command to test a connection to the AWS IoT endpoint:

```
openssl s_client -connect custom_endpoint.iot.aws-region.amazonaws.com:8443 -CAfile CA.pem -cert cert.pem -key privateKey.pem
```

For more information about using openssl s_client, see OpenSSL s_client documentation.

How do I check the status of a certificate?

• **List the certificates**

  If you don't know the certificate ID, you can see the status of all your certificates by using the aws iot list-certificates command.

• **Show a certificate's details**

  If you know the certificate's ID, this command shows you more detailed information about the certificate.
**Review the certificate in the AWS IoT Console**

In the [AWS IoT console](https://aws.amazon.com/iot/), in the left menu, choose **Secure**, and then choose **Certificates**.

Choose the certificate that you are using to connect from the list to open its detail page.

In the certificate's detail page, you can see its current status.

The certificate's status can be changed by using the **Actions** menu in the upper-right corner of the details page.

**Authorization**

AWS IoT resources use [AWS IoT Core policies (p. 336)](https://docs.aws.amazon.com/iot/core/latest/developerguide/security-identity.html) to authorize those resources to perform actions (p. 337). For an action to be authorized, the specified AWS IoT resources must have a policy document attached to it that grants permission to perform that action.

I received a PUBNACK or SUBNACK response from the broker. What do I do?

Make sure that there is a policy attached to the certificate you are using to call AWS IoT. All publish/subscribe operations are denied by default.

Make sure the attached policy authorizes the actions (p. 337) you are trying to perform.

Make sure the attached policy authorizes the resources (p. 339) that are trying to perform the authorized actions.

I have an **AUTHORIZATION_FAILURE** entry in my logs.

Make sure that there is a policy attached to the certificate you are using to call AWS IoT. All publish/subscribe operations are denied by default.

Make sure the attached policy authorizes the actions (p. 337) you are trying to perform.

Make sure the attached policy authorizes the resources (p. 339) that are trying to perform the authorized actions.

How do I check what the policy authorizes?

In the [AWS IoT console](https://aws.amazon.com/iot/), in the left menu, choose **Secure**, and then choose **Certificates**.

Choose the certificate that you are using to connect from the list to open its detail page.

In the certificate's detail page, you can see its current status.

In the left menu of the certificate's detail page, choose **Policies** to see the policies attached to the certificate.

Choose the desired policy to see its details page.

In the policy's details page, review the policy's **Policy document** to see what it authorizes.

Choose **Edit policy document** to make changes to the policy document.

**Security and identity**

When you provide the server certificates for AWS IoT custom domain configuration, the certificates have a maximum of four domain names.
Diagnosing rules issues

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This section describes some of the things to check when you encounter a problem with rule.

Configuring CloudWatch Logs for troubleshooting

The best way to debug issues you are having with rules is to use CloudWatch Logs. When you enable CloudWatch Logs for AWS IoT, you can see which rules are triggered and their success or failure. You also get information about whether WHERE clause conditions match. For more information, see Monitor AWS IoT using CloudWatch Logs (p. 461).

The most common rules issue is authorization. The logs show if your role is not authorized to perform AssumeRole on the resource. Here is an example log generated by fine-grained logging (p. 444):

```
{
    "timestamp": "2017-12-09 22:49:17.954",
    "logLevel": "ERROR",
    "traceId": "ff563525-6469-506a-e141-7bd40375fc4e",
    "accountId": "123456789012",
    "status": "Failure",
    "eventType": "RuleExecution",
    "clientId": "iotconsole-123456789012-3",
    "topicName": "test-topic",
    "ruleName": "rule1",
    "ruleAction": "DynamoAction",
    "resources": {
        "ItemHashKeyField": "id",
        "Table": "trashbin",
        "Operation": "Insert",
        "ItemHashKeyValue": "id",
        "IsPayloadJSON": "true"
    },
    "principalId": "ABCDEFG1234567ABCD890:outis",
    "details": "User: arn:aws:sts::123456789012:assumed-role/dynamo-testbin/5aUMInJH is not authorized to perform: dynamodb:PutItem on resource: arn:aws:dynamodb:us-east-1:123456789012:table/testbin (Service: AmazonDynamoDBv2; Status Code: 400; Error Code: AccessDeniedException; Request ID: AKQJ987654321AKQJ987654321AKQJ987654321AKQJ987654321)"
}
```

Here is a similar example log generated by global logging (p. 443):

```
```
For more information, see the section called “Viewing AWS IoT logs in the CloudWatch console” (p. 461).

