Red Hat Data Grid 8.0

Setting Up Cross-Site Replication

Data Grid Documentation

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Data Grid Documentation

Abstract

Replicate data between multiple Data Grid clusters.

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CHAPTER 1. RED HAT DATA GRID

Data Grid is a high-performance, distributed in-memory data store.

Schemaless data structure

Flexibility to store different objects as key-value pairs.

Grid-based data storage

Designed to distribute and replicate data across clusters.

Elastic scaling

Dynamically adjust the number of nodes to meet demand without service disruption.

Data interoperability

Store, retrieve, and query data in the grid from different endpoints.

1.1. DATA GRID DOCUMENTATION

Documentation for Data Grid is available on the Red Hat customer portal.

- Data Grid 8.0 Documentation
- Data Grid 8.0 Component Details
- Supported Configurations for Data Grid 8.0

1.2. DATA GRID DOWNLOADS

Access the Data Grid Software Downloads on the Red Hat customer portal.

NOTE

You must have a Red Hat account to access and download Data Grid software.

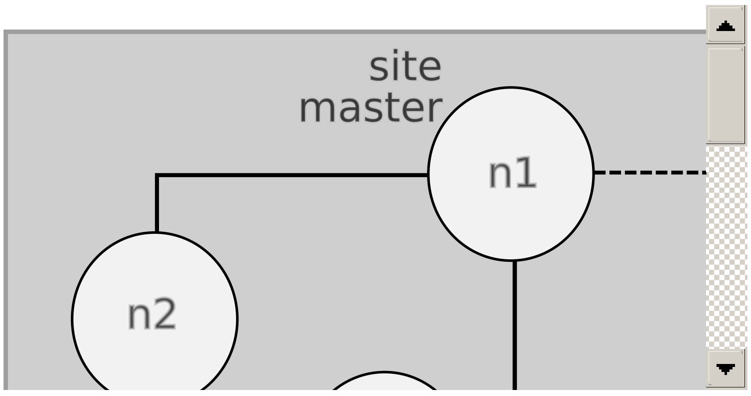
CHAPTER 2. DATA GRID CROSS-SITE REPLICATION

Cross-site replication allows you to back up data from one Data Grid cluster to another.

2.1. CROSS-SITE REPLICATION

Data Grid clusters running in different locations can discover and communicate with each other.

A site is a locally running Data Grid cluster. For demonstration purposes, this documentation illustrates sites as data centers in different geographic locations, as in the following diagram:



LON is a datacenter in London, England.
NYC is a datacenter in New York City, USA.

NOTE

Data Grid can form global clusters across two or more sites.

For example, configure a third Data Grid cluster running in San Francisco, **SFO**, as backup location for **LON** and **NYC**.

2.1.1. Site Masters

Site masters are the nodes in Data Grid clusters that are responsible for sending and receiving requests from backup locations.

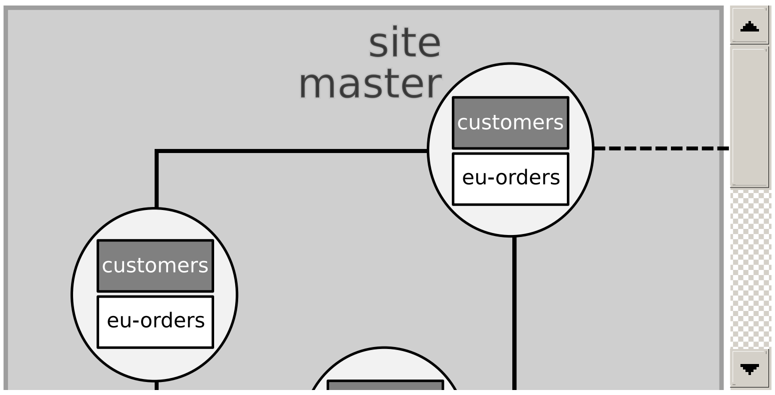
If a node is not a site master, it must forward backup requests to a local site master. Only site masters can send requests to backup locations.

For optimal performance, you should configure all nodes as site masters. This increases the speed of backup requests because each node in the cluster can backup to remote sites directly without having to forward backup requests to site masters.

