Cross-Region Replication Monitor: Implementation Guide
Copyright © 2022 Amazon Web Services, Inc. and/or its affiliates. All rights reserved.

Amazon's trademarks and trade dress may not be used in connection with any product or service that is not Amazon's, in any manner that is likely to cause confusion among customers, or in any manner that disparages or discredits Amazon. All other trademarks not owned by Amazon are the property of their respective owners, who may or may not be affiliated with, connected to, or sponsored by Amazon.
# Table of Contents

Home ............................................................................................................................................... 1
Overview ........................................................................................................................................... 2
Cost .................................................................................................................................................. 2
Architecture .................................................................................................................................... 2
crr-monitor Template .................................................................................................................. 3
crr-agent Template ....................................................................................................................... 4
Considerations ................................................................................................................................... 6
Regional Deployments .................................................................................................................. 6
Scaling .......................................................................................................................................... 6
Templates ......................................................................................................................................... 7
Deployment ....................................................................................................................................... 8
What We'll Cover ........................................................................................................................... 8
Step 1. Launch the Stack ............................................................................................................... 8
Step 2. Launch the Agent Stack (Optional) .................................................................................. 10
Step 3. Subscribe to Amazon SNS Topic ...................................................................................... 11
Security ........................................................................................................................................... 12
Resources ........................................................................................................................................ 13
Appendix ......................................................................................................................................... 14
Source Code .................................................................................................................................... 15
Revisions ......................................................................................................................................... 16

.............................................................................................................................................. 16
Automatically check the replication status of Amazon S3 objects across all AWS Regions with Cross-Region Replication Monitor

AWS Implementation Guide

AWS Solutions Builder Team

June 2017 (last update (p. 16): March 2020)

This implementation guide discusses architectural considerations and configuration steps for deploying the Cross-Region Replication Monitor (CRR Monitor) in the Amazon Web Services (AWS) Cloud. It includes links to AWS CloudFormation templates that launch, configure, and run the AWS compute, network, storage, and other services required to deploy this solution on AWS, using AWS best practices for security and availability.

The guide is intended for IT infrastructure architects, who have a working knowledge of data replication and practical experience architecting in the AWS Cloud.
Overview

Amazon Simple Storage Service (Amazon S3) offers cross-region replication, a bucket-level feature that enables automatic, asynchronous copying of objects across buckets in different AWS Regions. This feature can help companies minimize latency when accessing objects in different geographic regions, meet compliance requirements, and for operational purposes. Amazon S3 encrypts all data in transit across AWS Regions using SSL, and objects in the destination bucket are exact replicas of objects in the source bucket. For more information on cross-region replication, see the Amazon S3 Developer Guide.

Currently, AWS customers can retrieve the replication status of their objects manually or use an Amazon S3 inventory to generate metrics on a daily or weekly basis. To help customers more proactively monitor the replication status of their Amazon S3 objects, AWS offers the Cross-Region Replication Monitor (CRR Monitor) solution. The CRR Monitor automatically checks the replication status of Amazon S3 objects across all AWS Regions in a customer’s account, and provides near real-time metrics and failure notifications to help customers proactively identify failures and troubleshoot problems. The solution automatically provisions the necessary AWS services to monitor replication status, including AWS Lambda, Amazon CloudWatch, Amazon Simple Notification Service (Amazon SNS), AWS CloudTrail, Amazon Simple Queue Service (Amazon SQS), and Amazon DynamoDB and offers an option to use Amazon Kinesis Data Firehose to archive replication metadata in Amazon S3.

This guide assumes basic knowledge of Amazon S3 cross-region replication. It is also helpful to have working knowledge of Amazon S3, AWS Lambda, Amazon CloudWatch, Amazon SQS, Amazon SNS, and Amazon DynamoDB.

Cost

You are responsible for the cost of the AWS services used while running the CRR Monitor. The total cost for running this solution depends on the interval at which you run the Lambda functions.