**Diagnosing external services**

External services are controlled by the end user. Before rule execution, make sure that the external services you have linked to your rule are set up and have enough throughput and capacity units for your application.

**Diagnosing SQL problems**

If your SQL query is not returning the data you expect:

- Review the logs for error messages.
- Confirm that your SQL syntax matches the JSON document in the message.

Review the object and property names used in the query with those used in the JSON document of the topic's message payload. For more information about the JSON formatting in SQL queries, see JSON extensions (p. 646).

- Check to see if the JSON object or property names include reserved or numeric characters.

For more information about reserved characters in JSON object references in SQL queries, see JSON extensions (p. 646).

**Diagnosing problems with shadows**

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**Diagnosing shadows**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Troubleshooting guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>A device's shadow document is rejected with Invalid JSON document.</td>
<td>If you are unfamiliar with JSON, modify the examples provided in this guide for your own use. For more information, see Shadow document examples (p. 694).</td>
</tr>
<tr>
<td>I submitted correct JSON, but none or only parts of it are stored in the device's shadow document.</td>
<td>Be sure you are following the JSON formatting guidelines. Only JSON fields in the desired and reported sections are stored. JSON content (even if formally correct) outside of those sections is ignored.</td>
</tr>
<tr>
<td>I received an error that the device's shadow exceeds the allowed size.</td>
<td>The device's shadow supports 8 KB of data only. Try shortening field names inside of your JSON document or simply create more shadows by creating more things. A device can have an unlimited number of things/shadows associated with it. The only requirement is that each thing name must be unique in your account.</td>
</tr>
<tr>
<td>When I receive a device's shadow, it is larger than 8 KB. How can this happen?</td>
<td>Upon receipt, the AWS IoT service adds metadata to the device's shadow. The service includes this data in its response, but it does not count toward the limit of 8 KB. Only the data for desired and reported sections is stored.</td>
</tr>
</tbody>
</table>
### Issue

<table>
<thead>
<tr>
<th>Issue</th>
<th>Troubleshooting guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>reported state inside the state document sent to the device's shadow counts toward the limit.</td>
<td></td>
</tr>
<tr>
<td>My request has been rejected due to incorrect version. What should I do?</td>
<td>Perform a GET operation to sync to the latest state document version. When using MQTT, subscribe to the ./update/accepted topic to be notified about state changes and receive the latest version of the JSON document.</td>
</tr>
<tr>
<td>The timestamp is off by several seconds.</td>
<td>The timestamp for individual fields and the whole JSON document is updated when the document is received by the AWS IoT service or when the state document is published onto the ./update/accepted and ./update/delta message. Messages can be delayed over the network, which can cause the timestamp to be off by a few seconds.</td>
</tr>
<tr>
<td>My device can publish and subscribe on the corresponding shadow topics, but when I attempt to update the shadow document over the HTTP REST API, I get HTTP 403.</td>
<td>Be sure you have created policies in IAM to allow access to these topics and for the corresponding action (UPDATE/GET/DELETE) for the credentials you are using. IAM policies and certificate policies are independent.</td>
</tr>
<tr>
<td>Other issues.</td>
<td>The Device Shadow service logs errors to CloudWatch Logs. To identify device and configuration issues, enable CloudWatch Logs and view the logs for debug information.</td>
</tr>
</tbody>
</table>

### Diagnosing Salesforce IoT input stream action issues

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[Let us know what would help make it better](#)

#### Execution trace

How do I see the execution trace of a Salesforce action?

See the [Monitor AWS IoT using CloudWatch Logs (p. 461)](#) section. After you have activated the logs, you can see the execution trace of the Salesforce action.

#### Action success and failure

How do I check that messages have been sent successfully to a Salesforce IoT input stream?

View the logs generated by execution of the Salesforce action in CloudWatch Logs. If you see Action executed successfully, then it means that the AWS IoT rules engine received confirmation from the Salesforce IoT that the message was successfully pushed to the targeted input stream.

If you are experiencing problems with the Salesforce IoT platform, contact Salesforce IoT support.

What do I do if messages have not been sent successfully to a Salesforce IoT input stream?

View the logs generated by execution of the Salesforce action in CloudWatch Logs. Depending on the log entry, you can try the following actions:
Failed to locate the host

Check that the url parameter of the action is correct and that your Salesforce IoT input stream exists.

Received Internal Server Error from Salesforce

Retry. If the problem persists, contact Salesforce IoT Support.