2.2. ADDING BACKUPS TO CACHES

Name remote sites as backup locations in your cache definitions.

For example, the following diagram shows three caches, "customers", "eu-orders", and "us-orders":



- In **LON**, "customers" names **NYC** as a backup location.
- In **NYC**, "customers" names **LON** as a backup location.
- "eu-orders" and "us-orders" do not have backups and are local to the respective cluster.

2.3. BACKUP STRATEGIES

Data Grid clusters can use different strategies for backing up data to remote sites.

Data Grid replicates across sites at the same time that writes to local caches occur. For example, if a client writes "k1" to **LON**, Data Grid backs up "k1" to **NYC** at the same time.

2.3.1. Synchronous Backups

When Data Grid replicates data to backup locations, it waits until the operation completes before writing to the local cache.

You can control how Data Grid handles writes to the local cache if backup operations fail. For example, you can configure Data Grid to attempt to abort local writes and throw exceptions if backups to remote sites fail.

Synchronous backups also support two-phase commits with caches that participate in optimistic transactions. The first phase of the backup acquires a lock. The second phase commits the modification.

IMPORTANT

Two-phase commit with cross-site replication has a significant performance impact because it requires two round-trips across the network.

2.3.2. Asynchronous Backups

When Data Grid replicates data to backup locations, it does not wait until the operation completes before writing to the local cache.

Asynchronous backup operations and writes to the local cache are independent of each other. If backup operations fail, write operations to the local cache continue and no exceptions occur.

2.3.3. Synchronous vs Asynchronous Backups

Synchronous backups offer the strongest guarantee of data consistency across sites. If **strategy=sync**, when **cache.put()** calls return you know the value is up to date in the local cache and in the backup locations.

The trade-off for this consistency is performance. Synchronous backups have much greater latency in comparison to asynchronous backups.

Asynchronous backups, on the other hand, do not add latency to client requests so they have no performance impact. However, if **strategy=async**, when **cache.put()** calls return you cannot be sure of the value in the backup locations is the same as in the local cache.

2.4. TAKING SITES OFFLINE AUTOMATICALLY

Backup configurations include timeout values for operations to replicate data to remote sites. When backup operations reach the timeout, Data Grid records the operation as a failure.

To automatically take sites offline, you can then configure the number of **consecutive** failures that can occur.

For example, the **NYC** backup configuration specifies five as the number of failures after which **NYC** goes offline. If **LON** attempts five consecutive backup operations that fail, Data Grid automatically takes **NYC** offline. **LON** then stops backing up to **NYC** until you bring the site back online.

```
<backup site="NYC" strategy="ASYNC">
 <take-offline after-failures="5"/>
</backup>
```

You can also specify the amount of time to wait before taking sites offline. When backup operations fail, Data Grid waits before taking sites offline. If a backup request succeeds before the wait time runs out, Data Grid does not take the site offline.

```
<backup site="NYC" strategy="ASYNC">
 <take-offline after-failures="5"
               min-wait="10000"/>
</backup>
```

In the preceding example, if failures occur for 5 consecutive operations, Data Grid waits 10 seconds and, if no requests are successful within the 10 second wait time, Data Grid then takes **NYC** offline.

To use only a minimum wait time for automatically taking locations offline, set a negative or zero value for the **after-failures** attribute; for example:

```
<backup site="NYC" strategy="ASYNC">
 <take-offline after-failures="-1"
               min-wait="10000"/>
</backup>
```

TIP

You can manually take sites offline through the Data Grid command line interface or REST API.

Reference

Performing Cross-Site Replication Operations with the CLI or REST API

2.5. STATE TRANSFER

State transfer is an administrative operation that synchronizes data between sites.

For example, **LON** goes offline and **NYC** starts handling client requests. When you bring **LON** back online, the Data Grid cluster in **LON** does not have the same data as the cluster in **NYC**.

To ensure the data is consistent between **LON** and **NYC**, you can push state from **NYC** to **LON**.