As of the date of publication, the cost for running this solution with default settings in the US East (N. Virginia) Region is approximately $0.35 an hour, or less if you have AWS Lambda free tier monthly usage credit. This cost estimate assumes one million Lambda requests, and 100,000 AWS CloudTrail events.

Note
Pricing does not include the cost for Amazon DynamoDB. These charges will vary depending on the data volume being processed. (e.g. for a little less than $0.25/day ($7.50/month), you could support an application that performs 1 million writes and reads per day, 100K read requests from Streams, and stores 1GB of data). For more information, see Amazon DynamoDB pricing.

This pricing is subject to change and does not reflect variable charges from Amazon S3 data storage and replication, and the Amazon Athena query service. For full details, see the pricing webpage for each AWS service you will be using this solution.

Architecture Overview

Deploying this solution builds the following environment in the AWS Cloud.
The \textit{crr-monitor.template} is the solution’s primary AWS CloudFormation template. This template deploys the components to enable monitoring of cross-region replication either within a single AWS account or across AWS accounts. Monitoring across AWS accounts is possible when the Amazon S3 source buckets reside in the account where this template is deployed. The template deploys AWS Identity and Access Management (IAM) roles, AWS Lambda functions, an AWS CloudTrail trail, an Amazon CloudWatch rule, Amazon Simple Notification Service (Amazon SNS) topics, an Amazon SQS queue, and Amazon DynamoDB tables.

This solution enables AWS CloudTrail and begins logging S3 events for the \textit{source} and \textit{destination} buckets where cross-region replication is configured. If new buckets are configured with cross-region replication after the solution has been deployed, they can be added quickly to CloudTrail using the AWS Management Console.

When an object is added to the S3 source bucket, AWS CloudTrail logs the event data. This activity triggers a CloudWatch event rule that publishes a message to the Amazon SNS topic in the source bucket’s region. An Amazon SQS queue subscribed to the Amazon SNS topic receives the message for processing. Once the object replication to the destination bucket is successful, status information is sent back to the Amazon SQS queue.

A CloudWatch event automatically invokes the \texttt{CRRMonitor} Lambda function. By default, the function is invoked every 60 seconds but this is configurable in the CloudWatch console. The function reads messages from the SQS queue and updates the \texttt{CRRMonitor} DynamoDB table with the replication status. Status data in the DynamoDB table is deleted and replaced every 24 hours.
**crr-agent Template**

Deploy the crr-agent template in AWS accounts containing S3 source bucket(s) when you have the crr-monitor template deployed in a separate AWS account.

**Note**

The crr-monitor template is deployed in the AWS account containing the destination bucket(s).

The crr-agent template deploys a CloudWatch rule that forwards events to the AWS account event bus (where the crr-monitor template is deployed, or the Monitor account) to track the replication status. After the event is delivered to the Monitor account, the operations described in the crr-monitor Template section are performed. If the AWS account containing the S3 source buckets does not have CloudTrail monitoring, you can configure AWS CloudTrail data events to monitor them.

---

**Figure 2: Cross-Region Replication Agent architecture on AWS**

When an object is added to the Amazon S3 source bucket, AWS CloudTrail logs the data event. This activity triggers an Amazon CloudWatch event rule that delivers the status information to the CloudWatch Logs in the Monitor account using an event bus. In the Monitor account, CloudWatch Logs sends the event to Amazon SNS. An Amazon SQS queue subscribed to the Amazon SNS topic receives the message for processing. After the object replication to the destination bucket is successful, the replication triggers a similar event, and sends the status information back to the Amazon SQS queue in the Monitor account.
After the AWS Lambda function verifies an object was successfully replicated, it stores the data in an Amazon DynamoDB table for immediate access. Status data in the DynamoDB table is deleted and replaced every 24 hours.

