Abstract

This guide consists of information to install and configure Red Hat Single Sign-On 7.5
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MAKING OPEN SOURCE MORE INCLUSIVE

Red Hat is committed to replacing problematic language in our code, documentation, and web properties. We are beginning with these four terms: master, slave, blacklist, and whitelist. Because of the enormity of this endeavor, these changes will be implemented gradually over several upcoming releases. For more details, see our CTO Chris Wright’s message.
CHAPTER 1. GUIDE OVERVIEW

The purpose of this guide is to walk through the steps that need to be completed prior to booting up the Red Hat Single Sign-On server for the first time. If you just want to test drive Red Hat Single Sign-On, it pretty much runs out of the box with its own embedded and local-only database. For actual deployments that are going to be run in production you’ll need to decide how you want to manage server configuration at runtime (standalone or domain mode), configure a shared database for Red Hat Single Sign-On storage, set up encryption and HTTPS, and finally set up Red Hat Single Sign-On to run in a cluster. This guide walks through each and every aspect of any pre-boot decisions and setup you must do prior to deploying the server.

One thing to particularly note is that Red Hat Single Sign-On is derived from the JBoss EAP Application Server. Many aspects of configuring Red Hat Single Sign-On revolve around JBoss EAP configuration elements. Often this guide will direct you to documentation outside of the manual if you want to dive into more detail.

1.1. RECOMMENDED ADDITIONAL EXTERNAL DOCUMENTATION

Red Hat Single Sign-On is built on top of the JBoss EAP application server and its sub-projects like Infinispan (for caching) and Hibernate (for persistence). This guide only covers basics for infrastructure-level configuration. It is highly recommended that you peruse the documentation for JBoss EAP and its sub projects. Here is the link to the documentation:

- [JBoss EAP Configuration Guide](#)
You can install Red Hat Single Sign-On by downloading a ZIP file and unzipping it, or by using an RPM. This chapter reviews system requirements as well as the directory structure.

### 2.1. SYSTEM REQUIREMENTS

These are the requirements to run the Red Hat Single Sign-On authentication server:

- Can run on any operating system that runs Java
- Java 8 JDK
- zip or gzip and tar
- At least 512M of RAM
- At least 1G of disk space
- A shared external database like PostgreSQL, MySQL, Oracle, etc. Red Hat Single Sign-On requires an external shared database if you want to run in a cluster. Please see the database configuration section of this guide for more information.
- Network multicast support on your machine if you want to run in a cluster. Red Hat Single Sign-On can be clustered without multicast, but this requires a bunch of configuration changes. Please see the clustering section of this guide for more information.
- On Linux, it is recommended to use `/dev/urandom` as a source of random data to prevent Red Hat Single Sign-On hanging due to lack of available entropy, unless `/dev/random` usage is mandated by your security policy. To achieve that on Oracle JDK 8 and OpenJDK 8, set the `java.security.egd` system property on startup to `file:/dev/urandom`.

### 2.2. INSTALLING RH-SSO FROM A ZIP FILE

The Red Hat Single Sign-On server download ZIP file contains the scripts and binaries to run the Red Hat Single Sign-On server. You install the 7.5 server first, then the 7.5.1 server patch.

**Procedure**

1. Go to the Red Hat customer portal.
2. Download the Red Hat Single Sign-On 7.5 server.
3. Unpack the ZIP file using the appropriate `unzip` utility, such as unzip, tar, or Expand-Archive.
4. Return to the Red Hat customer portal.
5. Click the Patches tab.
6. Download the Red Hat Single Sign-On 7.5.1 server patch.
7. Place the downloaded file in a directory you choose.
8. Go to the `bin` directory of JBoss EAP.
9. Start the JBoss EAP command line interface.
Linux/Unix

$ jboss-cli.sh

Windows

> jboss-cli.bat

10. Apply the patch.

$ patch apply <path-to-zip>/rh-sso-7.5.1-patch.zip

Additional resources

For more details on applying patches, see Patching a ZIP/Installer Installation.

2.3. INSTALLING RH-SSO FROM AN RPM

NOTE

With Red Hat Enterprise Linux 7 and 8, the term channel was replaced with the term repository. In these instructions only the term repository is used.

You must subscribe to both the JBoss EAP 7.4 and RH-SSO 7.5 repositories before you can install RH-SSO from an RPM.

NOTE

You cannot continue to receive upgrades to EAP RPMs but stop receiving updates for RH-SSO.

2.3.1. Subscribing to the JBoss EAP 7.4 Repository

Prerequisites

1. Ensure that your Red Hat Enterprise Linux system is registered to your account using Red Hat Subscription Manager. For more information see the Red Hat Subscription Management documentation.

2. If you are already subscribed to another JBoss EAP repository, you must unsubscribe from that repository first.

For Red Hat Enterprise Linux 6, 7: Using Red Hat Subscription Manager, subscribe to the JBoss EAP 7.4 repository using the following command. Replace <RHEL_VERSION> with either 6 or 7 depending on your Red Hat Enterprise Linux version.

subscription-manager repos --enable=jb-eap-7.4-for-rhel-<RHEL_VERSION>-server-rpms --enable=rhel-<RHEL_VERSION>-server-rpms

For Red Hat Enterprise Linux 8: Using Red Hat Subscription Manager, subscribe to the JBoss EAP 7.4 repository using the following command:
2.3.2. Subscribing to the RH-SSO 7.5 Repository and Installing RH-SSO 7.5

Prerequisites

1. Ensure that your Red Hat Enterprise Linux system is registered to your account using Red Hat Subscription Manager. For more information see the Red Hat Subscription Management documentation.

2. Ensure that you have already subscribed to the JBoss EAP 7.4 repository. For more information see Subscribing to the JBoss EAP 7.4 repository.

To subscribe to the RH-SSO 7.5 repository and install RH-SSO 7.5, complete the following steps:

1. For Red Hat Enterprise Linux 6, 7: Using Red Hat Subscription Manager, subscribe to the RH-SSO 7.5 repository using the following command. Replace <RHEL_VERSION> with either 6 or 7 depending on your Red Hat Enterprise Linux version.

   ```
   subscription-manager repos --enable=jb-eap-7.4-for-rhel-8-x86_64-rpms --enable=rhel-8-for-x86_64-baseos-rpms --enable=rhel-8-for-x86_64-appstream-rpms
   ```

2. For Red Hat Enterprise Linux 8: Using Red Hat Subscription Manager, subscribe to the RH-SSO 7.5 repository using the following command:

   ```
   subscription-manager repos --enable=rh-sso-7.5-for-rhel-<RHEL-VERSION>-server-rpms
   ```

3. For Red Hat Enterprise Linux 6, 7: Install RH-SSO from your subscribed RH-SSO 7.5 repository using the following command:

   ```
   yum groupinstall rh-sso7
   ```

4. For Red Hat Enterprise Linux 8: Install RH-SSO from your subscribed RH-SSO 7.5 repository using the following command:

   ```
   dnf groupinstall rh-sso7
   ```

Your installation is complete. The default RH-SSO_HOME path for the RPM installation is /opt/rh/rh-sso7/root/usr/share/keycloak.

Additional resources

For details on installing the 7.5.1 patch for Red Hat Single Sign-On, see RPM patching.

2.4. DISTRIBUTION DIRECTORY STRUCTURE

This chapter walks you through the directory structure of the server distribution.

Let’s examine the purpose of some of the directories:

**bin/**

This contains various scripts to either boot the server or perform some other management action on the server.
domain/
This contains configuration files and working directory when running Red Hat Single Sign-On in domain mode.

modules/
These are all the Java libraries used by the server.

standalone/
This contains configuration files and working directory when running Red Hat Single Sign-On in standalone mode.

standalone/deployments/
If you are writing extensions to Red Hat Single Sign-On, you can put your extensions here. See the Server Developer Guide for more information on this.

themes/
This directory contains all the html, style sheets, JavaScript files, and images used to display any UI screen displayed by the server. Here you can modify an existing theme or create your own. See the Server Developer Guide for more information on this.
CHAPTER 3. CHOOSING AN OPERATING MODE

Before deploying Red Hat Single Sign-On in a production environment you need to decide which type of operating mode you are going to use. Will you run Red Hat Single Sign-On within a cluster? Do you want a centralized way to manage your server configurations? Your choice of operating mode affects how you configure databases, configure caching and even how you boot the server.

**TIP**

The Red Hat Single Sign-On is built on top of the JBoss EAP Application Server. This guide will only go over the basics for deployment within a specific mode. If you want specific information on this, a better place to go would be the [JBoss EAP Configuration Guide](#).

### 3.1. STANDALONE MODE

Standalone operating mode is only useful when you want to run one, and only one Red Hat Single Sign-On server instance. It is not usable for clustered deployments and all caches are non-distributed and local-only. It is not recommended that you use standalone mode in production as you will have a single point of failure. If your standalone mode server goes down, users will not be able to log in. This mode is really only useful to test drive and play with the features of Red Hat Single Sign-On

#### 3.1.1. Standalone Boot Script

When running the server in standalone mode, there is a specific script you need to run to boot the server depending on your operating system. These scripts live in the `bin/` directory of the server distribution.

**Standalone Boot Scripts**
To boot the server:

**Linux/Unix**

```
$ ../bin/standalone.sh
```

**Windows**

```
> ../\bin\standalone.bat
```

### 3.1.2. Standalone Configuration

The bulk of this guide walks you through how to configure infrastructure level aspects of Red Hat Single Sign-On. These aspects are configured in a configuration file that is specific to the application server that Red Hat Single Sign-On is a derivative of. In the standalone operation mode, this file lives in `../standalone/configuration/standalone.xml`. This file is also used to configure non-infrastructure level things that are specific to Red Hat Single Sign-On components.

**Standalone Config File**
WARNING

Any changes you make to this file while the server is running will not take effect and may even be overwritten by the server. Instead use the command line scripting or the web console of JBoss EAP. See the JBoss EAP Configuration Guide for more information.

3.2. STANDALONE CLUSTERED MODE

Standalone clustered operation mode is for when you want to run Red Hat Single Sign-On within a cluster. This mode requires that you have a copy of the Red Hat Single Sign-On distribution on each machine you want to run a server instance. This mode can be very easy to deploy initially, but can become quite cumbersome. To make a configuration change you’ll have to modify each distribution on each machine. For a large cluster this can become time consuming and error prone.

3.2.1. Standalone Clustered Configuration

The distribution has a mostly pre-configured app server configuration file for running within a cluster. It has all the specific infrastructure settings for networking, databases, caches, and discovery. This file resides in ...

```
../standalone/configuration/standalone-ha.xml
```

There’s a few things missing from this configuration. You can’t run Red Hat Single Sign-On in a cluster without configuring a shared database connection. You also need to deploy some type of load balancer in front of the cluster. The clustering and database sections of this guide walk you through these things.

Standalone HA Config
WARNING
Any changes you make to this file while the server is running will not take effect and may even be overwritten by the server. Instead use the command line scripting or the web console of JBoss EAP. See the JBoss EAP Configuration Guide for more information.

3.2.2. Standalone Clustered Boot Script

You use the same boot scripts to start Red Hat Single Sign-On as you do in standalone mode. The difference is that you pass in an additional flag to point to the HA config file.

Standalone Clustered Boot Scripts
To boot the server:

**Linux/Unix**

```shell
$ ...in/standalone.sh --server-config=standalone-ha.xml
```

**Windows**

```cmd
> ...in\standalone.bat --server-config=standalone-ha.xml
```

### 3.3. DOMAIN CLUSTERED MODE

Domain mode is a way to centrally manage and publish the configuration for your servers.

Running a cluster in standard mode can quickly become aggravating as the cluster grows in size. Every time you need to make a configuration change, you have to perform it on each node in the cluster. Domain mode solves this problem by providing a central place to store and publish configurations. It can be quite complex to set up, but it is worth it in the end. This capability is built into the JBoss EAP Application Server which Red Hat Single Sign-On derives from.

**NOTE**

The guide will go over the very basics of domain mode. Detailed steps on how to set up domain mode in a cluster should be obtained from the [JBoss EAP Configuration Guide](#).

Here are some of the basic concepts of running in domain mode.
domain controller

The domain controller is a process that is responsible for storing, managing, and publishing the general configuration for each node in the cluster. This process is the central point from which nodes in a cluster obtain their configuration.

host controller

The host controller is responsible for managing server instances on a specific machine. You configure it to run one or more server instances. The domain controller can also interact with the host controllers on each machine to manage the cluster. To reduce the number of running processes, a domain controller also acts as a host controller on the machine it runs on.

domain profile

A domain profile is a named set of configuration that can be used by a server to boot from. A domain controller can define multiple domain profiles that are consumed by different servers.

server group

A server group is a collection of servers. They are managed and configured as one. You can assign a domain profile to a server group and every service in that group will use that domain profile as their configuration.

In domain mode, a domain controller is started on a master node. The configuration for the cluster resides in the domain controller. Next a host controller is started on each machine in the cluster. Each host controller deployment configuration specifies how many Red Hat Single Sign-On server instances will be started on that machine. When the host controller boots up, it starts as many Red Hat Single Sign-On server instances as it was configured to do. These server instances pull their configuration from the domain controller.

NOTE

In some environments, such as Microsoft Azure, the domain mode is not applicable. Please consult the JBoss EAP documentation.

3.3.1. Domain Configuration

Various other chapters in this guide walk you through configuring various aspects like databases, HTTP network connections, caches, and other infrastructure related things. While standalone mode uses the standalone.xml file to configure these things, domain mode uses the .../domain/configuration/domain.xml configuration file. This is where the domain profile and server group for the Red Hat Single Sign-On server are defined.
WARNING

Any changes you make to this file while the domain controller is running will not take effect and may even be overwritten by the server. Instead use the command line scripting or the web console of JBoss EAP. See the JBoss EAP Configuration Guide for more information.

Let’s look at some aspects of this domain.xml file. The auth-server-standalone and auth-server-clustered profile XML blocks are where you are going to make the bulk of your configuration decisions. You’ll be configuring things here like network connections, caches, and database connections.

auth-server profile

```xml
<profiles>
  <profile name="auth-server-standalone">
    ...
  </profile>
  <profile name="auth-server-clustered">
    ...
  </profile>
</profiles>
```

The auth-server-standalone profile is a non-clustered setup. The auth-server-clustered profile is the clustered setup.

If you scroll down further, you’ll see various socket-binding-groups defined.
socket-binding-groups

This configuration defines the default port mappings for various connectors that are opened with each Red Hat Single Sign-On server instance. Any value that contains `${...}` is a value that can be overridden on the command line with the `-D` switch, i.e.

```
$ domain.sh -Djboss.http.port=80
```

The definition of the server group for Red Hat Single Sign-On resides in the `server-groups` XML block. It specifies the domain profile that is used (default) and also some default boot arguments for the Java VM when the host controller boots an instance. It also binds a `socket-binding-group` to the server group.

server group

```
<server-groups>
  <!-- load-balancer-group should be removed in production systems and replaced with a better software or hardware based one -->
  <server-group name="load-balancer-group" profile="load-balancer">
    <jvm name="default">
      <heap size="64m" max-size="512m"/>
    </jvm>
    <socket-binding-group ref="load-balancer-sockets"/>
  </server-group>
  <server-group name="auth-server-group" profile="auth-server-clustered">
    <jvm name="default">
      <heap size="64m" max-size="512m"/>
    </jvm>
    <socket-binding-group ref="ha-sockets"/>
  </server-group>
</server-groups>
```

3.3.2. Host Controller Configuration

Red Hat Single Sign-On comes with two host controller configuration files that reside in the.../domain/configuration/ directory: `host-master.xml` and `host-slave.xml`. `host-master.xml` is configured to boot up a domain controller, a load balancer, and one Red Hat Single Sign-On server instance. `host-slave.xml` is configured to talk to the domain controller and boot up one Red Hat Single Sign-On server instance.
NOTE

The load balancer is not a required service. It exists so that you can easily test drive clustering on your development machine. While usable in production, you have the option of replacing it if you have a different hardware or software based load balancer you want to use.

Host Controller Config

To disable the load balancer server instance, edit host-master.xml and comment out or remove the "load-balancer" entry.

```
<servers>
  <!-- remove or comment out next line -->
  <server name="load-balancer" group="loadbalancer-group"/>
  ...
</servers>
```

Another interesting thing to note about this file is the declaration of the authentication server instance. It has a port-offset setting. Any network port defined in the domain.xml socket-binding-group or the server group will have the value of port-offset added to it. For this example domain setup we do this so that ports opened by the load balancer server don’t conflict with the authentication server instance that is started.

```
<servers>
  ...
  <server name="server-one" group="auth-server-group" auto-start="true">
    <socket-bindings port-offset="150"/>
  </server>
</servers>
```
3.3.3. Server Instance Working Directories

Each Red Hat Single Sign-On server instance defined in your host files creates a working directory under 
.../domain/servers/{SERVER NAME}. Additional configuration can be put there, and any temporary, log, 
or data files the server instance needs or creates go there too. The structure of these per server 
directories ends up looking like any other JBoss EAP booted server.

Working Directories

![Diagram of working directories]

3.3.4. Domain Boot Script

When running the server in domain mode, there is a specific script you need to run to boot the server 
depending on your operating system. These scripts live in the bin/ directory of the server distribution.

Domain Boot Script

![Domain boot script]

Red Hat Single Sign-On 7.5 Server Installation and Configuration Guide
To boot the server:

**Linux/Unix**

```bash
$ .../bin/domain.sh --host-config=host-master.xml
```

**Windows**

```bat
> ...in\domain.bat --host-config=host-master.xml
```

When running the boot script you will need to pass in the host controlling configuration file you are going to use via the `--host-config` switch.