Received Bad Request Exception from Salesforce

Check the payload you are sending for errors.

Received Unsupported Media Type Exception from Salesforce

Salesforce IoT does not support a binary payload at this time. Check that you are sending a JSON payload.

Received Unauthorized Exception from Salesforce

Check that the token parameter of the action is correct and that your token is still valid.

Received Not Found Exception from Salesforce

Check that the url parameter of the action is correct and that your Salesforce IoT input stream exists.

If you receive an error that is not listed here, contact AWS IoT Support.

Diagnosing Stream Limits

Troubleshooting "Stream limit exceeded for your AWS account"

If you see "Error: You have exceeded the limit for the number of streams in your AWS account.", you can clean up the unused streams in your account instead of requesting a limit increase.

To clean up an unused stream that you created using the AWS CLI or SDK:

```
aws iot delete-stream --stream-id value
```

For more details, see delete-stream.

Note
You can use the list-streams command to find the stream IDs.

Troubleshooting device fleet disconnects

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AWS IoT device fleet disconnects can happen for multiple reasons. This article explains how to diagnose a disconnect reason and how to handle disconnects caused by regular maintenance of AWS IoT service or a throttling limit.

To diagnose the disconnect reason

You can check the AWSIotLogsV2 log group in CloudWatch to identify the disconnect reason in the disconnectReason field of the log entry.

You can also use AWS IoT's lifecycle events feature to identify the disconnect reason. If you've subscribed to lifecycle's disconnect event ($aws/events/presence/disconnected/clientId), you'll get a notification from AWS IoT when the disconnect happens. You can identify the disconnect reason in the disconnectReason field of the notification.
For more information, see CloudWatch AWS IoT log entries and Lifecycle events.

To troubleshoot disconnects due to AWS IoT service maintenance

Disconnects caused by AWS IoT's service maintenance are logged as SERVER_INITIATED_DISCONNECT in AWS IoT's lifecycle event and CloudWatch. To handle these disconnects, adjust your client-side setup to make sure your devices can be automatically reconnected to the AWS IoT platform.

To troubleshoot disconnects due to a throttling limit

Disconnects caused by a throttling limit are logged as THROTTLED in AWS IoT's lifecycle event and CloudWatch. To handle these disconnects, you can request message broker limit increases as the device count grows.

For more information, see AWS IoT Core Message Broker.

AWS IoT Device Defender troubleshooting guide

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General

Q: Are there any prerequisites for using AWS IoT Device Defender?

A: If you want to use device-reported metrics, you must first deploy an agent on your AWS IoT connected devices or device gateways. Devices must provide a consistent client identifier or thing name.

Audit

Q: I enabled a check and my audit has been showing "In-Progress" for a long time. Is something wrong? When can I expect results?

A: When a check is enabled, data collection starts immediately. However, if your account has a large amount of data to collect (for example, certificates, things, or policies), the results of the check might not be available for some time after you have enabled it.

Detect

Q: How do I know the thresholds to set in an AWS IoT Device Defender security profile behavior?

A: Start by creating a security profile behavior with low thresholds and attach it to a thing group that contains a representative set of devices. You can use AWS IoT Device Defender to view the current metrics, and then fine-tune the device behavior thresholds to match your use case.

Q: I created a behavior, but it is not triggering a violation when I expect it to. How should I fix it?

A: When you define a behavior, you are specifying how you expect your device to behave normally. For example, if you have a security camera that only connects to one central server on TCP port 8888, you don't expect it to make any other connections. To be alerted if the camera makes a connection on another port, you define a behavior like this:

```json
{
    "name": "Listening TCP Ports",
    "metric": "aws:listening-tcp-ports",
    "criteria": {
        "comparisonOperator": "in-port-set",
        "value": {
```
If the camera makes a TCP connection on TCP port 443, the device behavior would be violated and an alert would be triggered.

Q: One or more of my behaviors are in violation. How do I clear the violation?

A: Alarms clear after the device returns to expected behavior, as defined in the behavior profiles. Behavior profiles are evaluated upon receipt of metrics data for your device. If the device doesn’t publish any metrics for more than two days, the violation event is set to alarm-invalidated automatically.

Q: I deleted a behavior that was in violation, but how do I stop the alerts?

A: Deleting a behavior stops all future violations and alerts for that behavior. Earlier alerts must be drained from your notification mechanism. When you delete a behavior, the record of violations of that behavior is retained for the same time period as all other violations in your account.