- State transfer is bidirectional. For example, you can push state from **NYC** to **LON** or from **LON** to **NYC**.
- Pushing state to offline sites brings them back online.
- State transfer overwrites only data that exists on both sites, the originating site and the receiving site. Data Grid does not delete data.
  For example, "k2" exists on **LON** and **NYC**. "k2" is removed from **NYC** while **LON** is offline. When you bring **LON** back online, "k2" still exists at that location. If you push state from **NYC** to **LON**, the transfer does not affect "k2" on **LON**.

  TIP

  To ensure contents of the cache are identical after state transfer, remove all data from the cache on the receiving site before pushing state. Use the **clear()** method.

- State transfer does not overwrite updates to data that occur after you initiate the push.
  For example, "k1,v1" exists on **LON** and **NYC**. **LON** goes offline so you push state transfer to **LON** from **NYC**, which brings **LON** back online. Before state transfer completes, a client puts "k1,v2" on **LON**.

  In this case the state transfer from **NYC** does not overwrite "k1,v2" because that modification happened after you initiated the push.

Reference

- org.infinispan.Cache.clear()
- Clearing Caches with the CLI

  TIP

  Run **help clearcache** from the CLI for command details and examples.

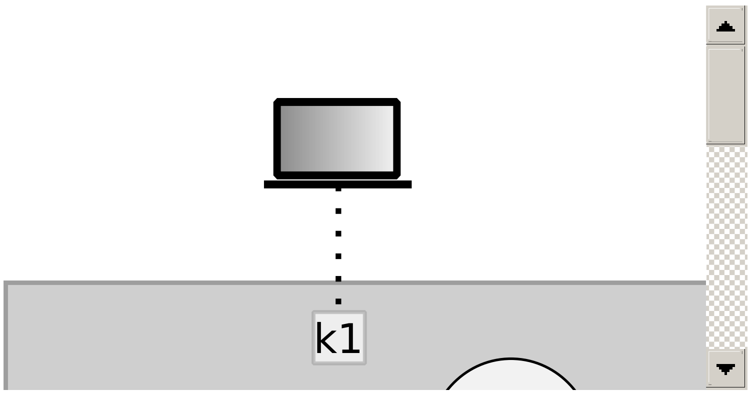
- Clearing Caches with the REST API

2.6. CLIENT CONNECTIONS ACROSS SITES

Clients can write to Data Grid clusters in either an Active/Passive or Active/Active configuration.

Active/Passive

The following diagram illustrates Active/Passive where Data Grid handles client requests from one site only:



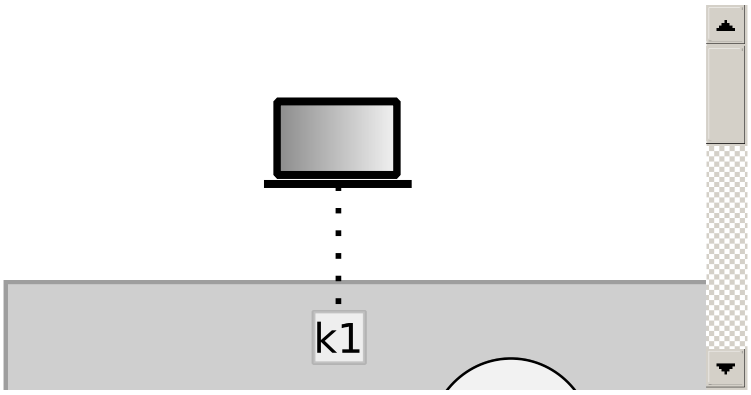
In the preceding image:

1. Client connects to the Data Grid cluster at **LON**.
2. Client writes "k1" to the cache.
3. The site master at **LON**, "n1", sends the request to replicate "k1" to the site master at **NYC**, "nA".

With Active/Passive, **NYC** provides data redundancy. If the Data Grid cluster at **LON** goes offline for any reason, clients can start sending requests to **NYC**. When you bring **LON** back online you can synchronize data with **NYC** and then switch clients back to **LON**.

Active/Active

The following diagram illustrates Active/Active where Data Grid handles client requests at two sites:



In the preceding image:

1. Client A connects to the Data Grid cluster at **LON**.
2. Client A writes "k1" to the cache.
3. Client B connects to the Data Grid cluster at **NYC**.
4. Client B writes "k2" to the cache.
5. Site masters at **LON** and **NYC** send requests so that "k1" is replicated to **NYC** and "k2" is replicated to **LON**.