**Note**

Customers who deploy this solution in an AWS Region that offers Amazon Kinesis Data Firehose can choose to archive solution data to Amazon S3. If you enable this feature, the solution uses a Firehose delivery stream to upload data to one of your existing S3 buckets for later analysis. You can use Amazon Athena, a serverless, interactive query service, to easily analyze historical data in Amazon S3.
Implementation Considerations

Regional Deployments

Customers can deploy the CRR Monitor in any AWS Region that supports AWS Lambda and Amazon Kinesis Data Firehose. (For the most current service availability by region, see AWS service offerings by region.) The solution uses a Firehose delivery stream as a part of an optional solution feature to archive data in Amazon Simple Storage Service (Amazon S3). You can choose to disable this feature (due to regional availability or other reasons) during initial configuration of the AWS CloudFormation template. If you disable data archiving, you can use the Amazon S3 inventory feature to get a daily or weekly replication status for your objects, but it will not include detailed metadata from this solution, such as CRR rate, elapsed time, etc.

Once deployed, the CRR Monitor applies the appropriate configuration for monitoring the replicated Amazon S3 buckets across all AWS Regions in a single account. For more information, see the cross-region replication in the Amazon S3 Developer Guide.

Scaling

This solution will run multiple concurrent instances of the AWS Lambda CRRMonitor function, based on workload, up to a default maximum of 20 per minute. Each instance can process 1,800 S3 PUT records in its five-minute maximum run time. This allows CRR Monitor to achieve scale within predictable and controllable bounds to limit impact on other Lambda workloads in your account.

The solution provisions Amazon DynamoDB throughput capacity to support the maximum read and write requests from the default limit (20) of Lambda functions. If you plan to monitor a large number of objects and anticipate a high number of concurrent requests, consider increasing both the Lambda and Amazon DynamoDB settings in this solution.
AWS CloudFormation Templates

This solution uses AWS CloudFormation to automate the deployment of the Cross-Region Replication Monitor (CRR Monitor). It includes the following AWS CloudFormation templates, which you can download before deployment:

**crr-monitor.template:** Use this template to launch CRR Monitor and enable cross-region replication monitoring in either a single account or across accounts where the source buckets reside. This template launches the following components: AWS Identity and Access Management (IAM) roles, AWS Lambda, Amazon CloudWatch, Amazon Simple Notification Service (Amazon SNS), Amazon Simple Queue Service (Amazon SQS), Amazon DynamoDB, and AWS CloudTrail. The template creates an Amazon CloudWatch event, and Amazon SNS topics in all AWS Regions. You can customize the template based on your specific needs.

**crr-agent.template:** This template enables replication events to be sent to the event bus in the crr-monitor template, which is in a separate AWS account. This enables the solution to monitor replication where other AWS accounts that deployed the crr-agent template contains source buckets. CloudTrail events are sent to the Monitor account event bus for processing.

**Note**
We recommend deploying crr-monitor.template in the destination account first to enable the necessary permissions for the AWS accounts that deploys the crr-agent template to send messages to the event bus.
Automated Deployment

This solution is intended for customers who have already configured Amazon S3 cross-region replication in their account. Before you launch the automated deployment, please review the architecture, configuration, and other considerations discussed in this guide. Follow the step-by-step instructions in this section to configure and deploy the Cross-Region Replication Monitor into your account.

**Time to deploy:** Approximately five minutes

### What We'll Cover

The procedure for deploying this architecture on AWS consists of the following steps. For detailed instructions, follow the links for each step.

**Step 1. Launch the Stack (p. 8)**
- Launch the AWS CloudFormation template into your AWS account.
- Enter values for optional parameters: **Archive to S3**, **S3 Archive Bucket**
- Review the other template parameters, and adjust if necessary.

**Step 2. Launch the Agent Stack (Optional) (p. 10)**
- Launch the AWS CloudFormation template into secondary AWS account(s).
- Enter values for optional parameters: **CRR Monitor Accounts**

**Step 3. Subscribe to Amazon SNS Topic (p. 11)**
- Subscribe to the custom Amazon SNS Topic to receive failure notifications.