### 3.3.5. Clustered Domain Example

You can test drive clustering using the out-of-the-box `domain.xml` configuration. This example domain is meant to run on one machine and boots up:

- a domain controller
- an HTTP load balancer
- 2 Red Hat Single Sign-On server instances

To simulate running a cluster on two machines, you’ll need to run the `domain.sh` script twice to start two separate host controllers. The first will be the master host controller which will start a domain controller, an HTTP load balancer, and one Red Hat Single Sign-On authentication server instance. The second will be a slave host controller that only starts up an authentication server instance.
3.3.5.1. Setup Slave Connection to Domain Controller

Before you can boot things up though, you have to configure the slave host controller so that it can talk securely to the domain controller. If you do not do this, then the slave host will not be able to obtain the centralized configuration from the domain controller. To set up a secure connection, you have to create a server admin user and a secret that will be shared between the master and the slave. You do this by running the `./bin/add-user.sh` script.

When you run the script select Management User and answer yes when it asks you if the new user is going to be used for one AS process to connect to another. This will generate a secret that you’ll need to cut and paste into the `./domain/configuration/host-slave.xml` file.

Add App Server Admin

```bash
$ add-user.sh
What type of user do you wish to add?
  a) Management User (mgmt-users.properties)
  b) Application User (application-users.properties)
(a): a
Enter the details of the new user to add.
Using realm 'ManagementRealm' as discovered from the existing property files.
Username : admin
Password recommendations are listed below. To modify these restrictions edit the add-
user.properties configuration file.
- The password should not be one of the following restricted values {root, admin, administrator}
- The password should contain at least 8 characters, 1 alphabetic character(s), 1 digit(s), 1 non-
alphanumeric symbol(s)
- The password should be different from the username
Password :
Re-enter Password :
What groups do you want this user to belong to? (Please enter a comma separated list, or leave blank for none)[ ]:
About to add user 'admin' for realm 'ManagementRealm'
Is this correct yes/no? yes
Added user 'admin' to file '/.../standalone/configuration/mgmt-users.properties'
Added user 'admin' to file '/.../domain/configuration/mgmt-users.properties'
Added user 'admin' with groups to file '/.../standalone/configuration/mgmt-groups.properties'
Added user 'admin' with groups to file '/.../domain/configuration/mgmt-groups.properties'
Is this new user going to be used for one AS process to connect to another AS process?
e.g. for a slave host controller connecting to the master or for a Remoting connection for server to server EJB calls.
yes/no? yes
To represent the user add the following to the server-identities definition <secret
value="bWdtDDeyMyE=" />
```

**NOTE**

The add-user.sh does not add user to Red Hat Single Sign-On server but to the underlying JBoss Enterprise Application Platform. The credentials used and generated in the above script are only for example purpose. Please use the ones generated on your system.

Next, cut and paste the secret value into the `./domain/configuration/host-slave.xml` file as follows:

```xml
<management>
```
You will also need to add the username of the created user in the `/domain/configuration/host-slave.xml` file:

```xml
<remote security-realm="ManagementRealm" username="admin">
```

3.3.5.2. Run the Boot Scripts

Since we’re simulating a two node cluster on one development machine, you’ll run the boot script twice:

**Boot up master**

```
$ domain.sh --host-config=host-master.xml
```

**Boot up slave**

```
$ domain.sh --host-config=host-slave.xml
```

To try it out, open your browser and go to `http://localhost:8080/auth`.

### 3.4. CROSS-DATACENTER REPLICATION MODE

**NOTE**

Cross-Datacenter Replication Mode is Technology Preview and is not fully supported.

Cross-Datacenter Replication mode lets you run Red Hat Single Sign-On in a cluster across multiple data centers, most typically using data center sites that are in different geographic regions. When using this mode, each data center will have its own cluster of Red Hat Single Sign-On servers.

This documentation will refer to the following example architecture diagram to illustrate and describe a simple Cross-Datacenter Replication use case.

**Example Architecture Diagram**
3.4.1. Prerequisites

As this is an advanced topic, we recommend you first read the following, which provide valuable background knowledge:

- **Clustering with Red Hat Single Sign-On** When setting up for Cross-Datacenter Replication, you will use more independent Red Hat Single Sign-On clusters, so you must understand how a cluster works and the basic concepts and requirements such as load balancing, shared databases, and multicasting.

- **Red Hat Data Grid Cross-Datacenter Replication** Red Hat Single Sign-On uses Red Hat Data Grid (RHDG) for the replication of data between the data centers.

3.4.2. Technical details

This section provides an introduction to the concepts and details of how Red Hat Single Sign-On Cross-Datacenter Replication is accomplished.

**Data**

Red Hat Single Sign-On is stateful application. It uses the following as data sources:

- A database is used to persist permanent data, such as user information.

- An Infinispan cache is used to cache persistent data from the database and also to save some short-lived and frequently-changing metadata, such as for user sessions. Infinispan is usually much faster than a database, however the data saved using Infinispan are not permanent and is not expected to persist across cluster restarts.

In our example architecture, there are two data centers called **site1** and **site2**. For Cross-Datacenter Replication, we must make sure that both sources of data work reliably and that Red Hat Single Sign-On servers from **site1** are eventually able to read the data saved by Red Hat Single Sign-On servers on **site2**.

Based on the environment, you have the option to decide if you prefer:
• Reliability - which is typically used in Active/Active mode. Data written on site1 must be visible immediately on site2.

• Performance - which is typically used in Active/Passive mode. Data written on site1 does not need to be visible immediately on site2. In some cases, the data may not be visible on site2 at all.

For more details, see Section 3.4.4, “Modes”.

3.4.3. Request processing

An end user’s browser sends an HTTP request to the front end load balancer. This load balancer is usually HTTPD or WildFly with mod_cluster, NGINX, HA Proxy, or perhaps some other kind of software or hardware load balancer.

The load balancer then forwards the HTTP requests it receives to the underlying Red Hat Single Sign-On instances, which can be spread among multiple data centers. Load balancers typically offer support for sticky sessions, which means that the load balancer is able to always forward all HTTP requests from the same user to the same Red Hat Single Sign-On instance in the same data center.

HTTP requests that are sent from client applications to the load balancer are called backchannel requests. These are not seen by an end user’s browser and therefore can not be part of a sticky session between the user and the load balancer. For backchannel requests, the loadbalancer can forward the HTTP request to any Red Hat Single Sign-On instance in any data center. This is challenging as some OpenID Connect and some SAML flows require multiple HTTP requests from both the user and the application. Because we can not reliably depend on sticky sessions to force all the related requests to be sent to the same Red Hat Single Sign-On instance in the same data center, we must instead replicate some data across data centers, so the data are seen by subsequent HTTP requests during a particular flow.

3.4.4. Modes

According your requirements, there are two basic operating modes for Cross-Datacenter Replication:

• Active/Passive - Here the users and client applications send the requests just to the Red Hat Single Sign-On nodes in just a single data center. The second data center is used just as a backup for saving the data. In case of the failure in the main data center, the data can be usually restored from the second data center.

• Active/Active - Here the users and client applications send the requests to the Red Hat Single Sign-On nodes in both data centers. It means that data need to be visible immediately on both sites and available to be consumed immediately from Red Hat Single Sign-On servers on both sites. This is especially true if Red Hat Single Sign-On server writes some data on site1, and it is required that the data are available immediately for reading by Red Hat Single Sign-On servers on site2 immediately after the write on site1 is finished.

The active/passive mode is better for performance. For more information about how to configure caches for either mode, see: Section 3.4.15, “SYNC or ASYNC backups”.

3.4.5. Database

Red Hat Single Sign-On uses a relational database management system (RDBMS) to persist some metadata about realms, clients, users, and so on. See this chapter of the server installation guide for more details. In a Cross-Datacenter Replication setup, we assume that either both data centers talk to the same database or that every data center has its own database node and both database nodes are
synchronously replicated across the data centers. In both cases, it is required that when a Red Hat Single Sign-On server on site1 persists some data and commits the transaction, those data are immediately visible by subsequent DB transactions on site2.

Details of DB setup are out-of-scope for Red Hat Single Sign-On, however many RDBMS vendors like MariaDB and Oracle offer replicated databases and synchronous replication. We test Red Hat Single Sign-On with these vendors:

- Oracle Database 19c RAC
- Galera 3.12 cluster for MariaDB server version 10.1.19-MariaDB

3.4.6. Infinispan caches

This section begins with a high level description of the Infinispan caches. More details of the cache setup follow.

Authentication sessions

In Red Hat Single Sign-On we have the concept of authentication sessions. There is a separate Infinispan cache called authenticationSessions used to save data during authentication of particular user. Requests from this cache usually involve only a browser and the Red Hat Single Sign-On server, not the application. Here we can rely on sticky sessions and the authenticationSessions cache content does not need to be replicated across data centers, even if you are in Active/Active mode.

Caching and invalidation of persistent data

Red Hat Single Sign-On uses Infinispan to cache persistent data to avoid many unnecessary requests to the database. Caching improves performance, however it adds an additional challenge. When some Red Hat Single Sign-On server updates any data, all other Red Hat Single Sign-On servers in all data centers need to be aware of it, so they invalidate particular data from their caches. Red Hat Single Sign-On uses local Infinispan caches called realms, users, and authorization to cache persistent data.

We use a separate cache, work, which is replicated across all data centers. The work cache itself does not cache any real data. It is used only for sending invalidation messages between cluster nodes and data centers. In other words, when data is updated, such as the user john, the Red Hat Single Sign-On node sends the invalidation message to all other cluster nodes in the same data center and also to all other data centers. After receiving the invalidation notice, every node then invalidates the appropriate data from their local cache.

User sessions

There are Infinispan caches called sessions, clientSessions, offlineSessions, and offlineClientSessions, all of which usually need to be replicated across data centers. These caches are used to save data about user sessions, which are valid for the length of a user’s browser session. The caches must handle the HTTP requests from the end user and from the application. As described above, sticky sessions can not be reliably used in this instance, but we still want to ensure that subsequent HTTP requests can see the latest data. For this reason, the data are usually replicated across data centers.

Brute force protection

Finally the loginFailures cache is used to track data about failed logins, such as how many times the user john entered a bad password. The details are described here. It is up to the admin whether this cache should be replicated across data centers. To have an accurate count of login failures, the replication is needed. On the other hand, not replicating this data can save some performance. So if performance is more important than accurate counts of login failures, the replication can be avoided.
For more detail about how caches can be configured see Section 3.4.14, “Tuning the RHDG cache configuration”.

3.4.7. Communication details

Red Hat Single Sign-On uses multiple, separate clusters of Infinispan caches. Every Red Hat Single Sign-On node is in the cluster with the other Red Hat Single Sign-On nodes in same data center, but not with the Red Hat Single Sign-On nodes in different data centers. A Red Hat Single Sign-On node does not communicate directly with the Red Hat Single Sign-On nodes from different data centers. Red Hat Single Sign-On nodes use external RHDG servers for communication across data centers. This is done using the Infinispan Hot Rod protocol.

The Infinispan caches on the Red Hat Single Sign-On side use remoteStore configuration to offload data to a remote RHDG cluster. RHDG clusters in separate data centers then replicate that data to ensure it is backed up.

The receiving RHDG server notifies the Red Hat Single Sign-On servers in its cluster through Client Listeners, which are a feature of the Hot Rod protocol. Red Hat Single Sign-On nodes on site2 then update their Infinispan caches and the particular user session is also visible on Red Hat Single Sign-On nodes on site2.

See the Example Architecture Diagram for more details.

3.4.8. Setting Up Cross DC with RHDG 8.1

Use the following procedures for RHDG 8.1 to perform a basic setup of Cross-Datacenter replication.

This example for RHDG 8.1 involves two data centers, site1 and site2. Each data center consists of 1 RHDG server and 2 Red Hat Single Sign-On servers. We will end up with 2 RHDG servers and 4 Red Hat Single Sign-On servers in total.

- **Site1** consists of RHDG server, server1, and 2 Red Hat Single Sign-On servers, node11 and node12.
- **Site2** consists of RHDG server, server2, and 2 Red Hat Single Sign-On servers, node21 and node22.
- RHDG servers server1 and server2 are connected to each other through the RELAY2 protocol and backup based RHDG caches in a similar way as described in the RHDG documentation.
- Red Hat Single Sign-On servers node11 and node12 form a cluster with each other, but they do not communicate directly with any server in site2. They communicate with the Infinispan server server1 using the Hot Rod protocol (Remote cache). See Section 3.4.7, “Communication details” for more information.
- The same details apply for node21 and node22. They cluster with each other and communicate only with server2 server using the Hot Rod protocol.

Our example setup assumes that the four Red Hat Single Sign-On servers talk to the same database. In production, we recommend that you use separate synchronously replicated databases across data centers as described in Section 3.4.5, “Database”.

3.4.8.1. Setting Up RHDG Servers

For Cross-Datacenter replication, you start by creating remote RHDG clusters that can back up Red Hat Single Sign-On data.
Prerequisites

- Download and install RHDG Server 8.1.

NOTE

RHDG Server 8.1 requires Java 11.

Procedure

1. Create a user to authenticate client connections from RHDG, for example:

   ```
   $ bin/cli.sh user create myuser -p "qwer1234!"
   ```

   NOTE
   
   You specify these credentials in the Hot Rod client configuration when you create remote caches on Red Hat Single Sign-On.

2. Create an SSL keystore and truststore to secure connections between RHDG and Red Hat Single Sign-On, for example:

   a. Create a keystore to provide an SSL identity to your RHDG cluster
   
   ```
   keytool -genkey -alias server -keyalg RSA -keystore server.jks -keysize 2048
   ```

   b. Export an SSL certificate from the keystore.
   
   ```
   keytool -exportcert -keystore server.jks -alias server -file server.crt
   ```

   c. Import the SSL certificate into a truststore that Red Hat Single Sign-On can use to verify the SSL identity for RHDG.
   
   ```
   keytool -importcert -keystore truststore.jks -alias server -file server.crt
   ```

   d. Remove `server.crt`.
   
   ```
   rm server.crt
   ```

3.4.8.2. Configuring RHDG Clusters

Configure RHDG clusters to replicate Red Hat Single Sign-On data across data centers.

Prerequisites

- Install and set up RHDG Server.

Procedure

1. Open `infinispan.xml` for editing.

   By default, RHDG Server uses `server/conf/infinispan.xml` for static configuration such as cluster transport and security mechanisms.
2. Create a stack that uses TCPPING as the cluster discovery protocol.

```xml
<stack name="global-cluster" extends="tcp">
<!-- Remove MPING protocol from the stack and add TCPPING -->
<TCPPING initial_hosts="server1[7800],server2[7800]">
    stack.combine="REPLACE" stack.position="MPING"/>
</stack>
```

Lists the host names for server1 and server2.

3. Configure the RHDG cluster transport to perform Cross-Datacenter replication.

   a. Add the RELAY2 protocol to a JGroups stack.

```xml
<jgroups>
    <stack name="xsite" extends="udp">
        <relay.RELAY2 site="site1" max_site_masters="1000"/>
        <remote-sites default-stack="global-cluster">
            <remote-site name="site1"/>
            <remote-site name="site2"/>
        </remote-sites>
    </stack>
</jgroups>
```

Creates a stack named xsite that extends the default UDP cluster transport.

   1. Adds the RELAY2 protocol and names the cluster you are configuring as site1. The site name must be unique to each RHDG cluster.

   2. Sets 1000 as the number of relay nodes for the cluster. You should set a value that is equal to or greater than the maximum number of nodes in your RHDG cluster.

   3. Names all RHDG clusters that backup caches with RHDG data and uses the default TCP stack for inter-cluster transport.

b. Configure the RHDG cluster transport to use the stack.

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

Uses the xsite stack for the cluster.

4. Configure the keystore as an SSL identity in the server security realm.

```xml
<server-identities>
    <ssl>
        <keystore path="server.jks" relative-to="infinispan.server.config.path"
            keystore-password="password"/>
    </ssl>
</server-identities>
```
Specifies the path of the keystore that contains the SSL identity.

2. Specifies the password to access the keystore.

3. Names the alias of the certificate in the keystore.

5. Configure the authentication mechanism for the Hot Rod endpoint.

```xml
<endpoints socket-binding="default">
  <hotrod-connector name="hotrod">
    <authentication>
      <sasl mechanisms="DIGEST-MD5" server-name="infinispan" />
    </authentication>
  </hotrod-connector>
  <rest-connector name="rest"/>
</endpoints>
```

1. Configures the SASL authentication mechanism for the Hot Rod endpoint. SCRAM-SHA-512 is the default SASL mechanism for Hot Rod. However you can use whatever is appropriate for your environment, such as DIGEST-MD5 or GSSAPI.

2. Defines the name that RHDG servers present to clients. You specify this name in the Hot Rod client configuration when you set up Red Hat Single Sign-On.

6. Create a cache template.

```xml
<cache-container ... >
  <replicated-cache-configuration name="sessions-cfg" mode="SYNC">
    <locking acquire-timeout="0" />
    <backups>
      <backup site="site2" strategy="SYNC" />
    </backups>
  </replicated-cache-configuration>
</cache-container>
```

1. Creates a cache template named `sessions-cfg`.

2. Defines a cache that synchronously replicates data across the cluster.

3. Disables timeout for lock acquisition.

4. Names the backup site for the RHDG cluster you are configuring.

**NOTE**

Add the cache template to `infinispan.xml` on each node in the RHDG cluster.
7. Start RHDG server1.

```
./server.sh -c infinispan.xml -b PUBLIC_IP_ADDRESS -k PUBLIC_IP_ADDRESS -Djgroups.mcast_addr=228.6.7.10
```


```
./server.sh -c infinispan.xml -b PUBLIC_IP_ADDRESS -k PUBLIC_IP_ADDRESS -Djgroups.mcast_addr=228.6.7.11
```

9. Check RHDG server logs to verify the clusters form cross-site views.

```
INFO [org.infinispan.XSITE] (jgroups-5,${server.hostname}) ISPN000439: Received new x-site view: [site1]
INFO [org.infinispan.XSITE] (jgroups-7,${server.hostname}) ISPN000439: Received new x-site view: [site1, site2]
```

**Additional resources**

- Getting Started with Data Grid Server
- Configuring Data Grid Clusters for Cross-Site Replication
- Setting Up SSL Identities for Data Grid Server
- Configuring Data Grid Endpoints
- Configuring Hot Rod Authentication Mechanisms

### 3.4.8.3. Creating Infinispan Caches

Create the Infinispan caches that Red Hat Single Sign-On requires.