Device Metrics

Q: I’m submitting metrics reports that I know violate my behaviors, but no violations are being triggered. What’s wrong?

A: Check that your metrics reports are being accepted by subscribing to the following MQTT topics:

```
$aws/things/THING_NAME/defender/metrics/FORMAT/rejected
$aws/things/THING_NAME/defender/metrics/FORMAT/accepted
```

THING_NAME is the name of the thing reporting the metric and FORMAT is either "JSON" or "CBOR," depending on the format of the metrics report submitted by the thing.

After you have subscribed, you should receive messages on these topics for each metric report submitted. A rejected message indicates that there was a problem parsing the metric report. An error message is included in the message payload to help you correct any errors in your metric report. An accepted message indicates that the metric report was parsed properly.

Q: What happens if I send an empty metric in my metric report?

A: An empty list of ports or IP addresses is always considered in conformity with the corresponding behavior. If the corresponding behavior was in violation, the violation is cleared.

Q: Why do my device metric reports contain messages for devices that aren’t in the AWS IoT registry?

If you have one or more security profiles attached to all things or to all unregistered things, AWS IoT Device Defender includes metrics from unregistered things. If you want to exclude metrics from unregistered things, you can attach the profiles to all registered devices instead of all devices.

Q: I’m not seeing messages from one or more unregistered devices even though I applied a security profile to all unregistered devices or all devices. How can I fix it?

Verify that you are sending a well-formed metrics report using one of the supported formats. For information, see Device metrics document specification (p. 1059). Verify that the unregistered devices are using a consistent client identifier or thing name. If the thing name contains control characters or is longer than 128 bytes of UTF-8 encoded characters, messages reported by devices are rejected.

Q: What happens if an unregistered device is added to the registry or a registered device becomes unregistered?

A: If a device is added to or removed from the registry:
• You see two separate violations for the device (one under its registered thing name, one under its unregistered identity) if it continues to publish metrics for violations. Active violations for the old identity stop appearing after two days, but are available in violations history for up to 14 days.

Q: Which value should I supply in the report ID field of my device metrics report?

A: Use a unique value for each metric report, expressed as a positive integer. A common practice is to use a Unix epoch timestamp.

Q: Should I create a dedicated MQTT connection for AWS IoT Device Defender metrics?

A: A separate MQTT connection is not required.

Q: Which client ID should I use when connecting to publish device metrics?

For devices (things) that are in the AWS IoT registry, use the registered thing name. For devices that are not in the AWS IoT registry, use a consistent identifier when you connect to AWS IoT. This practice helps match the violations to the thing name.

Q: Can I publish metrics for a device with a different client ID?

It is possible to publish metrics on behalf of another thing. You can do this by publishing the metrics to the AWS IoT Device Defender reserved topic for that device. For example, Thing-1 would like to publish metrics for itself and also on behalf of Thing-2. Thing-1 collects its own metrics and publishes them on the MQTT topic:

```
$aws/things/Thing-1/defender/metrics/json
```

Thing-1 then obtains metrics from Thing-2 and publishes those metrics on the MQTT topic:

```
$aws/things/Thing-2/defender/metrics/json
```

Q: How many security profiles and behaviors can I have in my account?

A: See AWS IoT Device Defender Endpoints and Quotas.

Q: What does a prototypical target role for an alert target look like?

A: A role that allows AWS IoT Device Defender to publish alerts on an alert target (SNS topic) requires two things:

• A trust relationship that specifies iot.amazonaws.com as the trusted entity.

• An attached policy that grants AWS IoT permission to publish on a specified SNS topic. For example:

```json
{
   "Version": "2012-10-17",
   "Statement": [
   {
      "Effect": "Allow",
      "Action": "sns:Publish",
      "Resource": "<sns-topic-arn>"
   }
   ]
}
```

• If the SNS topic used for publishing alerts is an encrypted topic, then along with the permission to publish to SNS topic, AWS IoT must be granted two more permissions. For example:

```json
{
   "Version": "2012-10-17",
   "Statement": [
   {
      "Effect": "Allow",
      "Action": "sns:Publish",
      "Resource": "<sns-topic-arn>"
   }
   ]
}
```
Q: My metric report submission with a custom metric type number fails with the error message Malformed metrics report. What's wrong?

A: The type number only takes a single metric value as an input, but while submitting the metrics value in the DeviceMetrics report, it must be passed as an array with a single value. Make sure you're submitting the metric value as an array.