With Active/Active both **NYC** and **LON** replicate data to remote caches while handling client requests. If either **NYC** or **LON** go offline, clients can start sending requests to the online site. You can then bring offline sites back online, push state to synchronize data, and switch clients as required.

2.6.1. Conflicting Entries with Cross-Site Replication

Conflicting entries can occur with Active/Active site configurations if clients write to the same entries at the same time but at different sites.

For example, client A writes to "k1" in **LON** at the same time that client B writes to "k1" in **NYC**. In this case, "k1" has a different value in **LON** than in **NYC**.

With synchronous replication, concurrent writes result in deadlocks because both sites lock the same key in different orders. To resolve deadlocks, client applications must wait until the locks time out.

With asynchronous replication, concurrent writes result in conflicting values because sites replicate after entries are modified locally. After replication occurs, there is no guarantee which value for "k1" exists at which site.

- Keys have conflicting values.
- One of the conflicting values is overwritten if sites do not replicate values at the same time. In this case, one of the values is lost and there is no guarantee which value is saved.

In all cases, inconsistencies in key values are resolved after the next non-conflicting **put()** operation updates the value.

NOTE

There currently is no conflict resolution policy that client applications can use to handle conflicts in asynchronous mode. However, conflict resolution techniques are planned for a future Data Grid version.

2.7. EXPIRATION AND CROSS-SITE REPLICATION

Data Grid expiration controls how long entries remain in the cache.

- **lifespan** expiration is suitable for cross-site replication. When entries reach the maximum lifespan, Data Grid expires them independently of the remote sites.
- **max-idle** expiration does not work with cross-site replication. Data Grid cannot determine when cache entries reach the idle timeout in remote sites.

CHAPTER 3. CONFIGURING DATA GRID FOR CROSS-SITE REPLICATION

Configuring Data Grid to replicate data across sites, you first set up cluster transport so Data Grid clusters can discover each other and site masters can communicate. You then add backup locations to cache definitions in your Data Grid configuration.

3.1. CONFIGURING CLUSTER TRANSPORT FOR CROSS-SITE REPLICATION

Add JGroups RELAY2 to your transport layer so that Data Grid clusters can communicate with backup locations.

Procedure

1. Open **infinispan.xml** for editing.
2. Add the RELAY2 protocol to a JGroups stack, for example:

```
<jgroups>
  <stack name="xsite" extends="udp">
    <relay.RELAY2 site="LON" xmlns="urn:org:jgroups" max_site_masters="1000"/>
    <remote-sites default-stack="tcp">
      <remote-site name="LON"/>
      <remote-site name="NYC"/>
    </remote-sites>
  </stack>
</jgroups>
```

3. Configure Data Grid cluster transport to use the stack, as in the following example:

```
<cache-container name="default" statistics="true">
  <transport cluster="${cluster.name}" stack="xsite"/>
</cache-container>
```

4. Save and close **infinispan.xml**.

Reference

- JGroups RELAY2 Stacks
- Data Grid Configuration Schema

3.1.1. JGroups RELAY2 Stacks

Data Grid clusters use JGroups RELAY2 for inter-cluster discovery and communication.

```
<jgroups>
  <stack name="xsite" (1)
       extends="udp"> (2)
    <relay.RELAY2 xmlns="urn:org:jgroups" (3)
              site="LON" (4)
```

```
                max_site_masters="1000"/> (5)
    <remote-sites default-stack="tcp"> (6)
      <remote-site name="LON"/> (7)
      <remote-site name="NYC"/>
    </remote-sites>
  </stack>
</jgroups>
```

1. Defines a stack named "xsite" that declares which protocols to use for your Data Grid cluster transport.
2. Uses the default JGroups UDP stack for intra-cluster traffic.
3. Adds **RELAY2** to the stack for inter-cluster transport.
4. Names the local site. Data Grid replicates data in caches from this site to backup locations.
5. Configures a maximum of 1000 site masters for the local cluster. You should set **max_site_masters** >= the number of nodes in the Data Grid cluster for optimal performance with backup requests.
6. Specifies all site names and uses the default JGroups TCP stack for inter-cluster transport.
7. Names each remote site as a backup location.