### Step 1. Launch the Stack

**Note**
You are responsible for the cost of the AWS services used while running this solution. See the [Cost (p. 2)] section for more details. For full details, see the pricing webpage for each AWS service you will be using in this solution.

1. Sign in to the AWS Management Console and click the button below to launch the `crr-monitor` AWS CloudFormation template.

   ![Launch Solution](image)

   You can also [download the template](image) as a starting point for your own implementation.

2. The template is launched in the US East (N. Virginia) by default. To launch the CRR Monitor in a different AWS Region, use the region selector in the console navigation bar.

   **Note**
   This solution uses the AWS Lambda service and Amazon Kinesis Data Firehose, which is currently available in specific AWS Regions only. Therefore, you must deploy this solution an
AWS Region where Lambda and Kinesis Firehose are available. For the most current service availability by region, see AWS service offerings by region.

3. On the **Select Template** page, verify that you selected the correct template and choose **Next**.
4. On the **Specify Details** page, assign a name to your CRR Monitor stack.
5. Under **Parameters**, review the parameters for the template, and modify them as necessary. This solution uses the following default values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archive to S3</td>
<td>No</td>
<td>This solution has the option to archive status data from DynamoDB to Amazon S3 for later analysis. To enable this feature, select <strong>Yes</strong>.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note</strong> If you use this feature, you must deploy this template in an AWS Region that supports Amazon Kinesis Data Firehose.</td>
</tr>
<tr>
<td>S3 Archive Bucket</td>
<td>&lt;Requires Input&gt;</td>
<td>If you chose to enable data archiving to Amazon S3, enter the name of an existing S3 bucket.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Note</strong> To use this feature, you must select <strong>Yes</strong> for the Archive to S3 parameter. You must specify an existing S3 bucket. If you plan to use multiple implementations of the solution in different AWS Regions, we recommend that you use the same bucket to collect all solution data.</td>
</tr>
<tr>
<td>Remote Accounts</td>
<td>&lt;Requires Input&gt;</td>
<td>A comma-separated list of remote accounts to be monitored. Enter IDs for accounts that have the crr-agent.template deployed.</td>
</tr>
</tbody>
</table>

6. Choose **Next**.
7. On the **Options** page, choose **Next**.
8. On the **Review** page, review and confirm the settings. Be sure to check the box acknowledging that the template will create AWS Identity and Access Management (IAM) resources.
9. Choose **Create** to deploy the stack.
You can view the status of the stack in the AWS CloudFormation console in the **Status** column. You should see a status of **CREATE_COMPLETE** in approximately five minutes.

**Note**
In addition to the solution's AWS Lambda functions, this solution includes the **solution-helper**, Lambda function, which runs only during initial configuration or when resources are updated or deleted.

When running this solution, you will see the regularly active Lambda function whose names contain **crr**. However, do not delete the **solution-helper** function as it is necessary to manage associated resources.

### Step 2. Launch the Agent Stack (Optional)

Use this template to enable cross-region replication and monitoring across multiple accounts and regions.

1. Sign in to the AWS Management Console and click the button below to launch the **crr-agent** AWS CloudFormation template.

![Launch Solution](image)

You can also [download the template](image) as a starting point for your own implementation.

2. The template is launched in the US East (N. Virginia) by default. To launch the CRR Monitor in a different AWS Region, use the region selector in the console navigation bar.

3. On the **Select Template** page, verify that you selected the correct template and choose **Next**.

4. On the **Specify Details** page, assign a name to your CRR Monitor stack.

5. Under **Parameters**, review the parameters for the template, and modify them as necessary. This solution uses the following default values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRR Monitor Accounts</td>
<td>&lt;Requires Input&gt;</td>
<td>The ID of the AWS account where the Monitor template is deployed</td>
</tr>
</tbody>
</table>

6. Choose **Next**.
7. On the **Options** page, choose **Next**.
8. On the **Review** page, review and confirm the settings. Be sure to check the box acknowledging that the template will create AWS Identity and Access Management (IAM) resources.
9. Choose **Create** to deploy the stack.