We recommend that you create caches on RHDG clusters at runtime rather than adding caches to `infinispan.xml`. This strategy ensures that your caches are automatically synchronized across the cluster and permanently stored.

The following procedure uses the RHDG Command Line Interface (CLI) to create all the required caches in a single batch command.

#### Prerequisites

- Configure your RHDG clusters.

#### Procedure

1. Create a batch file that contains caches, for example:

   ```bash
   cat > /tmp/caches.batch<<EOF
   echo "creating caches..."
   create cache work --template=sessions-cfg
   create cache sessions --template=sessions-cfg
   create cache clientSessions --template=sessions-cfg
   create cache offlineSessions --template=sessions-cfg
   create cache offlineClientSessions --template=sessions-cfg
   create cache actionTokens --template=sessions-cfg
   create cache loginFailures --template=sessions-cfg
   EOF
   ```
Create the caches with the CLI.

```
$ bin/cli.sh -c https://server1:11222 --trustall -f /tmp/caches.batch
```

**NOTE**
Instead of the `--trustall` argument you can specify the truststore with the `-t` argument and the truststore password with the `-s` argument.

Create the caches on the other site.

**Additional resources**
- Getting Started with Data Grid Server
- Remotely Creating Caches on Data Grid Clusters
- Performing Batch Operations with the CLI

### 3.4.8.4. Configuring Remote Cache Stores on Red Hat Single Sign-On

After you set up remote RHDG clusters, you configure the Infinispan subsystem on Red Hat Single Sign-On to externalize data to those clusters through remote stores.

#### Prerequisites
- Set up remote RHDG clusters for cross-site configuration.
- Create a truststore that contains the SSL certificate with the RHDG Server identity.

#### Procedure

1. Add the truststore to the Red Hat Single Sign-On deployment.

   ```
echo "verifying caches"
ls caches
EOF
```

2. Create a socket binding that points to your RHDG cluster.

   ```
<outbound-socket-binding name="remote-cache">  
<remote-destination host="${remote.cache.host:server_hostname}" port="${remote.cache.port:11222}"/>
</outbound-socket-binding>
```

1. Names the socket binding as `remote-cache`.
2. Specifies one or more hostnames for the RHDG cluster.
3. Defines the port of `11222` where the Hot Rod endpoint listens.

3. Add the `org.keycloak.keycloak-model-infinispan` module to the `keycloak` cache container in the Infinispan subsystem.
Update the work cache in the Infinispan subsystem so it has the following configuration:

```
<replicated-cache name="work">
  <remote-store cache="work">
    remote-servers="remote-cache"
passivation="false"
fetch-state="false"
purge="false"
preload="false"
shared="true">
  <property name="rawValues">true</property>
  <property name="marshaller" org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory/>
    <property name="infinispan.client.hotrod.auth_username">myuser</property>
    <property name="infinispan.client.hotrod.auth_password">qwer1234!</property>
    <property name="infinispan.client.hotrod.auth_realm">default</property>
    <property name="infinispan.client.hotrod.auth_server_name">infinispan</property>
    <property name="infinispan.client.hotrod.sasl_mechanism">DIGEST-MD5</property>
    <property name="infinispan.client.hotrod.trust_store_file_name">/path/to/truststore.jks</property>
    <property name="infinispan.client.hotrod.trust_store_type">JKS</property>
    <property name="infinispan.client.hotrod.trust_store_password">password</property>
  </remote-store>
</replicated-cache>
```

1. Names the cache in the RHDG configuration.
2. Names the corresponding cache on the remote RHDG cluster.
3. Specifies the `remote-cache` socket binding.

The preceding cache configuration includes recommended settings for RHDG caches. Hot Rod client configuration properties specify the RHDG user credentials and SSL keystore and truststore details.

Refer to the RHDG documentation for descriptions of each property.

5. Add distributed caches to the Infinispan subsystem for each of the following caches:

- sessions
- clientSessions
- offlineSessions
- offlineClientSessions
- actionTokens
- loginFailures
For example, add a cache named **sessions** with the following configuration:

```
<distributed-cache name="sessions">
  <owner class="org.infinispan.client.hotrod.impl.DefaultInfinispanClient">1</owner>
  <remote-store cache="sessions">2</remote-store>
    <remote-servers>remote-cache</remote-servers>
    <passivation>false</passivation>
    <fetch-state>false</fetch-state>
    <purge>false</purge>
    <preload>false</preload>
    <shared>true</shared>
  </remote-store>
  <property name="rawValues">true</property>
  <property name="marshaller">org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory</property>
  <property name="infinispan.client.hotrod.auth_username">myuser</property>
  <property name="infinispan.client.hotrod.auth_password">qwer1234!</property>
  <property name="infinispan.client.hotrod.auth_realm">default</property>
  <property name="infinispan.client.hotrod.auth_server_name">infinispan</property>
  <property name="infinispan.client.hotrod.sasl_mechanism">DIGEST-MD5</property>
  <property name="infinispan.client.hotrod.trust_store_file_name">/path/to/truststore.jks</property>
  <property name="infinispan.client.hotrod.trust_store_type">JKS</property>
  <property name="infinispan.client.hotrod.trust_store_password">password</property>
</distributed-cache>
```

1. Names the cache in the RHDG configuration.
2. Configures one replica of each cache entry across the RHDG cluster.
3. Names the corresponding cache on the remote RHDG cluster.
4. Specifies the **remote-cache** socket binding.

6. Copy the **NODE11** to 3 other directories referred later as **NODE12, NODE21** and **NODE22**.

7. Start **NODE11**:

```
cd NODE11/bin
./standalone.sh -c standalone-ha.xml -Djboss.node.name=node11 -Djboss.site.name=site1
-Djboss.default.multicast.address=234.56.78.1 -Dremote.cache.host=server1
-Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS
```

If you notice the following warning messages in logs, you can safely ignore them:

```
WARN [org.infinispan.CONFIG] (MSC service thread 1-5) ISPN000292: Unrecognized attribute 'infinispan.client.hotrod.auth_password'. Please check your configuration. Ignoring!
WARN [org.infinispan.CONFIG] (MSC service thread 1-5) ISPN000292: Unrecognized attribute 'infinispan.client.hotrod.auth_username'. Please check your configuration. Ignoring!
```

8. Start **NODE12**:
cd NODE12/bin
./standalone.sh -c standalone-ha.xml -Djboss.node.name=node12 -Djboss.site.name=site1 \ -Djboss.default.multicast.address=234.56.78.1 -Dremote.cache.host=server1 \ -Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS

The cluster nodes should be connected. Something like this should be in the log of both NODE11 and NODE12:

Received new cluster view for channel keycloak: [node11|1] (2) [node11, node12]

NOTE
The channel name in the log might be different.

9. Start **NODE21**:

    cd NODE21/bin
    ./standalone.sh -c standalone-ha.xml -Djboss.node.name=node21 -Djboss.site.name=site2 \ -Djboss.default.multicast.address=234.56.78.2 -Dremote.cache.host=server2 \ -Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS

    It shouldn’t be connected to the cluster with **NODE11** and **NODE12**, but to a separate one:

    Received new cluster view for channel keycloak: [node21|0] (1) [node21]

10. Start **NODE22**:

    cd NODE22/bin
    ./standalone.sh -c standalone-ha.xml -Djboss.node.name=node22 -Djboss.site.name=site2 \ -Djboss.default.multicast.address=234.56.78.2 -Dremote.cache.host=server2 \ -Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS

    It should be in cluster with **NODE21**:

    Received new cluster view for channel keycloak: [node21|1] (2) [node21, node22]

    NOTE
The channel name in the log might be different.

11. Test:

    a. Go to **http://node11:8080/auth/** and create the initial admin user.

    b. Go to **http://node11:8080/auth/admin** and login as admin to admin console.

    c. Open a second browser and go to any of nodes **http://node12:8080/auth/admin** or **http://node21:8080/auth/admin** or **http://node22:8080/auth/admin**. After login, you should be able to see the same sessions in tab **Sessions** of particular user, client or realm on all 4 servers.

    d. After making a change in the Red Hat Single Sign-On Admin Console, such as modifying a...
a. After making a change in the Red Hat Single Sign-On Admin Console, such as modifying a user or a realm, that change should be immediately visible on any of the four nodes. Caches should be properly invalidated everywhere.

e. Check server.logs if needed. After login or logout, the message like this should be on all the nodes NODEXY/standalone/log/server.log:

```
2017-08-25 17:35:17,737 DEBUG [org.keycloak.models.sessions.infinispan.remotestore.RemoteCacheSessionListener]
(Client-Listener-sessions-30012a77422542f5) Received event from remote store.
Event 'CLIENT_CACHE_ENTRY_REMOVED', key '193489e7-e2bc-4069-afe8-f1dfa73084ea', skip 'false'
```

Additional resources

Data Grid Configuration Guide
Hot Rod Client Configuration API
Data Grid Configuration Schema Reference

3.4.9. Setting up Cross DC with RHDG 7.3

This example for RHDG 7.3 involves two data centers, site1 and site2. Each data center consists of 1 RHDG server and 2 Red Hat Single Sign-On servers. We will end up with 2 RHDG servers and 4 Red Hat Single Sign-On servers in total.

- **Site1** consists of RHDG server, server1, and 2 Red Hat Single Sign-On servers, node11 and node12.
- **Site2** consists of RHDG server, server2, and 2 Red Hat Single Sign-On servers, node21 and node22.
- RHDG servers server1 and server2 are connected to each other through the RELAY2 protocol and backup based RHDG caches in a similar way as described in the RHDG documentation.
- Red Hat Single Sign-On servers node11 and node12 form a cluster with each other, but they do not communicate directly with any server in site2. They communicate with the Infinispan server server1 using the Hot Rod protocol (Remote cache). See Section 3.4.7, “Communication details” for the details.
- The same details apply for node21 and node22. They cluster with each other and communicate only with server2 server using the Hot Rod protocol.

Our example setup assumes all that all 4 Red Hat Single Sign-On servers talk to the same database. In production, it is recommended to use separate synchronously replicated databases across data centers as described in Section 3.4.5, “Database”.

3.4.9.1. Setting up the RHDG server

Follow these steps to set up the RHDG server:

1. Download RHDG 7.3 server and unzip to a directory you choose. This location will be referred in later steps as SERVER1_HOME.

2. Change those things in the SERVER1_HOME/server/conf/infinispan-xsite.xml in the configuration of JGroups subsystem:
a. Add the `xsite` channel, which will use `tcp` stack, under `channels` element:

```
<channels default="cluster">
  <channel name="cluster"/>
  <channel name="xsite" stack="tcp"/>
</channels>
```

b. Add a `relay` element to the end of the `udp` stack. We will configure it in a way that our site is `site1` and the other site, where we will backup, is `site2`:

```
<stack name="udp">
  ...
  <relay site="site1">
    <remote-site name="site2" channel="xsite"/>
    <property name="relay_multicasts">false</property>
  </relay>
</stack>
```

c. Configure the `tcp` stack to use `TCPPING` protocol instead of `MPING`. Remove the `MPING` element and replace it with the `TCPPING`. The `initial_hosts` element points to the hosts `server1` and `server2`:

```
<stack name="tcp">
  <transport type="TCP" socket-binding="jgroups-tcp"/>
  <protocol type="TCPPING">
    <property name="initial_hosts">server1[7600],server2[7600]</property>
    <property name="ergonomics">false</property>
  </protocol>
</stack>
```

**NOTE**

This is just an example setup to have things quickly running. In production, you are not required to use `tcp` stack for the JGroups RELAY2, but you can configure any other stack. For example, you could use the default `udp` stack, if the network between your data centers is able to support multicast. Just make sure that the RHDOG and Red Hat Single Sign-On clusters are mutually indiscernible. Similarly, you are not required to use TCPPING as discovery protocol. And in production, you probably won’t use TCPPING due it’s static nature. Finally, site names are also configurable. Details of this more-detailed setup are out-of-scope of the Red Hat Single Sign-On documentation. See the RHDOG documentation and JGroups documentation for more details.

3. Add this into `SERVER1_HOME/standalone/configuration/clustered.xml` under cache-container named `clustered`:

```
<cache-container name="clustered" default-cache="default" statistics="true">
  ...
  <replicated-cache-configuration name="sessions-cfg" mode="SYNC" start="EAGER" batching="false">
    <transaction mode="NON_DURABLE_XA" locking="PESSIMISTIC"/>
    <locking acquire-timeout="0"/>
  </replicated-cache-configuration>
</cache-container>
```
<backups>
  <backup site="site2" failure-policy="FAIL" strategy="SYNC" enabled="true">
    <take-offline min-wait="60000" after-failures="3"/>
  </backup>
</backups>
</replicated-cache-configuration>

<replicated-cache name="work" configuration="sessions-cfg"/>
<replicated-cache name="sessions" configuration="sessions-cfg"/>
<replicated-cache name="clientSessions" configuration="sessions-cfg"/>
<replicated-cache name="offlineSessions" configuration="sessions-cfg"/>
<replicated-cache name="offlineClientSessions" configuration="sessions-cfg"/>
<replicated-cache name="actionTokens" configuration="sessions-cfg"/>
<replicated-cache name="loginFailures" configuration="sessions-cfg"/>

</cache-container>

NOTE

Details about the configuration options inside replicated-cache-configuration
are explained in Section 3.4.14, “Tuning the RHDG cache configuration”, which
includes information about tweaking some of those options.

4. Some RHDG server releases require authorization before accessing protected caches over
network.

NOTE

You should not see any issue if you use recommended RHDG 7.3 server and this
step can (and should) be ignored. Issues related to authorization may exist just
for some other versions of RHDG server.

Red Hat Single Sign-On requires updates to ___script_cache cache containing scripts. If you
get errors accessing this cache, you will need to set up authorization in clustered.xml
configuration as described below:

a. In the <management> section, add a security realm:

<management>
  <security-realms>
    ...
    <security-realm name="AllowScriptManager">
      <authentication>
        <users>
          <user username="___script_manager">
            <password>not-so-secret-password</password>
          </user>
        </users>
      </authentication>
    </security-realm>
  </security-realms>
</management>

b. In the server core subsystem, add <security> as below:

<security>
  ...
  <users>
    <user username="___script_manager">
      <password>not-so-secret-password</password>
    </user>
  </users>
</security>
In the endpoint subsystem, add authentication configuration to Hot Rod connector:

```
<subsystem xmlns="urn:infinispan:server:endpoint:8.1">
  <hotrod-connector cache-container="clustered" socket-binding="hotrod">
    ...
  </hotrod-connector>
  <authentication security-realm="AllowScriptManager">
    <sasl mechanisms="DIGEST-MD5" qop="auth" server-name="keycloak-jdg-server">
      <policy>
        <no-anonymous value="false"/>
      </policy>
    </sasl>
  </authentication>
</subsystem>
```

c. In the endpoint subsystem, add authentication configuration to Hot Rod connector:

```
<subsystem xmlns="urn:infinispan:server:core:8.4">
  <cache-container name="clustered" default-cache="default" statistics="true">
    <security>
      <authorization>
        <identity-role-mapper/>
        <role name="___script_manager" permissions="ALL"/>
      </authorization>
    </security>
    ...
  </cache-container>
</subsystem>
```

5. Copy the server to the second location, which will be referred to later as SERVER2_HOME.

6. In the SERVER2_HOME/standalone/configuration/clustered.xml exchange site1 with site2 and vice versa, both in the configuration of relay in the JGroups subsystem and in configuration of backups in the cache-subsystem. For example:

   a. The relay element should look like this:

```
<relay site="site2">
  <remote-site name="site1" channel="xsite"/>
  <property name="relay_multicasts">false</property>
</relay>
```

   b. The backups element like this:

```
<backups>
  <backup site="site1" ....>
  ...
</backups>
```

**NOTE**

The PUBLIC_IP_ADDRESS below refers to the IP address or hostname, which can be used for your server to bind to. Note that every RHDD server and Red Hat Single Sign-On server needs to use different address. During example setup with all the servers running on the same host, you may need to add the option `-Djboss.bind.address.management=PUBLIC_IP_ADDRESS` as every server needs to use also different management interface. But this option usually should be omitted in production environments to avoid the ability for remote access to your server. For more information, see the JBoss EAP Configuration Guide.
7. Start server server1:

    cd SERVER1_HOME/bin
    ./standalone.sh -c clustered.xml -Djava.net.preferIPv4Stack=true
    -Djboss.default.multicast.address=234.56.78.99
    -Djboss.node.name=server1 -b PUBLIC_IP_ADDRESS

8. Start server server2. There is a different multicast address, so the server1 and server2 servers are not directly clustered with each other; rather, they are just connected through the RELAY2 protocol, and the TCP JGroups stack is used for communication between them. The start up command looks like this:

    cd SERVER2_HOME/bin
    ./standalone.sh -c clustered.xml -Djava.net.preferIPv4Stack=true
    -Djboss.default.multicast.address=234.56.78.100
    -Djboss.node.name=server2 -b PUBLIC_IP_ADDRESS

9. To verify that channel works at this point, you may need to use JConsole and connect either to the running SERVER1 or the SERVER2 server. When you use the MBean jgroups:type=protocol,cluster="cluster",protocol=RELAY2 and operation printRoutes, you should see output like this:

    site1 --> _server1:site1
    site2 --> _server2:site2

When you use the MBean jgroups:type=protocol,cluster="cluster",protocol=GMS, you should see that the attribute member contains just single member:

a. On SERVER1 it should be like this:

   (1) server1

b. And on SERVER2 like this:

   (1) server2

**NOTE**

In production, you can have more RHDG servers in every data center. You just need to ensure that RHDG servers in same data center are using the same multicast address (In other words, the same jboss.default.multicast.address during startup). Then in jconsole in GMS protocol view, you will see all the members of current cluster.