Error payload:

```json
{"header":{"report_id":12345678,"version":"1.0"},"metrics":{"network_stats":{"bytes_in":30680,"bytes_out":10652,"packets_in":113,"packets_out":118}},"custom_metrics":{"my_custom_metric":{"number":0}}}
```

Error message:

```json
{"thingName":"myThing","status":"REJECTED","statusDetails":{"ErrorCode":"InvalidPayload","ErrorMessage":"Malformed metrics report"},"timestamp":1635802047699}
```

No-error payload:

```json
{"header":{"report_id":12345678,"version":"1.0"},"metrics":{"network_stats":{"bytes_in":30680,"bytes_out":10652,"packets_in":113,"packets_out":118}},"custom_metrics":{"my_custom_metric":[{"number":0}]}}
```

Response:

```json
{"thingName":"myThing","12345678":1635800375,"status":"ACCEPTED","timestamp":1635801636023}
```
The mechanism can try to connect to our test endpoint every 5 seconds for a minute to two. In this way you can run multiple test cases in sequence in an automated manner.

Q: Can I get a history of Device Advisor API calls made on my account for security analysis and operational troubleshooting purposes?

A: Yes. To receive a history of Device Advisor API calls made on your account, you simply turn on CloudTrail in the AWS IoT Management Console and filter the event source to be iotdeviceadvisor.amazonaws.com.

Q: How do I view Device Advisor logs in CloudWatch?

A: Logs generated during a test suite run are uploaded to CloudWatch if you add the required policy (for example, CloudWatchFullAccess) to your service role (see Setting up (p. 1104)). If there is at least one test case in the test suite, a log group "aws/iot/deviceadvisor/$testSuiteId" is created with two log streams. One stream is the "$testRunId" and includes logs of actions taken before and after executing the test cases in your test suite, such as setup and cleanup steps. The other log stream is "$suiteRunId_$testRunId," which is specific to a test suite run. Events sent from devices and AWS IoT Core will be logged to this log stream.

Q: What is the purpose of the device permission role?

A: Device Advisor stands between your test device and AWS IoT Core to simulate test scenarios. It accepts connections and messages from your test devices and forwards them to AWS IoT Core by assuming your device permission role and initiating a connection on your behalf. It's important to make sure the device role permissions are the same as those on the certificate you use for running tests. AWS IoT certificate policies are not enforced when Device Advisor initiates a connection to AWS IoT Core on your behalf by using the device permission role. However, the permissions from the device permission role you set are enforced.

Q: In what Regions is Device Advisor supported?

A: Device Advisor is supported in us-east-1, us-west-2, ap-northeast-1, and eu-west-1 Regions.

Q: Why do I see inconsistent results?

A: One of the primary causes of inconsistent results is setting a test's EXECUTION_TIMEOUT to a value that is too low. For more information about recommended and default EXECUTION_TIMEOUT values, see Device Advisor test cases.

Q: What MQTT protocol does Device Advisor support?

A: Device Advisor supports MQTT Version 3.1.1 with X509 client certificates.

Q: What if my test case failed with an execution timed out message even though I tried to connect my device to the test endpoint?

A: Validate all the steps under Create an IAM role to be used as your device role. If the test still fails, it could be that the device is not sending the correct Server Name Indication (SNI) extension, which is required for Device Advisor to work. The correct SNI value is the endpoint address returned when following the Configure your device section. AWS IoT also requires devices to send the Server Name Indication (SNI) extension to the Transport Layer Security (TLS) protocol. For more information, see Transport security in AWS IoT.

Q: My MQTT connection fails with an "libaws-c-mqtt: AWS_ERROR_MQTT_UNEXPECTED_HANGUP" error (or) my device's MQTT connection is being automatically disconnected from the Device Advisor endpoint. How can this error be resolved?

A: This particular error code and unexpected disconnections can be caused by many different things, but is most likely related to the device role attached to the device. The below checkpoints (in order of priority) will resolve this issue.

- The device role attached to the device must have the minimum IAM permissions required to run the tests. Device Advisor will use the attached device role to perform AWS IoT MQTT actions on behalf of the test device. If required permissions are absent, then the AWS_ERROR_MQTT_UNEXPECTED_HANGUP error will be seen or unexpected disconnections will
happen while the device tries to connect to Device Advisor endpoint. For example, if you selected to run the MQTT Publish test case, both Connect and Publish actions must be included in the role with the corresponding ClientId and Topic (you can provide multiple values by using commas to separate the values, and you can provide prefix values using a wildcard (*) character. For example: To provide permissions to publish on any topic beginning with TestTopic, you can provide "TestTopic*" as the resource value. Here are some examples of policies.