You can view the status of the stack in the AWS CloudFormation console in the **Status** column. You should see a status of **CREATE_COMPLETE** in approximately five minutes.

**Note**
In addition to the solution's AWS Lambda functions, this solution includes the **solution-helper**, Lambda function, which runs only during initial configuration or when resources are updated or deleted.
When running this solution, you will see the regularly active Lambda function whose names contain \texttt{crr}. However, do not delete the \texttt{solution-helper} function as it is necessary to manage associated resources.

**Step 3. Subscribe to Amazon SNS Topic**

This solution uses the \texttt{FailedReplication} Amazon CloudWatch metric to trigger a CloudWatch alarm. If an object fails to replicate across AWS Regions, the CloudWatch alarm will trigger and Amazon SNS notification about the failure. This enables customers to identify failures in near real-time and troubleshoot them immediately.

To receive this notification, you must subscribe to the solution's custom Amazon SNS topic: \texttt{CRRMonitorMetricsTopic}. For detailed instructions, see \texttt{Subscribe to a Topic in the Amazon SNS Developer Guide}. 
Security

When you build systems on AWS infrastructure, security responsibilities are shared between you and AWS. This shared model can reduce your operational burden as AWS operates, manages, and controls the components from the host operating system and virtualization layer down to the physical security of the facilities in which the services operate. For more information about security on AWS, visit the AWS Security Center.
Additional Resources

AWS services documentation

- Amazon S3 Cross-Region Replication
- Amazon SQS
- AWS CloudTrail
- Amazon CloudWatch
- AWS CloudFormation
- AWS Lambda
- Amazon Dynamic DynamoDB
- Amazon S3
- Amazon SNS
- Amazon Athena
Appendix: Collection of Operational Metrics

This solution includes an option to send anonymous operational metrics to AWS. We use this data to better understand how customers use this solution to improve the services and products that we offer. When enabled, the following information is collected and sent to AWS each time the CRRMonitor Lambda function runs:

- **Solution ID**: The AWS solution identifier
- **Unique ID (UUID)**: Randomly generated, unique identifier for each CRR Monitor deployment
- **Number of Messages**: The total number of messages processed by CRR Monitor; an object that is put in a source bucket generates one message and for each replication of that object in a destination bucket, another message is processed

Note that AWS will own the data gathered via this survey. Data collection will be subject to the [AWS Privacy Policy](#). To opt out of this feature, modify the AWS CloudFormation template mapping section as follows:

```json
"Send" : {
  "AnonymousUsage" : { "Data" : "Yes" }
},
```
to

```json
"Send" : {
  "AnonymousUsage" : { "Data" : "No" }
},
```
Source Code

Visit our GitHub repository to download the templates and scripts for this solution, and to share your customizations with others.
Document Revisions

<table>
<thead>
<tr>
<th>Date</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 2017</td>
<td>Initial release</td>
</tr>
<tr>
<td>June 2019</td>
<td>Added a secondary template for cross-region replication across multiple accounts</td>
</tr>
<tr>
<td>March 2020</td>
<td>Changed from using the requests module provided by botocore to urllib. Updated runtime for Lambda functions to Python 3.8</td>
</tr>
</tbody>
</table>

Notices

This document is provided for informational purposes only. It represents current AWS product offerings and practices as of the date of issue of this document, which are subject to change without notice. Customers are responsible for making their own independent assessment of the information in this document and any use of AWS products or services, each of which is provided “as is” without warranty of any kind, whether express or implied. This document does not create any warranties, representations, contractual commitments, conditions or assurances from AWS, its affiliates, suppliers or licensors. The responsibilities and liabilities of AWS to its customers are controlled by AWS agreements, and this document is not part of, nor does it modify, any agreement between AWS and its customers.

The Cross-Region Replication Monitor solution is licensed under the terms of the Apache License Version 2.0 available at https://www.apache.org/licenses/LICENSE-2.0