### 3.4.9.2. Setting up Red Hat Single Sign-On servers

1. Unzip Red Hat Single Sign-On server distribution to a location you choose. It will be referred to later as NODE11.

2. Configure a shared database for KeycloakDS datasource. It is recommended to use MySQL or MariaDB for testing purposes. See Section 3.4.5, “Database” for more details.
In production you will likely need to have a separate database server in every data center and both database servers should be synchronously replicated to each other. In the example setup, we just use a single database and connect all 4 Red Hat Single Sign-On servers to it.

3. Edit `NODE11/standalone/configuration/standalone-ha.xml`:
   
a. Add the attribute `site` to the JGroups UDP protocol:
   ```xml
   <stack name="udp">
   <transport type="UDP" socket-binding="jgroups-udp" site="${jboss.site.name}"/>
   ```
   
b. Add the `remote-store` under `work` cache:
   ```xml
   <replicated-cache name="work">
   <remote-store cache="work" remote-servers="remote-cache" passivation="false" fetch-state="false" purge="false" preload="false" shared="true">
   <property name="rawValues">true</property>
   <property name="marshaller">org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory</property>
   <property name="protocolVersion">2.6</property>
   </remote-store>
   </replicated-cache>
   ```
   
c. Add the `remote-store` like this under `sessions` cache:
   ```xml
   <distributed-cache name="sessions" owners="1">
   <remote-store cache="sessions" remote-servers="remote-cache" passivation="false" fetch-state="false" purge="false" preload="false" shared="true">
   <property name="rawValues">true</property>
   <property name="marshaller">org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory</property>
   <property name="protocolVersion">2.6</property>
   </remote-store>
   </distributed-cache>
   ```
   
d. Do the same for `offlineSessions`, `clientSessions`, `offlineClientSessions`, `loginFailures`, and `actionTokens` caches (the only difference from `sessions` cache is that `cache` property value are different):
   ```xml
   <distributed-cache name="offlineSessions" owners="1">
   <remote-store cache="offlineSessions" remote-servers="remote-cache" passivation="false" fetch-state="false" purge="false" preload="false" shared="true">
   <property name="rawValues">true</property>
   <property name="marshaller">org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory</property>
   <property name="protocolVersion">2.6</property>
   </remote-store>
   </distributed-cache>
   <distributed-cache name="clientSessions" owners="1">
   <remote-store cache="clientSessions" remote-servers="remote-cache" passivation="false" fetch-state="false" purge="false" preload="false" shared="true">
   ```
Add outbound socket binding for the remote store into `socket-binding-group` element configuration:

```xml
<property name="rawValues">true</property>
<property name="marshaller" org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory>
  <property name="protocolVersion">2.6</property>
</remote-store>
</distributed-cache>

<distributed-cache name="offlineClientSessions" owners="1">
  <remote-store cache="offlineClientSessions" remote-servers="remote-cache" passivation="false" fetch-state="false" purge="false" preload="false" shared="true">
    <property name="rawValues">true</property>
  </remote-store>
  <property name="marshaller" org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory>
    <property name="protocolVersion">2.6</property>
  </remote-store>
</distributed-cache>

<distributed-cache name="loginFailures" owners="1">
  <remote-store cache="loginFailures" remote-servers="remote-cache" passivation="false" fetch-state="false" purge="false" preload="false" shared="true">
    <property name="rawValues">true</property>
  </remote-store>
  <property name="marshaller" org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory>
    <property name="protocolVersion">2.6</property>
  </remote-store>
</distributed-cache>

<distributed-cache name="actionTokens" owners="2">
  <object-memory size="-1"/>
  <expiration max-idle="-1" interval="300000"/>
  <remote-store cache="actionTokens" remote-servers="remote-cache" passivation="false" fetch-state="false" purge="false" preload="true" shared="true">
    <property name="rawValues">true</property>
  </remote-store>
  <property name="marshaller" org.keycloak.cluster.infinispan.KeycloakHotRodMarshallerFactory>
    <property name="protocolVersion">2.6</property>
  </remote-store>
</distributed-cache>
```

e. Add outbound socket binding for the remote store into `socket-binding-group` element configuration:

```xml
<outbound-socket-binding name="remote-cache">
  <remote-destination host="${remote.cache.host:localhost}" port="${remote.cache.port:11222}"/>
</outbound-socket-binding>
```

f. The configuration of distributed cache `authenticationSessions` and other caches is left unchanged.
g. It is recommended to add the remoteStoreSecurityEnabled property with the value of false (or eventually true if you enabled security for the RHDG servers as described above) to the connectionsInfinispan SPI in the keycloak-server subsystem:

```
<spi name="connectionsInfinispan">
  ...
  <provider ...>
    <properties>
      ...
      <property name="remoteStoreSecurityEnabled" value="false"/>
    </properties>
  ...
</spi>
```

h. Optionally enable DEBUG logging under the logging subsystem:

```
<logger category="org.keycloak.cluster.infinispan">
  <level name="DEBUG"/>
</logger>
<logger category="org.keycloak.connections.infinispan">
  <level name="DEBUG"/>
</logger>
<logger category="org.keycloak.models.cache.infinispan">
  <level name="DEBUG"/>
</logger>
<logger category="org.keycloak.models.sessions.infinispan">
  <level name="DEBUG"/>
</logger>
```

4. Copy the NODE11 to 3 other directories referred later as NODE12, NODE21 and NODE22.

5. Start NODE11:

```
cd NODE11/bin
./standalone.sh -c standalone-ha.xml -Djboss.node.name=node11 -Djboss.site.name=site1 \
-Djboss.default.multicast.address=234.56.78.1 -Dremote.cache.host=server1 \
-Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS
```

6. Start NODE12:

```
cd NODE12/bin
./standalone.sh -c standalone-ha.xml -Djboss.node.name=node12 -Djboss.site.name=site1 \
-Djboss.default.multicast.address=234.56.78.1 -Dremote.cache.host=server1 \
-Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS
```

The cluster nodes should be connected. Something like this should be in the log of both NODE11 and NODE12:

```
Received new cluster view for channel keycloak: [node11|1] (2) [node11, node12]
```

**NOTE**

The channel name in the log might be different.
7. Start **NODE21**:

```bash
cd NODE21/bin
./standalone.sh -c standalone-ha.xml -Djboss.node.name=node21 -Djboss.site.name=site2 \
-Djboss.default.multicast.address=234.56.78.2 -Dremote.cache.host=server2 \
-Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS
```

It shouldn’t be connected to the cluster with **NODE11** and **NODE12**, but to separate one:

- Received new cluster view for channel keycloak: [node21|0] (1) [node21]

8. Start **NODE22**:

```bash
cd NODE22/bin
./standalone.sh -c standalone-ha.xml -Djboss.node.name=node22 -Djboss.site.name=site2 \
-Djboss.default.multicast.address=234.56.78.2 -Dremote.cache.host=server2 \
-Djava.net.preferIPv4Stack=true -b PUBLIC_IP_ADDRESS
```

It should be in cluster with **NODE21**:

- Received new cluster view for channel keycloak: [node21|1] (2) [node21, node22]

**NOTE**

The channel name in the log might be different.

9. Test:

   a. Go to [http://node11:8080/auth/](http://node11:8080/auth/) and create the initial admin user.

   b. Go to [http://node11:8080/auth/admin](http://node11:8080/auth/admin) and login as admin to admin console.

   c. Open a second browser and go to any of nodes [http://node12:8080/auth/admin](http://node12:8080/auth/admin) or [http://node21:8080/auth/admin](http://node21:8080/auth/admin) or [http://node22:8080/auth/admin](http://node22:8080/auth/admin). After login, you should be able to see the same sessions in tab Sessions of particular user, client or realm on all 4 servers.

   d. After doing any change in Keycloak admin console (eg. update some user or some realm), the update should be immediately visible on any of 4 nodes as caches should be properly invalidated everywhere.

   e. Check server.logs if needed. After login or logout, the message like this should be on all the nodes **NODEXY/standalone/log/server.log**:

```log
2017-08-25 17:35:17,737 DEBUG [org.keycloak.models.sessions.infinispan.remotestore.RemoteCacheSessionListener] (Client-Listener-sessions-30012a77422542f5) Received event from remote store. Event 'CLIENT_CACHE_ENTRY_REMOVED', key '193489e7-e2bc-4069-afe8-f1dfa73084ea', skip 'false'
```

### 3.4.10. Administration of Cross DC deployment

This section contains some tips and options related to Cross-Datacenter Replication.
When you run the Red Hat Single Sign-On server inside a data center, it is required that the database referenced in KeycloakDS datasource is already running and available in that data center. It is also necessary that the RHDG server referenced by the outbound-socket-binding, which is referenced from the Infinispan cache remote-store element, is already running. Otherwise the Red Hat Single Sign-On server will fail to start.

Every data center can have more database nodes if you want to support database failover and better reliability. Refer to the documentation of your database and JDBC driver for the details how to set this up on the database side and how the KeycloakDS datasource on Keycloak side needs to be configured.

Every datacenter can have more RHDG servers running in the cluster. This is useful if you want some failover and better fault tolerance. The Hot Rod protocol used for communication between RHDG servers and Red Hat Single Sign-On servers has a feature that RHDG servers will automatically send new topology to the Red Hat Single Sign-On servers about the change in the RHDG cluster, so the remote store on Red Hat Single Sign-On side will know to which RHDG servers it can connect. Read the RHDG and WildFly documentation for more details.

It is highly recommended that a master RHDG server is running in every site before the Red Hat Single Sign-On servers in any site are started. As in our example, we started both server1 and server2 first, before all Red Hat Single Sign-On servers. If you still need to run the Red Hat Single Sign-On server and the backup site is offline, it is recommended to manually switch the backup site offline on the RHDG servers on your site, as described in Section 3.4.11, “Bringing sites offline and online”. If you do not manually switch the unavailable site offline, the first startup may fail or they may be some exceptions during startup until the backup site is taken offline automatically due the configured count of failed operations.

3.4.11. Bringing sites offline and online

For example, assume this scenario:

1. Site site2 is entirely offline from the site1 perspective. This means that all RHDG servers on site2 are off or the network between site1 and site2 is broken.

2. You run Red Hat Single Sign-On servers and RHDG server server1 in site site1


4. The Red Hat Single Sign-On server from site1 will try to write the session to the remote cache on server1 server, which is supposed to backup data to the server2 server in the site2. See Section 3.4.7, “Communication details” for more information.

5. Server server2 is offline or unreachable from server1. So the backup from server1 to server2 will fail.

6. The exception is thrown in server1 log and the failure will be propagated from server1 server to Red Hat Single Sign-On servers as well because the default FAIL backup failure policy is configured. See Backup failure policy for details around the backup policies.

7. The error will happen on Red Hat Single Sign-On side too and user may not be able to finish his login.

According to your environment, it may be more or less probable that the network between sites is unavailable or temporarily broken (split-brain). In case this happens, it is good that RHDG servers on site1 are aware of the fact that RHDG servers on site2 are unavailable, so they will stop trying to reach the servers in the server2 site and the backup failures won’t happen. This is called Take site offline.
Take site offline

There are 2 ways to take the site offline.

Manually by admin - Admin can use the jconsole or other tool and run some JMX operations to manually take the particular site offline. This is useful especially if the outage is planned. With jconsole or CLI, you can connect to the server1 server and take the site2 offline. More details about this are available in the RHDG documentation.

WARNING
These steps usually need to be done for all the Red Hat Single Sign-On caches mentioned in Section 3.4.15, “SYNC or ASYNC backups”.

Automatically - After some amount of failed backups, the site2 will usually be taken offline automatically. This is done due the configuration of take-offline element inside the cache configuration as configured in Section 3.4.9.1, “Setting up the RHDG server”.

```html
<take-offline min-wait="60000" after-failures="3" />
```

This example shows that the site will be taken offline automatically for the particular single cache if there are at least 3 subsequent failed backups and there is no any successful backup within 60 seconds.

Automatically taking a site offline is useful especially if the broken network between sites is unplanned. The disadvantage is that there will be some failed backups until the network outage is detected, which could also mean failures on the application side. For example, there will be failed logins for some users or big login timeouts. Especially if failure-policy with value FAIL is used.

WARNING
The tracking of whether a site is offline is tracked separately for every cache.

Take site online

Once your network is back and site1 and site2 can talk to each other, you may need to put the site online. This needs to be done manually through JMX or CLI in similar way as taking a site offline. Again, you may need to check all the caches and bring them online.

Once the sites are put online, it’s usually good to:

- Do the Section 3.4.12, “State transfer”.
- Manually Section 3.4.13, “Clear caches”.

3.4.12. State transfer
State transfer is a required, manual step. RHDG server does not do this automatically, for example during split-brain, it is only the admin who may decide which site has preference and hence if state transfer needs to be done bidirectionally between both sites or just unidirectionally, as in only from site1 to site2, but not from site2 to site1.

A bidirectional state transfer will ensure that entities which were created after split-brain on site1 will be transferred to site2. This is not an issue as they do not yet exist on site2. Similarly, entities created after split-brain on site2 will be transferred to site1. Possibly problematic parts are those entities which exist before split-brain on both sites and which were updated during split-brain on both sites. When this happens, one of the sites will win and will overwrite the updates done during split-brain by the second site.

Unfortunately, there is no any universal solution to this. Split-brains and network outages are just state, which is usually impossible to be handled 100% correctly with 100% consistent data between sites. In the case of Red Hat Single Sign-On, it typically is not a critical issue. In the worst case, users will need to re-login again to their clients, or have the improper count of loginFailures tracked for brute force protection. See the RHDG/JGroups documentation for more tips how to deal with split-brain.

The state transfer can be also done on the RHDG server side through JMX. The operation name is pushState. There are few other operations to monitor status, cancel push state, and so on. More info about state transfer is available in the RHDG docs.

3.4.13. Clear caches

After split-brain it is safe to manually clear caches in the Red Hat Single Sign-On admin console. This is because there might be some data changed in the database on site1 and because of the event, that the cache should be invalidated wasn’t transferred during split-brain to site2. Hence Red Hat Single Sign-On nodes on site2 may still have some stale data in their caches.

To clear the caches, see Clearing Server Caches.

When the network is back, it is sufficient to clear the cache just on one Red Hat Single Sign-On node on any random site. The cache invalidation event will be sent to all the other Red Hat Single Sign-On nodes in all sites. However, it needs to be done for all the caches (realms, users, keys). See Clearing Server Caches for more information.

3.4.14. Tuning the RHDG cache configuration

This section contains tips and options for configuring your JDG cache.

Backup failure policy

By default, the configuration of backup failure-policy in the Infinispan cache configuration in the RHDG clustered.xml file is configured as FAIL. You may change it to WARN or IGNORE, as you prefer.

The difference between FAIL and WARN is that when FAIL is used and the RHDG server tries to back data up to the other site and the backup fails then the failure will be propagated back to the caller (the Red Hat Single Sign-On server). The backup might fail because the second site is temporarily unreachable or there is a concurrent transaction which is trying to update same entity. In this case, the Red Hat Single Sign-On server will then retry the operation a few times. However, if the retry fails, then the user might see the error after a longer timeout.

When using WARN, the failed backups are not propagated from the RHDG server to the Red Hat Single Sign-On server. The user won’t see the error and the failed backup will be just ignored. There will be a shorter timeout, typically 10 seconds as that’s the default timeout for backup. It can be changed by the
attribute `timeout` of `backup` element. There won't be retries. There will just be a WARNING message in the RHDG server log.

The potential issue is, that in some cases, there may be just some a short network outage between sites, where the retry (usage of the `FAIL` policy) may help, so with `WARN` (without retry), there will be some data inconsistencies across sites. This can also happen if there is an attempt to update the same entity concurrently on both sites.

How bad are these inconsistencies? Usually only means that a user will need to re-authenticate.

When using the `WARN` policy, it may happen that the single-use cache, which is provided by the `actionTokens` cache and which handles that particular key is really single use, but may "successfully" write the same key twice. But, for example, the OAuth2 specification mentions that code must be single-use. With the `WARN` policy, this may not be strictly guaranteed and the same code could be written twice if there is an attempt to write it concurrently in both sites.

If there is a longer network outage or split-brain, then with both `FAIL` and `WARN`, the other site will be taken offline after some time and failures as described in Section 3.4.11, "Bringing sites offline and online". With the default 1 minute timeout, it is usually 1-3 minutes until all the involved caches are taken offline. After that, all the operations will work fine from an end user perspective. You only need to manually restore the site when it is back online as mentioned in Section 3.4.11, "Bringing sites offline and online".

In summary, if you expect frequent, longer outages between sites and it is acceptable for you to have some data inconsistencies and a not 100% accurate single-use cache, but you never want end-users to see the errors and long timeouts, then switch to `WARN`.

The difference between `WARN` and `IGNORE` is, that with `IGNORE` warnings are not written in the RHDG log. See more details in the Infinispan documentation.

**Lock acquisition timeout**

The default configuration is using transaction in NON_DURABLE_XA mode with acquire timeout 0. This means that transaction will fail-fast if there is another transaction in progress for the same key.