- Mismatch between the values defined in the device role for your resource types and the actual values used in code. For example: A mismatch in ClientId defined in the role and the actual ClientId used in your device code. Values like ClientId, Topic, and TopicFilter must be identical in the device role and code.
- The device certificate attached to your device must be active and have a policy attached to it with the required action permissions for resources. Note that, the device certificate policy grants or denies access to AWS IoT resources and AWS IoT Core data plane operations. Device Advisor requires you to have an active device certificate attached to your device which grants the action permissions used during a test case.

AWS IoT Device Management troubleshooting guide

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This is the troubleshooting section for AWS IoT Device Management.

Topics
- AWS IoT Jobs Troubleshooting (p. 1444)
- Fleet indexing troubleshooting guide (p. 1447)

AWS IoT Jobs Troubleshooting

This is the troubleshooting section for AWS IoT Jobs.

How do I locate an AWS IoT Jobs endpoint?

How do I locate the AWS IoT Jobs control plane endpoint?

AWS IoT Jobs supports controls plane API operations using the HTTPS protocol. Verify you have connected to the correct control plane endpoint using the HTTPS protocol.

For a list of AWS region-specific endpoints, see AWS IoT Core - control plane endpoints.

For a list of FIPS compliant AWS IoT Jobs control plane endpoints, see FIPS Endpoints by Service.

Note
AWS IoT Jobs and AWS IoT Core share the same AWS Region-specific endpoints.

How do I locate the AWS IoT Jobs data plane endpoint?

AWS IoT Jobs supports data plane API operations using the HTTPS and MQTT protocols. Verify you have connected to the correct data plane endpoint using the HTTPS or MQTT protocol.

- HTTPS protocol
  - Use the following describe-endpoint CLI command shown below or the DescribeEndpoint REST API. For the endpoint type, use iot:Jobs.
aws iot describe-endpoint --endpoint-type iot:Jobs

- MQTT protocol
- Use the following describe-endpoint CLI command shown below or the DescribeEndpoint REST API. For the endpoint type, use iot:Data-ATS (recommended) or iot:Data.

aws iot describe-endpoint --endpoint-type iot:Data-ATS (recommended)

aws iot describe-endpoint --endpoint-type iot:Data

For a list of FIPS compliant AWS IoT Jobs data plane endpoints, see FIPS Endpoints by Service

How do I monitor AWS IoT Jobs activity and provide metrics?

Monitoring AWS IoT Jobs activity using Amazon CloudWatch provides real-time visibility into ongoing AWS IoT Jobs operations and helps control costs with CloudWatch alarms via AWS IoT Rules. You must configure logging before you can monitor AWS IoT Jobs activity and setup CloudWatch alarms. For more information on setting up logging, see Configure AWS IoT logging (p. 439).

For more information on Amazon CloudWatch and how to setup permission via an IAM user role to use CloudWatch resources, see Identity and access management for Amazon CloudWatch.

How do I set up AWS IoT Jobs metrics and monitoring using Amazon CloudWatch?

To set up AWS IoT logging, follow the steps outlined in Configure AWS IoT logging. AWS IoT logging set up can be done in the AWS Management Console, AWS CLI, or API. AWS IoT logging set up for specific thing groups must be done in the AWS CLI or API only.

The AWS IoT Jobs metrics section contains the AWS IoT Jobs metrics used for monitoring AWS IoT Jobs activity. It explains how to view the metrics in the AWS Management Console and AWS CLI.

Additionally, you can set up CloudWatch alarms to alert you of specific metrics you want to closely monitor. For guidance on alarm setup, see Using Amazon CloudWatch alarms.

Device fleets and single device troubleshooting

A job execution maintains a status of QUEUED indefinitely

When a job execution with a status state of QUEUED does not proceed to the next logical status state such as IN_PROGRESS, FAILED, or TIMED_OUT, one of the following scenarios may be the cause:

- Review your device activity in the CloudWatch logs located in the CloudWatch console. For more information, refer to Monitor AWS IoT using CloudWatch Logs.
- The IAM role associated with the job and subsequent job execution may not have the correct permissions listed in one of the policy statements of the IAM policy attached to that IAM role. Use the describe-job API to identify the IAM role linked to that job and subsequent job execution and review the IAM policy for correct permissions. Once the policy permission statements have been updated, you should be able to perform the AssumeRole API command on the resource.