3.1.2. Custom JGroups RELAY2 Stacks

```
<jgroups>
  <stack-file name="relay-global" path="jgroups-relay.xml"/> (1)
  <stack name="xsite" extends="udp">
    <relay.RELAY2 site="LON" xmlns="urn:org:jgroups"
                max_site_masters="10" (2)
                can_become_site_master="true"/>
    <remote-sites default-stack="relay-global">
      <remote-site name="LON"/>
      <remote-site name="NYC"/>
    </remote-sites>
  </stack>
</jgroups>
```

1. Adds a custom RELAY2 stack defined in **jgroups-relay.xml**.
2. Sets the maximum number of site masters and optionally specifies additional RELAY2 properties. See JGroups RELAY2 documentation.

Example jgroups-relay.xml

```
<config xmlns="urn:org:jgroups"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:org:jgroups http://www.jgroups.org/schema/jgroups-4.1.xsd">

   <!-- Use TCP for inter-cluster transport. -->
   <TCP bind_addr="127.0.0.1"
```

```
         bind_port="7200"
         port_range="30"

         thread_pool.min_threads="0"
         thread_pool.max_threads="8"
         thread_pool.keep_alive_time="5000"
    />

    <!-- Use TCPPING for inter-cluster discovery. -->
    <TCPPING timeout="3000"
             initial_hosts="127.0.0.1[7200]"
             port_range="3"
             ergonomics="false"/>

    <!-- Provide other configuration as required. -->
</config>
```

Reference

- Cluster Transport Configuration
- JGroups RELAY2
- Relaying between multiple sites (RELAY2)

3.2. ADDING BACKUP LOCATIONS TO CACHES

Specify the names of remote sites so Data Grid can back up data to those locations.

Procedure

1. Add the **backups** element to your cache definition.
2. Specify the name of each remote site with the **backup** element.
   As an example, in the **LON** configuration, specify **NYC** as the remote site.
3. Repeat the preceding steps so that each site is a backup for all other sites. For example, you cannot add **LON** as a backup for **NYC** without adding **NYC** as a backup for **LON**.

NOTE

Cache configurations can be different across sites and use different backup strategies. Data Grid replicates data based on cache names.

Example "customers" configuration in LON

```
<replicated-cache name="customers">
  <backups>
    <backup site="NYC" strategy="ASYNC" />
  </backups>
</replicated-cache>
```

Example "customers" configuration in NYC

```
<distributed-cache name="customers">
  <backups>
    <backup site="LON" strategy="SYNC" />
  </backups>
</replicated-cache>
```

Reference

- Data Grid Configuration Schema

3.3. BACKING UP TO CACHES WITH DIFFERENT NAMES

By default, Data Grid replicates data between caches that have the same name.

Procedure

- Use **backup-for** to replicate data from a remote site into a cache with a different name on the local site.

For example, the following configuration backs up the "customers" cache on **LON** to the "eu-customers" cache on **NYC**.

```
<distributed-cache name="eu-customers">
  <backups>
    <backup site="LON" strategy="SYNC" />
  </backups>
  <backup-for remote-cache="customers" remote-site="LON" />
</replicated-cache>
```

3.4. VERIFYING CROSS-SITE VIEWS

After you configure Data Grid for cross-site replication, you should verify that Data Grid clusters successfully form cross-site views.

Procedure

- Check log messages for **ISPN000439: Received new x-site view** messages.

For example, if the Data Grid cluster in **LON** has formed a cross-site view with the Data Grid cluster in **NYC**, it provides the following messages:

```
INFO  [org.infinispan.XSITE] (jgroups-5,${server.hostname}) ISPN000439: Received new x-site view:
[NYC]
INFO  [org.infinispan.XSITE] (jgroups-7,${server.hostname}) ISPN000439: Received new x-site view:
[NYC, LON]
```

3.5. CONFIGURING HOT ROD CLIENTS FOR CROSS-SITE REPLICATION

Configure Hot Rod clients to use Data Grid clusters at different sites.