The reason to switch this to 0 instead of default 10 seconds was to avoid possible deadlock issues. With Red Hat Single Sign-On, it can happen that the same entity (typically session entity or loginFailure) is updated concurrently from both sites. This can cause deadlock under some circumstances, which will cause the transaction to be blocked for 10 seconds. See this JIRA report for details.

With timeout 0, the transaction will immediately fail and then will be retried from Red Hat Single Sign-On if backup `failure-policy` with the value `FAIL` is configured. As long as the second concurrent transaction is finished, the retry will usually be successful and the entity will have applied updates from both concurrent transactions.

We see very good consistency and results for concurrent transaction with this configuration, and it is recommended to keep it.

The only (non-functional) problem is the exception in the RHDG server log, which happens every time when the lock is not immediately available.

**3.4.15. SYNC or ASYNC backups**

An important part of the `backup` element is the `strategy` attribute. You must decide whether it needs to be `SYNC` or `ASYNC`. We have 7 caches which might be Cross-Datacenter Replication aware, and these can be configured in 3 different modes regarding cross-dc:
1. **SYNC backup**

2. **ASYNC backup**

3. **No backup at all**

If the **SYNC** backup is used, then the backup is synchronous and operation is considered finished on the caller (Red Hat Single Sign-On server) side once the backup is processed on the second site. This has worse performance than **ASYNC**, but on the other hand, you are sure that subsequent reads of the particular entity, such as user session, on site2 will see the updates from site1. Also, it is needed if you want data consistency. As with **ASYNC** the caller is not notified at all if backup to the other site failed.

For some caches, it is even possible to not backup at all and completely skip writing data to the RHSDG server. To set this up, do not use the `remote-store` element for the particular cache on the Red Hat Single Sign-On side (file `KEYCLOAK_HOME/standalone/configuration/standalone-ha.xml`) and then the particular `replicated-cache` element is also not needed on the RHSDG server side.

By default, all 7 caches are configured with **SYNC** backup, which is the safest option. Here are a few things to consider:

- If you are using active/passive mode (all Red Hat Single Sign-On servers are in single site site1 and the RHSDG server in site2 is used purely as backup. See Section 3.4.4, “Modes” for more details), then it is usually fine to use **ASYNC** strategy for all the caches to save the performance.

- The **work** cache is used mainly to send some messages, such as cache invalidation events, to the other site. It is also used to ensure that some special events, such as userStorage synchronizations, happen only on single site. It is recommended to keep this set to **SYNC**.

- The **actionTokens** cache is used as single-use cache to track that some tokens/tickets were used just once. For example action tokens or OAuth2 codes. It is possible to set this to **ASYNC** to slightly improved performance, but then it is not guaranteed that particular ticket is really single-use. For example, if there is concurrent request for same ticket in both sites, then it is possible that both requests will be successful with the **ASYNC** strategy. So what you set here will depend on whether you prefer better security (**SYNC** strategy) or better performance (**ASYNC** strategy).

- The **loginFailures** cache may be used in any of the 3 modes. If there is no backup at all, it means that count of login failures for a user will be counted separately for every site (See Section 3.4.6, “Infinispan caches” for details). This has some security implications, however it has some performance advantages. Also it mitigates the possible risk of denial of service (DoS) attacks. For example, if an attacker simulates 1000 concurrent requests using the username and password of the user on both sites, it will mean lots of messages being passed between the sites, which may result in network congestion. The **ASYNC** strategy might be even worse as the attacker requests won’t be blocked by waiting for the backup to the other site, resulting in potentially even more congested network traffic. The count of login failures also will not be accurate with the **ASYNC** strategy.

For the environments with slower network between data centers and probability of DoS, it is recommended to not backup the **loginFailures** cache at all.

- It is recommended to keep the **sessions** and **clientSessions** caches in **SYNC**. Switching them to **ASYNC** is possible only if you are sure that user requests and backchannel requests (requests from client applications to Red Hat Single Sign-On as described in Section 3.4.3, “Request processing”) will be always processed on same site. This is true, for example, if:
  - You use active/passive mode as described Section 3.4.4, “Modes”.
All your client applications are using the Red Hat Single Sign-On JavaScript Adapter. The JavaScript adapter sends the backchannel requests within the browser and hence they participate on the browser sticky session and will end on same cluster node (hence on same site) as the other browser requests of this user.

Your load balancer is able to serve the requests based on client IP address (location) and the client applications are deployed on both sites. For example you have 2 sites LON and NYC. As long as your applications are deployed in both LON and NYC sites too, you can ensure that all the user requests from London users will be redirected to the applications in LON site and also to the Red Hat Single Sign-On servers in LON site. Backchannel requests from the LON site client deployments will end on Red Hat Single Sign-On servers in LON site too. On the other hand, for the American users, all the Red Hat Single Sign-On requests, application requests and backchannel requests will be processed on NYC site.

- For **offlineSessions** and **offlineClientSessions** it is similar, with the difference that you even don’t need to backup them at all if you never plan to use offline tokens for any of your client applications.

Generally, if you are in doubt and performance is not a blocker for you, it’s safer to keep the caches in **SYNC** strategy.

### WARNING

Regarding the switch to SYNC/ASYNC backup, make sure that you edit the **strategy** attribute of the **backup** element. For example like this:

```xml
<backup site="site2" failure-policy="FAIL" strategy="ASYNC" enabled="true"/>
```

Note the **mode** attribute of cache-configuration element.

### 3.4.16. Troubleshooting

The following tips are intended to assist you should you need to troubleshoot:

- It is recommended to go through the Section 3.4.9, "Setting up Cross DC with RHDG 7.3" and have this one working first, so that you have some understanding of how things work. It is also wise to read this entire document to have some understanding of things.

- Check in jconsole cluster status (GMS) and the JGroups status (RELAY) of RHDG as described in Section 3.4.9.1, “Setting up the RHDG server”. If things do not look as expected, then the issue is likely in the setup of RHDG servers.

- For the Red Hat Single Sign-On servers, you should see a message like this during the server startup:

```
18:09:30,156 INFO [org.keycloak.connections.infinispan.DefaultInfinispanConnectionProviderFactory] (ServerService Thread Pool -- 54)
Node name: node11, Site name: site1
```
Check that the site name and the node name looks as expected during the startup of Red Hat Single Sign-On server.

- Check that Red Hat Single Sign-On servers are in cluster as expected, including that only the Red Hat Single Sign-On servers from the same data center are in cluster with each other. This can be also checked in JConsole through the GMS view. See cluster troubleshooting for additional details.

- If there are exceptions during startup of Red Hat Single Sign-On server like this:


Caused by: org.infinispan.client.hotrod.exceptions.TransportException:: Could not connect to server: 127.0.0.1:12232

at org.infinispan.client.hotrod.impl.transport.tcp.TcpTransport.<init>(TcpTransport.java:82)

it usually means that Red Hat Single Sign-On server is not able to reach the RHDG server in his own datacenter. Make sure that firewall is set as expected and RHDG server is possible to connect.

- If there are exceptions during startup of Red Hat Single Sign-On server like this:


then check the log of corresponding RHDG server of your site and check if has failed to backup to the other site. If the backup site is unavailable, then it is recommended to switch it offline, so that RHDG server won’t try to backup to the offline site causing the operations to pass successfully on Red Hat Single Sign-On server side as well. See Section 3.4.10, ”Administration of Cross DC deployment” for more information.

- Check the Infinispan statistics, which are available through JMX. For example, try to login and then see if the new session was successfully written to both RHDG servers and is available in the sessions cache there. This can be done indirectly by checking the count of elements in the sessions cache for the MBean jboss.datagrid-infinispan:type=Cache,name="sessions(repl_sync)",manager="clustered",component=Statistics and attribute numberOfEntries. After login, there should be one more entry for numberOfEntries on both RHDG servers on both sites.

- Enable DEBUG logging as described Section 3.4.9.2, “Setting up Red Hat Single Sign-On servers”. For example, if you log in and you think that the new session is not available on the second site, it’s good to check the Red Hat Single Sign-On server logs and check that listeners were triggered as described in the Section 3.4.9.2, “Setting up Red Hat Single Sign-On servers”. If you do not know and want to ask on keycloak-user mailing list, it is helpful to send the log files from Red Hat Single Sign-On servers on both datacenters in the email. Either add the log snippets to the mails or put the logs somewhere and reference them in the email.

- If you updated the entity, such as user, on Red Hat Single Sign-On server on site1 and you do not see that entity updated on the Red Hat Single Sign-On server on site2, then the issue can be either in the replication of the synchronous database itself or that Red Hat Single Sign-On caches are not properly invalidated. You may try to temporarily disable the Red Hat Single Sign-
On caches as described here to nail down if the issue is at the database replication level. Also it may help to manually connect to the database and check if data are updated as expected. This is specific to every database, so you will need to consult the documentation for your database.

- Sometimes you may see the exceptions related to locks like this in RHDG server log:

  (HotRodServerHandler-6-35) ISP0000136: Error executing command ReplaceCommand, writing keys [[B0x033E243034396234..[39]]: org.infinispan.util.concurrent.TimeoutException: ISP0000299: Unable to acquire lock after 0 milliseconds for key [B0x033E243034396234..[39] and requestor GlobalTx:server1:4353. Lock is held by GlobalTx:server1:4352

Those exceptions are not necessarily an issue. They may happen anytime when a concurrent edit of the same entity is triggered on both DCs. This is common in a deployment. Usually the Red Hat Single Sign-On server is notified about the failed operation and will retry it, so from the user’s point of view, there is usually not any issue.

- If there are exceptions during startup of Red Hat Single Sign-On server, like this:

  16:44:18,321 WARN [org.infinispan.client.hotrod.impl.protocol.Codec21] (ServerService Thread Pool -- 55) ISP0004005: Error received from the server: java.lang.SecurityException: ISP000287: Unauthorized access: subject 'Subject with principal(s): []' lacks 'READ' permission ...

These log entries are the result of Red Hat Single Sign-On automatically detecting whether authentication is required on RHDG and mean that authentication is necessary. At this point you will notice that either the server starts successfully and you can safely ignore these or that the server fails to start. If the server fails to start, ensure that RHDG has been configured properly for authentication as described in Section 3.4.9.1, “Setting up the RHDG server”. To prevent this log entry from being included, you can force authentication by setting remoteStoreSecurityEnabled property to true in spi=connectionsInfinispan/provider=default configuration:

```xml
<subsystem xmlns="urn:jboss:domain:keycloak-server:1.1">
  ...
  <spi name="connectionsInfinispan">
    ...
    <provider name="default" enabled="true">
      <properties>
        ...
        <property name="remoteStoreSecurityEnabled" value="true"/>
      </properties>
    </provider>
  </spi>

```

- If you try to authenticate with Red Hat Single Sign-On to your application, but authentication fails with an infinite number of redirects in your browser and you see the errors like this in the Red Hat Single Sign-On server log:

  2017-11-27 14:50:31,587 WARN [org.keycloak.events] (default task-17) type=LOGIN_ERROR, realmId=master, clientId=null, userId=null, ipAddress=aa.bb.cc.dd, error=expired_code, restart_after_timeout=true

it probably means that your load balancer needs to be set to support sticky sessions. Make sure
that the provided route name used during startup of Red Hat Single Sign-On server (Property `jboss.node.name`) contains the correct name used by the load balancer server to identify the current server.

- If the RHSG work cache grows indefinitely, you may be experiencing this RHSG issue, which is caused by cache items not being properly expired. In that case, update the cache declaration with an empty `<expiration />` tag like this:

  ```xml
  <replicated-cache name="work" configuration="sessions-cfg">
    <expiration />
  </replicated-cache>
  ```

- If you see Warnings in the RHSG server log like:

  ```java
  18:06:19,687 WARN  [org.infinispan.server.hotrod.Decoder2x] (HotRod-ServerWorker-7-12)
  ISPN006011: Operation 'PUT_IF_ABSENT' forced to return previous value should be used on transactional caches, otherwise data inconsistency issues could arise under failure situations
  18:06:19,700 WARN  [org.infinispan.server.hotrod.Decoder2x] (HotRod-ServerWorker-7-10)
  ISPN006010: Conditional operation 'REPLACE_IF_UNMODIFIED' should be used with transactional caches, otherwise data inconsistency issues could arise under failure situations
  ```

  you can just ignore them. To avoid the warning, the caches on RHSG server side could be changed to transactional caches, but this is not recommended as it can cause some other issues caused by the bug https://issues.redhat.com/browse/ISPN-9323. So for now, the warnings just need to be ignored.

- If you see errors in the RHSG server log like:

  ```java
  12:08:32,921 ERROR [org.infinispan.server.hotrod.CacheDecodeContext] (HotRod-ServerWorker-7-11) ISPN005003: Exception reported:
  org.infinispan.server.hotrod.InvalidMagicIdException: Error reading magic byte or message id: 7
  at org.infinispan.server.hotrod.HotRodDecoder.readHeader(HotRodDecoder.java:184)
  at org.infinispan.server.hotrod.HotRodDecoder.decodeHeader(HotRodDecoder.java:133)
  at org.infinispan.server.hotrod.HotRodDecoder.decode(HotRodDecoder.java:92)
  at io.netty.handler.codec.ByteToMessageDecoder.callDecode(ByteToMessageDecoder.java:411)
  at io.netty.handler.codec.ByteToMessageDecoder.channelRead(ByteToMessageDecoder.java:248)
  ```

  and you see some similar errors in the Red Hat Single Sign-On log, it can indicate that there are incompatible versions of the Hot Rod protocol being used. This is likely happen when you try to use Red Hat Single Sign-On with an old version of the Infinispan server. It will help if you add the `protocolVersion` property as an additional property to the `remote-store` element in the Red Hat Single Sign-On configuration file. For example:

  ```xml
  <property name="protocolVersion">2.6</property>
  ```
CHAPTER 4. MANAGE SUBSYSTEM CONFIGURATION

Low-level configuration of Red Hat Single Sign-On is done by editing the *standalone.xml*, *standalone-ha.xml*, or *domain.xml* file in your distribution. The location of this file depends on your operating mode.

While there are endless settings you can configure here, this section will focus on configuration of the *keycloak-server* subsystem. No matter which configuration file you are using, configuration of the *keycloak-server* subsystem is the same.

The *keycloak-server* subsystem is typically declared toward the end of the file like this:

```xml
<subsystem xmlns="urn:jboss:domain:keycloak-server:1.1">
  <web-context>auth</web-context>
  ...
</subsystem>
```

Note that anything changed in this subsystem will not take effect until the server is rebooted.

### 4.1. CONFIGURE SPI PROVIDERS

The specifics of each configuration setting is discussed elsewhere in context with that setting. However, it is useful to understand the format used to declare settings on SPI providers.

Red Hat Single Sign-On is a highly modular system that allows great flexibility. There are more than 50 service provider interfaces (SPIs), and you are allowed to swap out implementations of each SPI. An implementation of an SPI is known as a *provider*.

All elements in an SPI declaration are optional, but a full SPI declaration looks like this:

```xml
<spi name="myspi">
  <default-provider>myprovider</default-provider>
  <provider name="myprovider" enabled="true">
    <properties>
      <property name="foo" value="bar"/>
    </properties>
  </provider>
  <provider name="mysecondprovider" enabled="true">
    <properties>
      <property name="foo" value="foo"/>
    </properties>
  </provider>
</spi>
```

Here we have two providers defined for the SPI *myspi*. The *default-provider* is listed as *myprovider*. However it is up to the SPI to decide how it will treat this setting. Some SPIs allow more than one provider and some do not. So *default-provider* can help the SPI to choose.

Also notice that each provider defines its own set of configuration properties. The fact that both providers above have a property called *foo* is just a coincidence.

The type of each property value is interpreted by the provider. However, there is one exception. Consider the *jpa* provider for the *eventsStore* SPI:
We see that the value begins and ends with square brackets. That means that the value will be passed to the provider as a list. In this example, the system will pass the provider a list with two element values `EVENT1` and `EVENT2`. To add more values to the list, just separate each list element with a comma. Unfortunately, you do need to escape the quotes surrounding each list element with `"`.

Follow the steps in Server Developer Guide for more details on custom providers and the configuration of providers.

### 4.2. START THE JBOSS EAP CLI

Besides editing the configuration by hand, you also have the option of changing the configuration by issuing commands via the `jboss-cli` tool. CLI allows you to configure servers locally or remotely. And it is especially useful when combined with scripting.

To start the JBoss EAP CLI, you need to run `jboss-cli`.

**Linux/Unix**

```
$ .../bin/jboss-cli.sh
```

**Windows**

```
> ...in\jboss-cli.bat
```

This will bring you to a prompt like this:

**Prompt**

```
[disconnected /]
```

If you wish to execute commands on a running server, you will first execute the `connect` command.

**connect**

```
[disconnected /] connect
connect
[standalone@localhost:9990 /]
```

You may be thinking to yourself, "I didn’t enter in any username or password!". If you run `jboss-cli` on the same machine as your running standalone server or domain controller and your account has appropriate file permissions, you do not have to setup or enter in an admin username and password. See the JBoss EAP Configuration Guide for more details on how to make things more secure if you are uncomfortable with that setup.
4.3. CLI EMBEDDED MODE

If you do happen to be on the same machine as your standalone server and you want to issue commands while the server is not active, you can embed the server into CLI and make changes in a special mode that disallows incoming requests. To do this, first execute the `embed-server` command with the config file you wish to change.

```
embed-server
```

```
[disconnected /] embed-server --server-config=standalone.xml
[standalone@embedded /]
```

4.4. CLI GUI MODE

The CLI can also run in GUI mode. GUI mode launches a Swing application that allows you to graphically view and edit the entire management model of a running server. GUI mode is especially useful when you need help formatting your CLI commands and learning about the options available. The GUI can also retrieve server logs from a local or remote server.