A job execution was not created for my thing or thing group

When a job updates its status state to IN_PROGRESS, it will begin the job document rollout to all devices in your target group. This status state update will create a job execution for each target
device. If a job execution was not created for one of the target devices, refer to the following guidance:

- Is the thing directly targeted by the job, the job has a status state of IN_PROGRESS, and the job is concurrent? If all three conditions are met, then the job is still sending out job executions to all devices in your target group and that specific thing has not received its job execution yet.
- Review the devices in your target group for the job and the job status state in the AWS Management Console or use the `describe-job` API command.
- Use the `describe-job` API command to review if the job has the IsConcurrent property set to true or false. For more information, see Job limits.
- The thing is not directly targeted by the job.
  - If the Thing was added to a ThingGroup and the job targeted the ThingGroup, then verify the Thing is part of the ThingGroup.
  - If the job is a snapshot job with a status state of IN_PROGRESS and is concurrent, then the job is still sending out job executions to all devices in your target group and that specific Thing has not received its job execution yet.
  - If the job is a continuous job with a status state of IN_PROGRESS and is concurrent, then the job is still sending out job executions to all devices in your target group and that specific Thing has not received its job execution yet. For continuous jobs only, you can also remove the Thing from the ThingGroup and then add the Thing back to the ThingGroup.

**New job fails due to LimitedExceededException error**

If your job creation fails with an error response of LimitedExceededException, then call the `list-jobs` API and review all jobs with `isConcurrent=true` to determine if you are at your job concurrency limit. See Job limits for additional information on concurrent jobs. To view your job concurrency limits and to request a limit increase, see AWS IoT Device Management jobs limits and quotas.

**Job document size limit**

The job document size is limited by the MQTT payload size. If you need a job document larger than 32 kB (kilobytes), 32,000 B (bytes), then create and store the job document in Amazon S3 and add an Amazon S3 object URL in the `documentSource` field for the `CreateJob` API or using the AWS CLI. For the AWS Management Console, add an Amazon S3 object URL in the Amazon S3 URL text box when creating a job.

- AWS Management Console create job documentation: Create and manage jobs by using the AWS Management Console
- AWS CLI create job documentation: Create and manage jobs using the AWS CLI
- CreateJob API documentation: CreateJob

**Device Side MQTT message requests throttle limits**

If you receive an error code 400 ThrottlingException, the device side MQTT message failed due to reaching the limit of simultaneous device side requests. See AWS IoT Device Management jobs limits and quotas for more information on throttle limits and if it is adjustable.

**Connection timeout error**

An error code 400 RequestExpired indicates a connection failure due to high latency or low client side timeout values.

- See Testing connectivity with your device data endpoint for information on testing connection between the client side and server side.
Invalid API command

Confirm the correct API command is entered to avoid an error message stating the API command is invalid. See the [AWS IoT API Reference](https://docs.aws.amazon.com/iot/core/latest/developerguide/api-index.html) for a comprehensive list of all AWS IoT API commands.

Service side connection error

An error code 503 ServiceUnavailable indicates the error originated from the server side.

- See [AWS Health Dashboard (all AWS services)](https://console.aws.amazon.com/health/home) for the current status of all AWS services.
- See [AWS Health Dashboard (personal AWS account)](https://console.aws.amazon.com/health/home) for the current status of your personal AWS account.

Fleet indexing troubleshooting guide

Troubleshooting aggregation queries for the fleet indexing service

If you are having type mismatch errors, you can use CloudWatch Logs to troubleshoot the problem. CloudWatch Logs must be enabled before logs are written by the Fleet Indexing service. For more information, see [Monitor AWS IoT using CloudWatch Logs](https://docs.aws.amazon.com/iot/core/latest/developerguide/monitor-iot-using-cloudwatch-logs.html) (p. 461).

To make aggregation queries on non-managed fields, you must specify a field you defined in the customFields argument passed to `UpdateIndexingConfiguration` or `update-indexing-configuration`. If the field value is inconsistent with the configured field data type, this value is ignored when you perform an aggregation query.