hotrod-client.properties

```
# Servers at the active site
infinispan.client.hotrod.server_list = LON_host1:11222,LON_host2:11222,LON_host3:11222

# Servers at the backup site
infinispan.client.hotrod.cluster.NYC =
NYC_hostA:11222,NYC_hostB:11222,NYC_hostC:11222,NYC_hostD:11222
```

ConfigurationBuilder

```
ConfigurationBuilder builder = new ConfigurationBuilder();
builder.addServers("LON_host1:11222;LON_host2:11222;LON_host3:11222")
       .addCluster("NYC")

.addClusterNodes("NYC_hostA:11222;NYC_hostB:11222;NYC_hostC:11222;NYC_hostD:11222")
```

TIP

Use the following methods to switch Hot Rod clients to the default cluster or to a cluster at a different site:

- **RemoteCacheManager.switchToDefaultCluster()**
- **RemoteCacheManager.switchToCluster(${site.name})**

Reference

- org.infinispan.client.hotrod.configuration package description
- org.infinispan.client.hotrod.configuration.ConfigurationBuilder
- org.infinispan.client.hotrod.RemoteCacheManager

CHAPTER 4. PERFORMING CROSS-SITE REPLICATION OPERATIONS

Bring sites online and offline. Transfer cache state to remote sites.

4.1. CROSS-SITE OPERATIONS WITH THE CLI

The Data Grid command line interface lets you remotely connect to Data Grid servers, manage sites, and push state transfer to backup locations.

Prerequisites

- Start the Data Grid CLI.
- Connect to a running Data Grid cluster.

4.1.1. Bringing Backup Locations Offline and Online

Take backup locations offline manually and bring them back online.

Procedure

- Check if backup locations are online or offline with the **site status** command:

```
//containers/default]> site status --cache=cacheName --site=NYC
```

NOTE

--site is an optional argument. If not set, the CLI returns all backup locations.

- Bring backup locations online with the **bring-online** command:

```
//containers/default]> site bring-online --cache=customers --site=NYC
```

- Take backup locations offline with the **take-offline** command:

```
//containers/default]> site take-offline --cache=customers --site=NYC
```

For more information and examples, run the **help site** command.

4.1.2. Pushing State to Backup Locations

Transfer cache state to remote backup locations.

Procedure

- Use the **site** command to push state transfer, as in the following example:

```
//containers/default]> site push-site-state --cache=cacheName --site=NYC
```

For more information and examples, run the **help site** command.

Reference

Data Grid Command Line Interface

4.2. CROSS-SITE OPERATIONS WITH THE REST API

Data Grid servers provide a REST API that allows you to perform cross-site operations.

4.2.1. Getting Status of All Backup Locations

Retrieve the status of all backup locations with **GET** requests.

```
GET /v2/caches/{cacheName}/x-site/backups/
```

Data Grid responds with the status of each backup location in JSON format, as in the following example:

```
{
  "NYC": "online",
  "LON": "offline"
}
```

Table 4.1. Returned Status

Value	Description
online	All nodes in the local cluster have a cross-site view with the backup location.
offline	No nodes in the local cluster have a cross-site view with the backup location.
mixed	Some nodes in the local cluster have a cross-site view with the backup location, other nodes in the local cluster do not have a cross-site view. The response indicates status for each node.

4.2.2. Getting Status of Specific Backup Locations

Retrieve the status of a backup location with **GET** requests.

```
GET /v2/caches/{cacheName}/x-site/backups/{siteName}
```

Data Grid responds with the status of each node in the site in JSON format, as in the following example:

```
{
  "NodeA":"offline",
  "NodeB":"online"
}
```

Table 4.2. Returned Status

Value	Description
online	The node is online.
offline	The node is offline.
failed	Not possible to retrieve status. The remote cache could be shutting down or a network error occurred during the request.