Start in GUI mode

```
$ .../bin/jboss-cli.sh --gui
```

*Note: to connect to a remote server, you pass the `--connect` option as well. Use the `--help` option for more details.*

After launching GUI mode, you will probably want to scroll down to find the node, `subsystem=keycloak-server`. If you right-click on the node and click `Explore subsystem=keycloak-server`, you will get a new tab that shows only the keycloak-server subsystem.
4.5. CLI SCRIPTING

The CLI has extensive scripting capabilities. A script is just a text file with CLI commands in it. Consider a simple script that turns off theme and template caching.

```
<subsystem=keyslem=server/theme=defaults/:write-attribute(name=cacheThemes,value=false)
/subsystem=keycloen-server/theme=defaults/:write-attribute(name=cacheTemplates,value=false)
```

To execute the script, I can follow the **Scripts** menu in CLI GUI, or execute the script from the command line as follows:

```
$ .../bin/jboss-cli.sh --file=turn-off-caching.cli
```

4.6. CLI RECIPES

Here are some configuration tasks and how to perform them with CLI commands. Note that in all but the first example, we use the wildcard path ** to mean you should substitute or the path to the keycloak-server subsystem.

For standalone, this just means:

```
** = /subsystem=keycloak-server
```

For domain mode, this would mean something like:
** = /profile=auth-server-clustered/subsystem=keycloak-server

4.6.1. Change the web context of the server

/subsystem=keycloak-server/:write-attribute(name=web-context,value=myContext)

4.6.2. Set the global default theme

/**theme=defaults/:write-attribute(name=default,value=myTheme)

4.6.3. Add a new SPI and a provider

/**spi=mySPI/:add
/**spi=mySPI/provider=myProvider/:add(enabled=true)

4.6.4. Disable a provider

/**spi=mySPI/provider=myProvider/:write-attribute(name=enabled,value=false)

4.6.5. Change the default provider for an SPI

/**spi=mySPI/:write-attribute(name=default-provider,value=myProvider)

4.6.6. Configure the dblock SPI

/**spi=dblock/:add(default-provider=jpa)
/**spi=dblock/provider=jpa/:add(properties={lockWaitTimeout => "900"},enabled=true)

4.6.7. Add or change a single property value for a provider

/**spi=dblock/provider=jpa/:map-put(name=properties,key=lockWaitTimeout,value=3)

4.6.8. Remove a single property from a provider

/**spi=dblock/provider=jpa/:map-remove(name=properties,key=lockRecheckTime)

4.6.9. Set values on a provider property of type List

/**spi=eventsStore/provider=jpa/:map-put(name=properties,key=exclude-events,value= [EVENT1,EVENT2])
CHAPTER 5. PROFILES

There are features in Red Hat Single Sign-On that are not enabled by default, these include features that are not fully supported. In addition there are some features that are enabled by default, but that can be disabled.

The features that can be enabled and disabled are:

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Enabled by default</th>
<th>Support level</th>
</tr>
</thead>
<tbody>
<tr>
<td>account2</td>
<td>New Account Management Console</td>
<td>Yes</td>
<td>Supported</td>
</tr>
<tr>
<td>account_api</td>
<td>Account Management REST API</td>
<td>Yes</td>
<td>Supported</td>
</tr>
<tr>
<td>admin_fine_grained_aut_hz</td>
<td>Fine-Grained Admin Permissions</td>
<td>No</td>
<td>Preview</td>
</tr>
<tr>
<td>ciba</td>
<td>OpenID Connect Client Initiated Backchannel Authentication (CIBA)</td>
<td>Yes</td>
<td>Supported</td>
</tr>
<tr>
<td>client_policies</td>
<td>Add client configuration policies</td>
<td>Yes</td>
<td>Supported</td>
</tr>
<tr>
<td>par</td>
<td>OAuth 2.0 Pushed Authorization Requests (PAR)</td>
<td>Yes</td>
<td>Supported</td>
</tr>
<tr>
<td>declarative_user_profile</td>
<td>Configure user profiles using a declarative style</td>
<td>No</td>
<td>Preview</td>
</tr>
<tr>
<td>docker</td>
<td>Docker Registry protocol</td>
<td>No</td>
<td>Supported</td>
</tr>
<tr>
<td>impersonation</td>
<td>Ability for admins to impersonate users</td>
<td>Yes</td>
<td>Supported</td>
</tr>
<tr>
<td>openshift_integration</td>
<td>Extension to enable securing OpenShift</td>
<td>No</td>
<td>Preview</td>
</tr>
<tr>
<td>scripts</td>
<td>Write custom authenticators using JavaScript</td>
<td>No</td>
<td>Preview</td>
</tr>
<tr>
<td>token_exchange</td>
<td>Token Exchange Service</td>
<td>No</td>
<td>Preview</td>
</tr>
<tr>
<td>upload_scripts</td>
<td>Upload scripts</td>
<td>No</td>
<td>Deprecated</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
<td>Enabled by default</td>
<td>Support level</td>
</tr>
<tr>
<td>------------</td>
<td>---------------------------------------</td>
<td>--------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>web_authn</td>
<td>W3C Web Authentication (WebAuthn)</td>
<td>No</td>
<td>Preview</td>
</tr>
</tbody>
</table>

To enable all preview features start the server with:

```
bin/standalone.sh|bat -Dkeycloak.profile=preview
```

You can set this permanently by creating the file `standalone/configuration/profile.properties` (or `domain/servers/server-one/configuration/profile.properties` for `server-one` in domain mode). Add the following to the file:

```
profile=preview
```

To enable a specific feature start the server with:

```
bin/standalone.sh|bat -Dkeycloak.profile.feature.<feature name>=enabled
```

For example to enable Docker use `-Dkeycloak.profile.feature.docker=enabled`.

You can set this permanently in the `profile.properties` file by adding:

```
feature.docker=enabled
```

To disable a specific feature start the server with:

```
bin/standalone.sh|bat -Dkeycloak.profile.feature.<feature name>=disabled
```

For example to disable Impersonation use `-Dkeycloak.profile.feature.impersonation=disabled`.

You can set this permanently in the `profile.properties` file by adding:

```
feature.impersonation=disabled
```
CHAPTER 6. RELATIONAL DATABASE SETUP

Red Hat Single Sign-On comes with its own embedded Java-based relational database called H2. This is the default database that Red Hat Single Sign-On will use to persist data and really only exists so that you can run the authentication server out of the box. We highly recommend that you replace it with a more production ready external database. The H2 database is not very viable in high concurrency situations and should not be used in a cluster either. The purpose of this chapter is to show you how to connect Red Hat Single Sign-On to a more mature database.

Red Hat Single Sign-On uses two layered technologies to persist its relational data. The bottom layered technology is JDBC. JDBC is a Java API that is used to connect to a RDBMS. There are different JDBC drivers per database type that are provided by your database vendor. This chapter discusses how to configure Red Hat Single Sign-On to use one of these vendor-specific drivers.

The top layered technology for persistence is Hibernate JPA. This is an object to relational mapping API that maps Java Objects to relational data. Most deployments of Red Hat Single Sign-On will never have to touch the configuration aspects of Hibernate, but we will discuss how that is done if you run into that rare circumstance.

NOTE
Datasource configuration is covered much more thoroughly in the datasource configuration chapter in the JBoss EAP Configuration Guide.

6.1. RDBMS SETUP CHECKLIST

These are the steps you will need to perform to get an RDBMS configured for Red Hat Single Sign-On.

1. Locate and download a JDBC driver for your database
2. Package the driver JAR into a module and install this module into the server
3. Declare the JDBC driver in the configuration profile of the server
4. Modify the datasource configuration to use your database’s JDBC driver
5. Modify the datasource configuration to define the connection parameters to your database

This chapter will use PostgreSQL for all its examples. Other databases follow the same steps for installation.

6.2. PACKAGE THE JDBC DRIVER

Find and download the JDBC driver JAR for your RDBMS. Before you can use this driver, you must package it up into a module and install it into the server. Modules define JARs that are loaded into the Red Hat Single Sign-On classpath and the dependencies those JARs have on other modules. They are pretty simple to set up.

Within the .../modules/ directory of your Red Hat Single Sign-On distribution, you need to create a directory structure to hold your module definition. The convention is use the Java package name of the JDBC driver for the name of the directory structure. For PostgreSQL, create the directory org/postgresql/main. Copy your database driver JAR into this directory and create an empty module.xml file within it too.

Module Directory
After you have done this, open up the `module.xml` file and create the following XML:

**Module XML**

```xml
<?xml version="1.0" ?>
<module xmlns="urn:jboss:module:1.3" name="org.postgresql">
  <resources>
    <resource-root path="postgresql-9.4.1212.jar"/>
  </resources>
  <dependencies>
    <module name="javax.api"/>
  </dependencies>
</module>
```
The module name should match the directory structure of your module. So, org/postgresql maps to org.postgresql. The resource-root path attribute should specify the JAR filename of the driver. The rest are just the normal dependencies that any JDBC driver JAR would have.

### 6.3. DECLARE AND LOAD JDBC DRIVER

The next thing you have to do is declare your newly packaged JDBC driver into your deployment profile so that it loads and becomes available when the server boots up. Where you perform this action depends on your operating mode. If you’re deploying in standard mode, edit `/standalone/configuration/standalone.xml`. If you’re deploying in standard clustering mode, edit `/standalone/configuration/standalone-ha.xml`. If you’re deploying in domain mode, edit `/domain/configuration/domain.xml`. In domain mode, you’ll need to make sure you edit the profile you are using: either auth-server-standalone or auth-server-clustered.

Within the profile, search for the drivers XML block within the datasources subsystem. You should see a pre-defined driver declared for the H2 JDBC driver. This is where you’ll declare the JDBC driver for your external database.

#### JDBC Drivers

```
<subsystem xmlns="urn:jboss:domain:datasources:6.0">
<datasources>
  ...
  <drivers>
    <driver name="h2" module="com.h2database.h2">
      <xa-datasource-class>org.h2.jdbcx.JdbcDataSource</xa-datasource-class>
    </driver>
  </drivers>
</datasources>
</subsystem>
```

Within the drivers XML block you’ll need to declare an additional JDBC driver. It needs to have a name which you can choose to be anything you want. You specify the module attribute which points to the package you created earlier for the driver JAR. Finally you have to specify the driver’s Java class. Here’s an example of installing PostgreSQL driver that lives in the module example defined earlier in this chapter.

#### Declare Your JDBC Drivers

```
<subsystem xmlns="urn:jboss:domain:datasources:6.0">
<datasources>
  ...
  <drivers>
    <driver name="postgresql" module="org.postgresql">
      <xa-datasource-class>org.postgresql.xa.PGXADatasource</xa-datasource-class>
    </driver>
    <driver name="h2" module="com.h2database.h2">
      <xa-datasource-class>org.h2.jdbcx.JdbcDataSource</xa-datasource-class>
    </driver>
  </drivers>
</datasources>
</subsystem>
```
6.4. MODIFY THE RED HAT SINGLE SIGN-ON DATASOURCE

After declaring your JDBC driver, you have to modify the existing datasource configuration that Red Hat Single Sign-On uses to connect it to your new external database. You’ll do this within the same configuration file and XML block that you registered your JDBC driver in. Here’s an example that sets up the connection to your new database:

Declare Your JDBC Drivers

```xml
<subsystem xmlns="urn:jboss:domain:datasources:6.0">
  <datasources>
    ...
    <datasource jndi-name="java:jboss/datasources/KeycloakDS" pool-name="KeycloakDS" enabled="true" use-java-context="true">
      <connection-url>jdbc:postgresql://localhost/keycloak</connection-url>
      <driver>postgresql</driver>
      <pool>
        <max-pool-size>20</max-pool-size>
      </pool>
      <security>
        <user-name>William</user-name>
        <password>password</password>
      </security>
    </datasource>
    ...
  </datasources>
</subsystem>
```

Search for the datasource definition for KeycloakDS. You’ll first need to modify the connection-url. The documentation for your vendor’s JDBC implementation should specify the format for this connection URL value.

Next define the driver you will use. This is the logical name of the JDBC driver you declared in the previous section of this chapter.

It is expensive to open a new connection to a database every time you want to perform a transaction. To compensate, the datasource implementation maintains a pool of open connections. The max-pool-size specifies the maximum number of connections it will pool. You may want to change the value of this depending on the load of your system.

Finally, with PostgreSQL at least, you need to define the database username and password that is needed to connect to the database. You may be worried that this is in clear text in the example. There are methods to obfuscate this, but this is beyond the scope of this guide.

NOTE

For more information about datasource features, see the datasource configuration chapter in the JBoss EAP Configuration Guide.

6.5. DATABASE CONFIGURATION
The configuration for this component is found in the `standalone.xml`, `standalone-ha.xml`, or `domain.xml` file in your distribution. The location of this file depends on your operating mode.

**Database Config**

```xml
<subsystem xmlns="urn:jboss:domain:keycloak-server:1.1">
  ...
  <spi name="connectionsJpa">
    <provider name="default" enabled="true">
      <properties>
        <property name="dataSource" value="java:jboss/datasources/KeycloakDS"/>
        <property name="initializeEmpty" value="false"/>
        <property name="migrationStrategy" value="manual"/>
        <property name="migrationExport" value="${jboss.home.dir}/keycloak-database-update.sql"/>
      </properties>
    </provider>
  </spi>
  ...
</subsystem>
```

Possible configuration options are:

**dataSource**

JNDI name of the dataSource

**jta**

boolean property to specify if datasource is JTA capable

**driverDialect**

Value of database dialect. In most cases you don’t need to specify this property as dialect will be autodetected by Hibernate.

**initializeEmpty**

Initialize database if empty. If set to false the database has to be manually initialized. If you want to manually initialize the database set migrationStrategy to `manual` which will create a file with SQL commands to initialize the database. Defaults to true.

**migrationStrategy**

Strategy to use to migrate database. Valid values are `update`, `manual` and `validate`. Update will automatically migrate the database schema. Manual will export the required changes to a file with SQL commands that you can manually execute on the database. Validate will simply check if the database is up-to-date.

**migrationExport**

Path for where to write manual database initialization/migration file.

**showSql**

Specify whether Hibernate should show all SQL commands in the console (false by default). This is very verbose!

**formatSql**

Specify whether Hibernate should format SQL commands (true by default)

**globalStatsInterval**

Will log global statistics from Hibernate about executed DB queries and other things. Statistics are always reported to server log at specified interval (in seconds) and are cleared after each report.
Specify the database schema to use

NOTE

These configuration switches and more are described in the *JBoss EAP Development Guide*.

### 6.6. UNICODE CONSIDERATIONS FOR DATABASES

Database schema in Red Hat Single Sign-On only accounts for Unicode strings in the following special fields:

- Realms: display name, HTML display name
- Federation Providers: display name
- Users: username, given name, last name, attribute names and values
- Groups: name, attribute names and values
- Roles: name
- Descriptions of objects

Otherwise, characters are limited to those contained in database encoding which is often 8-bit. However, for some database systems, it is possible to enable UTF-8 encoding of Unicode characters and use full Unicode character set in all text fields. Often, this is counterbalanced by shorter maximum length of the strings than in case of 8-bit encodings.

Some of the databases require special settings to database and/or JDBC driver to be able to handle Unicode characters. Please find the settings for your database below. Note that if a database is listed here, it can still work properly provided it handles UTF-8 encoding properly both on the level of database and JDBC driver.

Technically, the key criterion for Unicode support for all fields is whether the database allows setting of Unicode character set for `VARCHAR` and `CHAR` fields. If yes, there is a high chance that Unicode will be plausible, usually at the expense of field length. If it only supports Unicode in `NVARCHAR` and `NCHAR` fields, Unicode support for all text fields is unlikely as Keycloak schema uses `VARCHAR` and `CHAR` fields extensively.

#### 6.6.1. Oracle Database

Unicode characters are properly handled provided the database was created with Unicode support in `VARCHAR` and `CHAR` fields (e.g. by using `AL32UTF8` character set as the database character set). No special settings is needed for JDBC driver.

If the database character set is not Unicode, then to use Unicode characters in the special fields, the JDBC driver needs to be configured with the connection property `oracle.jdbc.defaultNChar` set to `true`. It might be wise, though not strictly necessary, to also set the `oracle.jdbc.convertNcharLiterals` connection property to `true`. These properties can be set either as system properties or as connection properties. Please note that setting `oracle.jdbc.defaultNChar` may have negative impact on performance. For details, please refer to Oracle JDBC driver configuration documentation.

#### 6.6.2. Microsoft SQL Server Database
Unicode characters are properly handled only for the special fields. No special settings of JDBC driver or database is necessary.

6.6.3. MySQL Database

Unicode characters are properly handled provided the database was created with Unicode support in VARCHAR and CHAR fields in the CREATE DATABASE command (e.g. by using utf8 character set as the default database character set in MySQL 5.5. Please note that utf8mb4 character set does not work due to different storage requirements to utf8 character set [1]). Note that in this case, length restriction to non-special fields does not apply because columns are created to accommodate given amount of characters, not bytes. If the database default character set does not allow storing Unicode, only the special fields allow storing Unicode values.

At the side of JDBC driver settings, it is necessary to add a connection property characterEncoding=UTF-8 to the JDBC connection settings.

6.6.4. PostgreSQL Database

Unicode is supported when the database character set is UTF8. In that case, Unicode characters can be used in any field, there is no reduction of field length for non-special fields. No special settings of JDBC driver is necessary.

The character set of a PostgreSQL database is determined at the time it is created. You can determine the default character set for a PostgreSQL cluster with the SQL command

```
show server_encoding;
```

If the default character set is not UTF 8, then you can create the database with UTF8 as its character set like this:

```
create database keycloak with encoding 'UTF8';
```

CHAPTER 7. HOSTNAME

Red Hat Single Sign-On uses the public hostname for a number of things. For example, in the token issuer fields and URLs sent in password reset emails.