If a field cannot be indexed because of a mismatched type, the Fleet Indexing service sends an error log to CloudWatch Logs. The error log contains the field name, the value that could not be converted, and the thing name for the device. The following is an example error log:

```json
{
  "timestamp": "2017-02-20 20:31:22.932",
  "logLevel": "ERROR",
  "traceId": "79738924-1025-3a00-a669-7bec69f7f07a",
  "accountId": "000000000000",
  "status": "SucceededWithIssues",
  "eventType": "IndexingCustomFieldFailed",
  "thingName": "thing0",
  "failedCustomFields": [
    {
      "Name": "attributeName1",
      "Value": "apple",
      "ExpectedType": "String"
    },
    {
      "Name": "attributeName2",
      "Value": "2",
      "ExpectedType": "Boolean"
    }
  ]
}
```

If a device has been disconnected for approximately an hour, the connectivity status timestamp value might be missing. For persistent sessions, the value might be missing after a client has been disconnected longer than the configured time-to-live (TTL) for the persistent session. The connectivity status data is indexed only for connections where the client ID has a matching thing name. (The client ID is the value used to connect a device to AWS IoT Core.)
Troubleshooting fleet indexing configuration

Can't downgrade fleet indexing configuration

Downgrading fleet indexing configuration is not supported when you want to remove the data sources that are associated with a fleet metric or a dynamic group.

For example, if your indexing configuration has registry data, shadow data, and connectivity data, and a fleet metric exists with the query thingName:TempSensor* AND shadow.desired.temperature>80, updating the indexing configuration to include only the registry data will result in an error.

Modifying custom fields used by existing fleet metrics is not supported.

Can't update your indexing configuration due to incompatible fleet metrics or dynamic groups

If you can't update your indexing configuration due to incompatible fleet metrics or dynamic groups, delete the incompatible fleet metrics or dynamic groups before you update the indexing configuration.

Troubleshooting fleet metrics

Can't see data points in CloudWatch

If you're able to create a fleet metric but you can't see data points in CloudWatch, it's likely that you don't have a thing that meets the query string criteria.

See this example command of how to create a fleet metric:

aws iot create-fleet-metric --metric-name "example_FM" --query-string "thingName:TempSensor* AND attributes.temperature>80" --period 60 --aggregation-field "attributes.temperature" --aggregation-type name=Statistics,values=count

If you don't have a thing that meets the query string criteria --query-string "thingName:TempSensor* AND attributes.temperature>80":

- With values=count, you'll be able to create a fleet metric and there'll be data points to show in CloudWatch. The data points of the value count is always 0.
- With values other than count, you'll be able to create a fleet metric but you won't see the fleet metric in CloudWatch and there'll be no data points to show in CloudWatch.

AWS IoT errors

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This section lists the error codes sent by AWS IoT.

Message broker error codes

<table>
<thead>
<tr>
<th>Error code</th>
<th>Error description</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Bad request.</td>
</tr>
<tr>
<td>401</td>
<td>Unauthorized.</td>
</tr>
<tr>
<td>403</td>
<td>Forbidden.</td>
</tr>
<tr>
<td>Error code</td>
<td>Error description</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>503</td>
<td>Service unavailable.</td>
</tr>
</tbody>
</table>

**Identity and security error codes**

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>401</td>
<td>Unauthorized.</td>
</tr>
</tbody>
</table>

**Device shadow error codes**

<table>
<thead>
<tr>
<th>Error code</th>
<th>Error description</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Bad request.</td>
</tr>
<tr>
<td>401</td>
<td>Unauthorized.</td>
</tr>
<tr>
<td>403</td>
<td>Forbidden.</td>
</tr>
<tr>
<td>404</td>
<td>Not found.</td>
</tr>
<tr>
<td>409</td>
<td>Conflict.</td>
</tr>
<tr>
<td>413</td>
<td>Request too large.</td>
</tr>
<tr>
<td>422</td>
<td>Failed to process request.</td>
</tr>
<tr>
<td>429</td>
<td>Too many requests.</td>
</tr>
<tr>
<td>500</td>
<td>Internal error.</td>
</tr>
<tr>
<td>503</td>
<td>Service unavailable.</td>
</tr>
</tbody>
</table>
AWS IoT quotas

You can find information about AWS IoT quotas in the AWS General Reference.

- For AWS IoT Core quotas information, see AWS IoT Core Endpoints and Quotas.
- For AWS IoT Device Management quotas information, see AWS IoT Device Management Endpoints and Quotas.
- For AWS IoT Device Defender quotas information, see AWS IoT Device Defender Endpoints and Quotas.
AWS IoT Core pricing

You can find information about AWS IoT Core pricing in the AWS Marketing page and the AWS Pricing Calculator.

- To check AWS IoT Core pricing information, see AWS IoT Core Pricing.
- To estimate the cost of your architect solution, see AWS Pricing Calculator.