4.2.3. Taking Backup Locations Offline

Take backup locations offline with **GET** requests and the **?action=take-offline** parameter.

```
GET /v2/caches/{cacheName}/x-site/backups/{siteName}?action=take-offline
```

4.2.4. Bringing Backup Locations Online

Bring backup locations online with the **?action=bring-online** parameter.

```
GET /v2/caches/{cacheName}/x-site/backups/{siteName}?action=bring-online
```

4.2.5. Pushing State to Backup Locations

Push cache state to a backup location with the **?action=start-push-state** parameter.

```
GET /v2/caches/{cacheName}/x-site/backups/{siteName}?action=start-push-state
```

4.2.6. Canceling State Transfer

Cancel state transfer operations with the **?action=cancel-push-state** parameter.

```
GET /v2/caches/{cacheName}/x-site/backups/{siteName}?action=cancel-push-state
```

4.2.7. Getting State Transfer Status

Retrieve status of state transfer operations with the **?action=push-state-status** parameter.

```
GET /v2/caches/{cacheName}/x-site/backups?action=push-state-status
```

Data Grid responds with the status of state transfer for each backup location in JSON format, as in the following example:

```
{
  "NYC":"CANCELED",
  "LON":"OK"
}
```

Table 4.3. Returned Status

Value	Description
SENDING	State transfer to the backup location is in progress.
OK	State transfer completed successfully.
ERROR	An error occurred with state transfer. Check log files.
CANCELLING	State transfer cancellation is in progress.

4.2.8. Clearing State Transfer Status

Clear state transfer status for sending sites with the **?action=clear-push-state-status** parameter.

```
GET /v2/caches/{cacheName}/x-site/local?action=clear-push-state-status
```

4.2.9. Modifying Take Offline Conditions

Sites go offline if certain conditions are met. Modify the take offline parameters to control when backup locations automatically go offline.

Procedure

1. Check configured take offline parameters with **GET** requests and the **take-offline-config** parameter.

   ```
   GET /v2/caches/{cacheName}/x-site/backups/{siteName}/take-offline-config
   ```

   The Data Grid response includes **after_failures** and **min_wait** fields as follows:

   ```
   {
     "after_failures": 2,
     "min_wait": 1000
   }
   ```

2. Modify take offline parameters in the body of **PUT** requests.

   ```
   PUT /v2/caches/{cacheName}/x-site/backups/{siteName}/take-offline-config
   ```

4.2.10. Canceling State Transfer from Receiving Sites

If the connection between two backup locations breaks, you can cancel state transfer on the site that is receiving the push.

Cancel state transfer from a remote site and keep the current state of the local cache with the **?action=cancel-receive-state** parameter.

```
GET /v2/caches/{cacheName}/x-site/backups/{siteName}?action=cancel-receive-state
```

4.2.11. Getting Status of Backup Locations

Retrieve the status of all backup locations from Cache Managers with **GET** requests.

```
GET /rest/v2/cache-managers/{cacheManagerName}/x-site/backups/
```

Data Grid responds with status in JSON format, as in the following example:

```
{
  "SFO-3":{
    "status":"online"
  },
  "NYC-2":{
    "status":"mixed",
    "online":[
      "CACHE_1"
    ],
    "offline":[
      "CACHE_2"
    ]
  }
}
```

Table 4.4. Returned Status

Value	Description
online	All nodes in the local cluster have a cross-site view with the backup location.
offline	No nodes in the local cluster have a cross-site view with the backup location.
mixed	Some nodes in the local cluster have a cross-site view with the backup location, other nodes in the local cluster do not have a cross-site view. The response indicates status for each node.

4.2.12. Taking Backup Locations Offline

Take backup locations offline with the **?action=take-offline** parameter.

```
GET /rest/v2/cache-managers/{cacheManagerName}/x-site/backups/{siteName}?action=take-offline
```

4.2.13. Bringing Backup Locations Online

Bring backup locations online with the **?action=bring-online** parameter.

```
GET /rest/v2/cache-managers/{cacheManagerName}/x-site/backups/{siteName}?action=bring-online
```

4.2.14. Starting State Transfer

Push state of all caches to remote sites with the **?action=start-push-state** parameter.

```
GET /rest/v2/cache-managers/{cacheManagerName}/x-site/backups/{siteName}?action=start-push-
state
```

4.2.15. Canceling State Transfer

Cancel ongoing state transfer operations with the **?action=cancel-push-state** parameter.

```
GET /rest/v2/cache-managers/{cacheManagerName}/x-site/backups/{siteName}?action=cancel-push-
state
```