The Hostname SPI provides a way to configure the hostname for a request. The default provider allows setting a fixed URL for frontend requests, while allowing backend requests to be based on the request URL. It is also possible to develop your own provider in the case the built-in provider does not provide the functionality needed.

7.1. DEFAULT PROVIDER

The default hostname provider uses the configured **frontendUrl** as the base URL for frontend requests (requests from user-agents) and uses the request URL as the basis for backend requests (direct requests from clients).

Frontend request do not have to have the same context-path as the Keycloak server. This means you can expose Keycloak on for example [https://auth.example.org](https://auth.example.org) or [https://example.org/keycloak](https://example.org/keycloak) while internally its URL could be [https://10.0.0.10:8080/auth](https://10.0.0.10:8080/auth).

This makes it possible to have user-agents (browsers) send requests to Red Hat Single Sign-On through the public domain name, while internal clients can use an internal domain name or IP address.

This is reflected in the OpenID Connect Discovery endpoint for example where the **authorization_endpoint** uses the frontend URL, while **token_endpoint** uses the backend URL. As a note here a public client for instance would contact Keycloak through the public endpoint, which would result in the base of **authorization_endpoint** and **token_endpoint** being the same.

To set the frontendUrl for Keycloak you can either pass add `-Dkeycloak.frontendUrl=https://auth.example.org` to the startup or you can configure it in **standalone.xml**. See the example below:

```xml
<spi name="hostname">
  <default-provider>
    <provider name="default" enabled="true">
      <properties>
        <property name="frontendUrl" value="https://auth.example.com"/>
        <property name="forceBackendUrlToFrontendUrl" value="false"/>
      </properties>
    </provider>
  </default-provider>
</spi>
```

To update the **frontendUrl** with jboss-cli use the following command:

```
/subsystem=keycloak-server/spi=hostname/provider=default:write-attribute(name=properties.frontendUrl,value="https://auth.example.com")
```

If you want all requests to go through the public domain name you can force backend requests to use the frontend URL as well by setting **forceBackendUrlToFrontendUrl** to **true**.

It is also possible to override the default frontend URL for individual realms. This can be done in the admin console.

If you do not want to expose the admin endpoints and console on the public domain use the property **adminUrl** to set a fixed URL for the admin console, which is different to the **frontendUrl**. It is also
required to block access to /auth/admin externally, for details on how to do that refer to the Server Administration Guide.

7.2. CUSTOM PROVIDER

To develop a custom hostname provider you need to implement org.keycloak.urls.HostnameProviderFactory and org.keycloak.urls.HostnameProvider.

Follow the instructions in the Service Provider Interfaces section in Server Developer Guide for more information on how to develop a custom provider.
CHAPTER 8. NETWORK SETUP

Red Hat Single Sign-On can run out of the box with some networking limitations. For one, all network endpoints bind to localhost so the auth server is really only usable on one local machine. For HTTP based connections, it does not use default ports like 80 and 443. HTTPS/SSL is not configured out of the box and without it, Red Hat Single Sign-On has many security vulnerabilities. Finally, Red Hat Single Sign-On may often need to make secure SSL and HTTPS connections to external servers and thus need a trust store set up so that endpoints can be validated correctly. This chapter discusses all of these things.

8.1. BIND ADDRESSES

By default Red Hat Single Sign-On binds to the localhost loopback address 127.0.0.1. That’s not a very useful default if you want the authentication server available on your network. Generally, what we recommend is that you deploy a reverse proxy or load balancer on a public network and route traffic to individual Red Hat Single Sign-On server instances on a private network. In either case though, you still need to set up your network interfaces to bind to something other than localhost.

Setting the bind address is quite easy and can be done on the command line with either the standalone.sh or domain.sh boot scripts discussed in the Choosing an Operating Mode chapter.

$ standalone.sh -b 192.168.0.5

The -b switch sets the IP bind address for any public interfaces.

Alternatively, if you don’t want to set the bind address at the command line, you can edit the profile configuration of your deployment. Open up the profile configuration file (standalone.xml or domain.xml depending on your operating mode) and look for the interfaces XML block.

```
<interfaces>
  <interface name="management">
    <inet-address value="${jboss.bind.address.management:127.0.0.1}"/>
  </interface>
  <interface name="public">
    <inet-address value="${jboss.bind.address:127.0.0.1}"/>
  </interface>
</interfaces>
```

The public interface corresponds to subsystems creating sockets that are available publicly. An example of one of these subsystems is the web layer which serves up the authentication endpoints of Red Hat Single Sign-On. The management interface corresponds to sockets opened up by the management layer of the JBoss EAP. Specifically the sockets which allow you to use the jboss-cli.sh command line interface and the JBoss EAP web console.

In looking at the public interface you see that it has a special string ${jboss.bind.address:127.0.0.1}. This string denotes a value 127.0.0.1 that can be overridden on the command line by setting a Java system property, i.e.:

$ domain.sh -Djboss.bind.address=192.168.0.5

The -b is just a shorthand notation for this command. So, you can either change the bind address value directly in the profile config, or change it on the command line when you boot up.
NOTE
There are many more options available when setting up interface definitions. For more information, see the network interface in the JBoss EAP Configuration Guide.

8.2. SOCKET PORT BINDINGS

The ports opened for each socket have a pre-defined default that can be overridden at the command line or within configuration. To illustrate this configuration, let’s pretend you are running in standalone mode and open up the .../standalone/configuration/standalone.xml. Search for socket-binding-group.

```xml
<socket-binding-group name="standard-sockets" default-interface="public" port-offset="${jboss.socket.binding.port-offset:0}"
  <socket-binding name="management-http" interface="management"
    port="${jboss.management.http.port:9990}"/>
  <socket-binding name="management-https" interface="management"
    port="${jboss.management.https.port:9993}"/>
  <socket-binding name="ajp" port="${jboss.ajp.port:8009}"/>
  <socket-binding name="http" port="${jboss.http.port:8080}"/>
  <socket-binding name="https" port="${jboss.https.port:8443}"/>
  <socket-binding name="txn-recovery-environment" port="4712"/>
  <socket-binding name="txn-status-manager" port="4713"/>
  <outbound-socket-binding name="mail-smtp">
    <remote-destination host="localhost" port="25"/>
  </outbound-socket-binding>
</socket-binding-group>
```

socket-bindings define socket connections that will be opened by the server. These bindings specify the interface (bind address) they use as well as what port number they will open. The ones you will be most interested in are:

http
- Defines the port used for Red Hat Single Sign-On HTTP connections

https
- Defines the port used for Red Hat Single Sign-On HTTPS connections

ajp
- This socket binding defines the port used for the AJP protocol. This protocol is used by Apache HTTPD server in conjunction mod-cluster when you are using Apache HTTPD as a load balancer.

management-http
- Defines the HTTP connection used by JBoss EAP CLI and web console.

When running in domain mode setting the socket configurations is a bit trickier as the example domain.xml file has multiple socket-binding-groups defined. If you scroll down to the server-group definitions you can see what socket-binding-group is used for each server-group.

domain socket bindings

```xml
<server-groups>
  <server-group name="load-balancer-group" profile="load-balancer">
    ...
  </server-group>
</server-groups>
```
8.3. SETTING UP HTTPS/SSL

WARNING

Red Hat Single Sign-On is not set up by default to handle SSL/HTTPS. It is highly recommended that you either enable SSL on the Red Hat Single Sign-On server itself or on a reverse proxy in front of the Red Hat Single Sign-On server.

This default behavior is defined by the SSL/HTTPS mode of each Red Hat Single Sign-On realm. This is discussed in more detail in the Server Administration Guide, but let’s give some context and a brief overview of these modes.

external requests

Red Hat Single Sign-On can run out of the box without SSL so long as you stick to private IP addresses like localhost, 127.0.0.1, 10.x.x.x, 192.168.x.x, and 172.16.x.x. If you don’t have SSL/HTTPS configured on the server or you try to access Red Hat Single Sign-On over HTTP from a non-private IP address you will get an error.

none

Red Hat Single Sign-On does not require SSL. This should really only be used in development when you are playing around with things.

all requests

Red Hat Single Sign-On requires SSL for all IP addresses.

The SSL mode for each realm can be configured in the Red Hat Single Sign-On admin console.

8.3.1. Enabling SSL/HTTPS for the Red Hat Single Sign-On Server

If you are not using a reverse proxy or load balancer to handle HTTPS traffic for you, you’ll need to enable HTTPS for the Red Hat Single Sign-On server. This involves

1. Obtaining or generating a keystore that contains the private key and certificate for SSL/HTTP traffic
2. Configuring the Red Hat Single Sign-On server to use this keypair and certificate.

8.3.1.1. Creating the Certificate and Java Keystore
In order to allow HTTPS connections, you need to obtain a self signed or third-party signed certificate and import it into a Java keystore before you can enable HTTPS in the web container you are deploying the Red Hat Single Sign-On Server to.

8.3.1.1. Self Signed Certificate

In development, you will probably not have a third party signed certificate available to test a Red Hat Single Sign-On deployment so you'll need to generate a self-signed one using the keytool utility that comes with the Java JDK.

```
$ keytool -genkey -alias localhost -keyalg RSA -keystore keycloak.jks -validity 10950
   Enter keystore password: secret
   Re-enter new password: secret
   What is your first and last name?
   [Unknown]:  localhost
   What is the name of your organizational unit?
   [Unknown]:  Keycloak
   What is the name of your organization?
   [Unknown]:  Red Hat
   What is the name of your City or Locality?
   [Unknown]:  Westford
   What is the name of your State or Province?
   [Unknown]:  MA
   What is the two-letter country code for this unit?
   [Unknown]:  US
   Is CN=localhost, OU=Keycloak, O=Test, L=Westford, ST=MA, C=US correct?
   [no]:  yes
```

You should answer What is your first and last name? question with the DNS name of the machine you're installing the server on. For testing purposes, localhost should be used. After executing this command, the keycloak.jks file will be generated in the same directory as you executed the keytool command in.

If you want a third-party signed certificate, but don't have one, you can obtain one for free at cacert.org. You'll have to do a little set up first before doing this though.

The first thing to do is generate a Certificate Request:

```
$ keytool -certreq -alias yourdomain -keystore keycloak.jks > keycloak.careq
```

Where yourdomain is a DNS name for which this certificate is generated for. Keytool generates the request:

```
-----BEGIN NEW CERTIFICATE REQUEST-----
MIIICjCCAcICAQAwZTELMAkGA1UEBhMCVVMxCToAaGBnCUAgTTEwDgYDVQQIEvrQ==
ZDEQMA4GA1UEChMHUmVkIEhhdDESMBAGA1UEAxMJbG9jYxob3N0
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAr7kck2TaavIEOGbcpl9c0mcY4HhdzmY
Ax2nZIfq1eZEdlPq15aTxwQZzzLDK9qbeAd8Ji79HzSqnRDrxNYaZu7mAYhFKHgixsoIE3o5Yfzbw1
29RyveUVe+wZVcx5o9wolVp5SNIMEL2aFhtX/c1dqlqYVpfnvFshZQalg2nL8juzZcBjj4as
H98qIS7kqi/dkZKsw9NLvyxgJvp7PaXurX29fN3ihig+oFrL22oFyV54BWxXCKUGPN61EGZGW
Fl2qSIGLdctpMD1aJR2bclIhejZKDksjQZoQ5YMxAAGkcYkG6QkgrocDE2YXDbi7Gldf9MegVJ35
2DQmpwIDAQABoDAwLgYJKoZIhvcNAQkOMSEwHzAdBgNVHQ4EFgQUQwlZJBA+fjDdiVzaO9vrE/i
-----END NEW CERTIFICATE REQUEST-----
```
Send this ca request to your CA. The CA will issue you a signed certificate and send it to you. Before you import your new cert, you must obtain and import the root certificate of the CA. You can download the cert from CA (ie.: root.crt) and import as follows:

```bash
$ keytool -import -keystore keycloak.jks -file root.crt -alias root
```

Last step is to import your new CA generated certificate to your keystore:

```bash
$ keytool -import -alias yourdomain -keystore keycloak.jks -file your-certificate.cer
```

### 8.3.1.2. Configure Red Hat Single Sign-On to Use the Keystore

Now that you have a Java keystore with the appropriate certificates, you need to configure your Red Hat Single Sign-On installation to use it. First, you must edit the `standalone.xml`, `standalone-ha.xml`, or `host.xml` file to use the keystore and enable HTTPS. You may then either move the keystore file to the `configuration/` directory of your deployment or the file in a location you choose and provide an absolute path to it. If you are using absolute paths, remove the optional `relative-to` parameter from your configuration (See operating mode).

Add the new `security-realm` element using the CLI:

```bash
$ /core-service=management/security-realm=UndertowRealm:add()
$ /core-service=management/security-realm=UndertowRealm/server-identity=ssl:add(keystore-path=keycloak.jks, keystore-relative-to=jboss.server.config.dir, keystore-password=secret)
```

If using domain mode, the commands should be executed in every host using the `/host=<host_name>/` prefix (in order to create the `security-realm` in all of them), like this, which you would repeat for each host:

```bash
$ /host=<host_name>/core-service=management/security-realm=UndertowRealm/server-identity=ssl:add(keystore-path=keycloak.jks, keystore-relative-to=jboss.server.config.dir, keystore-password=secret)
```

In the standalone or host configuration file, the `security-realms` element should look like this:

```xml
<security-realm name="UndertowRealm">
  <server-identities>
    <ssl>
      <keystore path="keycloak.jks" relative-to="jboss.server.config.dir" keystore-password="secret"
    </ssl>
  </server-identities>
</security-realm>
```
Next, in the standalone or each domain configuration file, search for any instances of `security-realm`. Modify the `https-listener` to use the created realm:

```
$ /subsystem=undertow/server=default-server/https-listener=https:write-attribute(name=security-realm, value=UndertowRealm)
```

If using domain mode, prefix the command with the profile that is being used with: `/profile=<profile_name>/`.

The resulting element, `server name="default-server"`, which is a child element of `<subsystem xmlns="urn:jboss:domain:undertow:12.0">` should contain the following stanza:

```
<subsystem xmlns="urn:jboss:domain:undertow:12.0">
  <buffer-cache name="default"/>
  <server name="default-server">
    <https-listener name="https" socket-binding="https" security-realm="UndertowRealm"/>
    ...
  </server>
</subsystem>
```

### 8.4. OUTGOING HTTP REQUESTS

The Red Hat Single Sign-On server often needs to make non-browser HTTP requests to the applications and services it secures. The auth server manages these outgoing connections by maintaining an HTTP client connection pool. There are some things you'll need to configure in `standalone.xml`, `standalone-ha.xml`, or `domain.xml`. The location of this file depends on your operating mode.

#### HTTP client Config example

```
<spi name="connectionsHttpClient">
  <provider name="default" enabled="true">
    <properties>
      <property name="connection-pool-size" value="256"/>
    </properties>
  </provider>
</spi>
```

Possible configuration options are:

- **establish-connection-timeout-millis**
  
  Timeout for establishing a socket connection.

- **socket-timeout-millis**
  
  If an outgoing request does not receive data for this amount of time, timeout the connection.

- **connection-pool-size**
  
  How many connections can be in the pool (128 by default).

- **max-pooled-per-route**
  
  How many connections can be pooled per host (64 by default).

- **connection-ttl-millis**
  
  Maximum connection time to live in milliseconds. Not set by default.

- **max-connection-idle-time-millis**
  
  Maximum time a connection can stay idle in the connection pool (900 seconds by default).
Maximum time the connection might stay idle in the connection pool (900 seconds by default). Will start background cleaner thread of Apache HTTP client. Set to -1 to disable this checking and the background thread.

**disable-cookies**

true by default. When set to true, this will disable any cookie caching.

**client-keystore**

This is the file path to a Java keystore file. This keystore contains client certificate for two-way SSL.

**client-keystore-password**

Password for the client keystore. This is REQUIRED if client-keystore is set.

**client-key-password**

Password for the client’s key. This is REQUIRED if client-keystore is set.

**proxy-mappings**

Denotes proxy configurations for outgoing HTTP requests. See the section on Proxy Mappings for Outgoing HTTP Requests for more details.

**disable-trust-manager**

If an outgoing request requires HTTPS and this config option is set to true you do not have to specify a truststore. This setting should only be used during development and never in production as it will disable verification of SSL certificates. This is OPTIONAL. The default value is false.

### 8.4.1. Proxy Mappings for Outgoing HTTP Requests

Outgoing HTTP requests sent by Red Hat Single Sign-On can optionally use a proxy server based on a comma delimited list of proxy-mappings. A proxy-mapping denotes the combination of a regex based hostname pattern and a proxy-uri in the form of `hostnamePattern;proxyUri`, e.g:

```
.*\.(google|googleapis).com;http://www-proxy.acme.com:8080
```

To determine the proxy for an outgoing HTTP request the target hostname is matched against the configured hostname patterns. The first matching pattern determines the proxy-uri to use. If none of the configured patterns match for the given hostname then no proxy is used.

If the proxy server requires authentication, include the proxy user’s credentials in this format `username:password@`. For example:

```
.*\.(google|googleapis).com;http://user01:pas2w0rd@www-proxy.acme.com:8080
```

The special value NO_PROXY for the proxy-uri can be used to indicate that no proxy should be used for hosts matching the associated hostname pattern. It is possible to specify a catch-all pattern at the end of the proxy-mappings to define a default proxy for all outgoing requests.

The following example demonstrates the proxy-mapping configuration.

```
# All requests to Google APIs should use http://www-proxy.acme.com:8080 as proxy
.*\.(google|googleapis).com;http://www-proxy.acme.com:8080

# All requests to internal systems should use no proxy
.*\..acme\..com;NO_PROXY

# All other requests should use http://fallback:8080 as proxy
.*;http://fallback:8080
```
This can be configured via the following `jboss-cli` command. Note that you need to properly escape the regex-pattern as shown below.

```
# In case there is no connectionsHttpClient definition yet
/subsystem=keycloak-server/spi=connectionsHttpClient/provider=default:add(enabled=true)

# Configure the proxy-mappings
/subsystem=keycloak-server/spi=connectionsHttpClient/provider=default:write-attribute(name=properties.proxy-mappings,value="\[\".*\.(google|googleapis)\.com;http://www-proxy.acme.com:8080",".*\.acme\.com;NO_PROXY",".*;http://fallback:8080\]")
```

The `jboss-cli` command results in the following subsystem configuration. Note that one needs to encode "" characters with `"`:

```
<spi name="connectionsHttpClient">
  <provider name="default" enabled="true">
    <properties>
      <property name="proxy-mappings" value="\[\".*\.(google|googleapis)\.com;http://www-proxy.acme.com:8080",".*\.acme\.com;NO_PROXY",".*;http://fallback:8080\]"/>
    </properties>
  </provider>
</spi>
```

### 8.4.2. Outgoing HTTPS Request Truststore

When Red Hat Single Sign-On invokes on remote HTTPS endpoints, it has to validate the remote server’s certificate in order to ensure it is connecting to a trusted server. This is necessary in order to prevent man-in-the-middle attacks. The certificates of these remote server’s or the CA that signed these certificates must be put in a truststore. This truststore is managed by the Red Hat Single Sign-On server.

The truststore is used when connecting securely to identity brokers, LDAP identity providers, when sending emails, and for backchannel communication with client applications.

**WARNING**

By default, a truststore provider is not configured, and any https connections fall back to standard java truststore configuration as described in *Java’s JSSE Reference Guide*. If there is no trust established, then these outgoing HTTPS requests will fail.

You can use `keytool` to create a new truststore file or add trusted host certificates to an existing one:

```
$ keytool -import -alias HOSTDOMAIN -keystore truststore.jks -file host-certificate.cer
```
The truststore is configured within the `standalone.xml`, `standalone-ha.xml`, or `domain.xml` file in your distribution. The location of this file depends on your operating mode. You can add your truststore configuration by using the following template:

```xml
<spi name="truststore">
  <provider name="file" enabled="true">
    <properties>
      <property name="file" value="path to your .jks file containing public certificates"/>
      <property name="password" value="password"/>
      <property name="hostname-verification-policy" value="WILDCARD"/>
      <property name="enabled" value="true"/>
    </properties>
  </provider>
</spi>
```

Possible configuration options for this setting are:

**file**

The path to a Java keystore file. HTTPS requests need a way to verify the host of the server they are talking to. This is what the trustore does. The keystore contains one or more trusted host certificates or certificate authorities. This truststore file should only contain public certificates of your secured hosts. This is REQUIRED if enabled is true.

**password**

Password for the truststore. This is REQUIRED if enabled is true.

**hostname-verification-policy**

WILDCARD by default. For HTTPS requests, this verifies the hostname of the server’s certificate. ANY means that the hostname is not verified. WILDCARD Allows wildcards in subdomain names i.e. *.foo.com. STRICT CN must match hostname exactly.

**enabled**

If false (default value), truststore configuration will be ignored, and certificate checking will fall back to JSSE configuration as described. If set to true, you must configure file, and password for the truststore.
CHAPTER 9. CLUSTERING

This section covers configuring Red Hat Single Sign-On to run in a cluster. There’s a number of things you have to do when setting up a cluster, specifically:

- Pick an operation mode
- Configure a shared external database
- Set up a load balancer
- Supplying a private network that supports IP multicast

Picking an operation mode and configuring a shared database have been discussed earlier in this guide. In this chapter we’ll discuss setting up a load balancer and supplying a private network. We’ll also discuss some issues that you need to be aware of when booting up a host in the cluster.

NOTE

It is possible to cluster Red Hat Single Sign-On without IP Multicast, but this topic is beyond the scope of this guide. For more information, see JGroups chapter of the JBoss EAP Configuration Guide.

9.1. RECOMMENDED NETWORK ARCHITECTURE

The recommended network architecture for deploying Red Hat Single Sign-On is to set up an HTTP/HTTPS load balancer on a public IP address that routes requests to Red Hat Single Sign-On servers sitting on a private network. This isolates all clustering connections and provides a nice means of protecting the servers.

NOTE

By default, there is nothing to prevent unauthorized nodes from joining the cluster and broadcasting multicast messages. This is why cluster nodes should be in a private network, with a firewall protecting them from outside attacks.

9.2. CLUSTERING EXAMPLE

Red Hat Single Sign-On does come with an out of the box clustering demo that leverages domain mode. Review the Clustered Domain Example chapter for more details.

9.3. SETTING UP A LOAD BALANCER OR PROXY

This section discusses a number of things you need to configure before you can put a reverse proxy or load balancer in front of your clustered Red Hat Single Sign-On deployment. It also covers configuring the built-in load balancer that was Clustered Domain Example.

The following diagram illustrates the use of a load balancer. In this example, the load balancer serves as a reverse proxy between three clients and a cluster of three Red Hat Single Sign-On servers.

Example Load Balancer Diagram
9.3.1. Identifying Client IP Addresses

A few features in Red Hat Single Sign-On rely on the fact that the remote address of the HTTP client connecting to the authentication server is the real IP address of the client machine. Examples include:

- Event logs - a failed login attempt would be logged with the wrong source IP address
- SSL required - if the SSL required is set to external (the default) it should require SSL for all external requests
- Authentication flows - a custom authentication flow that uses the IP address to for example show OTP only for external requests
- Dynamic Client Registration

This can be problematic when you have a reverse proxy or loadbalancer in front of your Red Hat Single Sign-On authentication server. The usual setup is that you have a frontend proxy sitting on a public network that load balances and forwards requests to backend Red Hat Single Sign-On server instances located in a private network. There is some extra configuration you have to do in this scenario so that the actual client IP address is forwarded to and processed by the Red Hat Single Sign-On server instances. Specifically:

- Configure your reverse proxy or loadbalancer to properly set **X-Forwarded-For** and **X-Forwarded-Proto** HTTP headers.
- Configure your reverse proxy or loadbalancer to preserve the original 'Host' HTTP header.
- Configure the authentication server to read the client’s IP address from **X-Forwarded-For** header.

Configuring your proxy to generate the **X-Forwarded-For** and **X-Forwarded-Proto** HTTP headers and
preserving the original Host HTTP header is beyond the scope of this guide. Take extra precautions to ensure that the X-Forwarded-For header is set by your proxy. If your proxy isn’t configured correctly, then rogue clients can set this header themselves and trick Red Hat Single Sign-On into thinking the client is connecting from a different IP address than it actually is. This becomes really important if you are doing any black or white listing of IP addresses.

Beyond the proxy itself, there are a few things you need to configure on the Red Hat Single Sign-On side of things. If your proxy is forwarding requests via the HTTP protocol, then you need to configure Red Hat Single Sign-On to pull the client’s IP address from the X-Forwarded-For header rather than from the network packet. To do this, open up the profile configuration file (standalone.xml, standalone-ha.xml, or domain.xml depending on your operating mode) and look for the urn:jboss:domain:undertow:12.0 XML block.

X-Forwarded-For HTTP Config

```xml
<subsystem xmlns="urn:jboss:domain:undertow:12.0">
  <buffer-cache name="default"/>
  <server name="default-server">
    <ajp-listener name="ajp" socket-binding="ajp"/>
    <http-listener name="default" socket-binding="http" redirect-socket="https"
      proxy-address-forwarding="true"/>
    ...
  </server>
  ...
</subsystem>
```

Add the proxy-address-forwarding attribute to the http-listener element. Set the value to true.

If your proxy is using the AJP protocol instead of HTTP to forward requests (i.e. Apache HTTPD + mod-cluster), then you have to configure things a little differently. Instead of modifying the http-listener, you need to add a filter to pull this information from the AJP packets.

X-Forwarded-For AJP Config

```xml
<subsystem xmlns="urn:jboss:domain:undertow:12.0">
  <buffer-cache name="default"/>
  <server name="default-server">
    <ajp-listener name="ajp" socket-binding="ajp"/>
    <http-listener name="default" socket-binding="http" redirect-socket="https"/>
    <host name="default-host" alias="localhost">
      ...
      <filter-ref name="proxy-peer"/>
    </host>
  </server>
  ...
</subsystem>
```

9.3.2. Enable HTTPS/SSL with a Reverse Proxy
Assuming that your reverse proxy doesn’t use port 8443 for SSL you also need to configure what port HTTPS traffic is redirected to.

```xml
<subsystem xmlns="urn:jboss:domain:undertow:12.0">
  ...
  <http-listener name="default" socket-binding="http"
    proxy-address-forwarding="true" redirect-socket="proxy-https"/>
  ...
</subsystem>
```

Add the `redirect-socket` attribute to the `http-listener` element. The value should be `proxy-https` which points to a socket binding you also need to define.

Then add a new `socket-binding` element to the `socket-binding-group` element:

```xml
<socket-binding-group name="standard-sockets" default-interface="public"
  port-offset="${jboss.socket.binding.port-offset:0}">
  ...
  <socket-binding name="proxy-https" port="443"/>
  ...
</socket-binding-group>
```

### 9.3.3. Verify Configuration

You can verify the reverse proxy or load balancer configuration by opening the path `/auth/realm/master/.well-known/openid-configuration` through the reverse proxy. For example if the reverse proxy address is `https://acme.com/` then open the URL `https://acme.com/auth/realm/master/.well-known/openid-configuration`. This will show a JSON document listing a number of endpoints for Red Hat Single Sign-On. Make sure the endpoints starts with the address (scheme, domain and port) of your reverse proxy or load balancer. By doing this you make sure that Red Hat Single Sign-On is using the correct endpoint.

You should also verify that Red Hat Single Sign-On sees the correct source IP address for requests. To check this, you can try to login to the admin console with an invalid username and/or password. This should show a warning in the server log something like this:

```
```

Check that the value of `ipAddress` is the IP address of the machine you tried to login with and not the IP address of the reverse proxy or load balancer.

### 9.3.4. Using the Built-In Load Balancer

This section covers configuring the built-in load balancer that is discussed in the Clustered Domain Example.

The Clustered Domain Example is only designed to run on one machine. To bring up a slave on another host, you’ll need to
1. Edit the *domain.xml* file to point to your new host slave

2. Copy the server distribution. You don’t need the *domain.xml*, *host.xml*, or *host-master.xml* files. Nor do you need the *standalone/ directory*.

3. Edit the *host-slave.xml* file to change the bind addresses used or override them on the command line.

**9.3.4.1. Register a New Host With Load Balancer**

Let’s look first at registering the new host slave with the load balancer configuration in *domain.xml*. Open this file and go to the undertow configuration in the *load-balancer profile*. Add a new *host* definition called *remote-host3* within the *reverse-proxy* XML block.

```xml
<subsystem xmlns="urn:jboss:domain:undertow:12.0">
  ...
  <handlers>
    <reverse-proxy name="lb-handler">
      <host name="host1" outbound-socket-binding="remote-host1" scheme="ajp" path="/" instance-id="myroute1"/>
      <host name="host2" outbound-socket-binding="remote-host2" scheme="ajp" path="/" instance-id="myroute2"/>
      <host name="remote-host3" outbound-socket-binding="remote-host3" scheme="ajp" path="/" instance-id="myroute3"/>
    </reverse-proxy>
  </handlers>
  ...
</subsystem>
```

The *output-socket-binding* is a logical name pointing to a *socket-binding* configured later in the *domain.xml* file. The *instance-id* attribute must also be unique to the new host as this value is used by a cookie to enable sticky sessions when load balancing.

Next go down to the *load-balancer-sockets socket-binding-group* and add the *outbound-socket-binding* for *remote-host3*. This new binding needs to point to the host and port of the new host.

```xml
<socket-binding-group name="load-balancer-sockets" default-interface="public">
  ...
  <outbound-socket-binding name="remote-host1">
    <remote-destination host="localhost" port="8159"/>
  </outbound-socket-binding>
  <outbound-socket-binding name="remote-host2">
    <remote-destination host="localhost" port="8259"/>
  </outbound-socket-binding>
  <outbound-socket-binding name="remote-host3">
    <remote-destination host="192.168.0.5" port="8259"/>
  </outbound-socket-binding>
</socket-binding-group>
```

**9.3.4.2. Master Bind Addresses**
Next thing you’ll have to do is to change the public and management bind addresses for the master host. Either edit the domain.xml file as discussed in the Bind Addresses chapter or specify these bind addresses on the command line as follows:

```
$ domain.sh --host-config=host-master.xml -Djboss.bind.address=192.168.0.2 -Djboss.bind.address.management=192.168.0.2
```

9.3.4.3. Host Slave Bind Addresses

Next you’ll have to change the public, management, and domain controller bind addresses (jboss.domain.master-address). Either edit the host-slave.xml file or specify them on the command line as follows:

```
$ domain.sh --host-config=host-slave.xml
-Djboss.bind.address=192.168.0.5
-Djboss.bind.address.management=192.168.0.5
-Djboss.domain.master.address=192.168.0.2
```

The values of jboss.bind.address and jboss.bind.address.management pertain to the host slave’s IP address. The value of jboss.domain.master.address needs to be the IP address of the domain controller, which is the management address of the master host.

9.3.5. Configuring Other Load Balancers

See the load balancing section in the JBoss EAP Configuration Guide for information how to use other software-based load balancers.

9.4. STICKY SESSIONS

Typical cluster deployment consists of the load balancer (reverse proxy) and 2 or more Red Hat Single Sign-On servers on private network. For performance purposes, it may be useful if load balancer forwards all requests related to particular browser session to the same Red Hat Single Sign-On backend node.

The reason is, that Red Hat Single Sign-On is using Infinispan distributed cache under the covers for save data related to current authentication session and user session. The Infinispan distributed caches are configured with one owner by default. That means that particular session is saved just on one cluster node and the other nodes need to lookup the session remotely if they want to access it.

For example if authentication session with ID 123 is saved in the Infinispan cache on node1, and then node2 needs to lookup this session, it needs to send the request to node1 over the network to return the particular session entity.

It is beneficial if particular session entity is always available locally, which can be done with the help of sticky sessions. The workflow in the cluster environment with the public frontend load balancer and two backend Red Hat Single Sign-On nodes can be like this:

- User sends initial request to see the Red Hat Single Sign-On login screen
- This request is served by the frontend load balancer, which forwards it to some random node (eg. node1). Strictly said, the node doesn’t need to be random, but can be chosen according to some other criterias (client IP address etc). It all depends on the implementation and configuration of underlying load balancer (reverse proxy).
- Red Hat Single Sign-On creates authentication session with random ID (eg. 123) and saves it to the Infinispan cache.

- Infinispan distributed cache assigns the primary owner of the session based on the hash of session ID. See Infinispan documentation for more details around this. Let’s assume that Infinispan assigned node2 to be the owner of this session.

- Red Hat Single Sign-On creates the cookie AUTH_SESSION_ID with the format like `<session-id>.<owner-node-id>`. In our example case, it will be `123.node2`.

- Response is returned to the user with the Red Hat Single Sign-On login screen and the AUTH_SESSION_ID cookie in the browser.

From this point, it is beneficial if load balancer forwards all the next requests to the node2 as this is the node, who is owner of the authentication session with ID 123 and hence Infinispan can lookup this session locally. After authentication is finished, the authentication session is converted to user session, which will be also saved on node2 because it has same ID 123.

The sticky session is not mandatory for the cluster setup, however it is good for performance for the reasons mentioned above. You need to configure your loadbalancer to sticky over the AUTH_SESSION_ID cookie. How exactly do this is dependent on your loadbalancer.

It is recommended on the Red Hat Single Sign-On side to use the system property `jboss.node.name` during startup, with the value corresponding to the name of your route. For example, `-Djboss.node.name=node1` will use node1 to identify the route. This route will be used by Infinispan caches and will be attached to the AUTH_SESSION_ID cookie when the node is the owner of the particular key. Here is an example of the start up command using this system property:

```
cd $RHSSO_NODE1
./standalone.sh -c standalone-ha.xml -Djboss.socket.binding.port-offset=100 -Djboss.node.name=node1
```

Typically in production environment the route name should use the same name as your backend host, but it is not required. You can use a different route name. For example, if you want to hide the host name of your Red Hat Single Sign-On server inside your private network.

### 9.4.1. Disable adding the route

Some load balancers can be configured to add the route information by themselves instead of relying on the back end Red Hat Single Sign-On node. However, as described above, adding the route by the Red Hat Single Sign-On is recommended. This is because when done this way performance improves, since Red Hat Single Sign-On is aware of the entity that is the owner of particular session and can route to that node, which is not necessarily the local node.

You are permitted to disable adding route information to the AUTH_SESSION_ID cookie by Red Hat Single Sign-On, if you prefer, by adding the following into your `RHSSO_HOME/standalone/configuration/standalone-ha.xml` file in the Red Hat Single Sign-On subsystem configuration:

```
<subsystem xmlns="urn:jboss:domain:keycloak-server:1.1">
  ...
  <spi name="stickySessionEncoder">
    <provider name="infinispan" enabled="true">
      <properties>
        <property name="shouldAttachRoute" value="false"/>
      </properties>
    </provider>
  </spi>
</subsystem>
```
9.5. MULTICAST NETWORK SETUP

Out of the box clustering support needs IP Multicast. Multicast is a network broadcast protocol. This protocol is used at boot time to discover and join the cluster. It is also used to broadcast messages for the replication and invalidation of distributed caches used by Red Hat Single Sign-On.

The clustering subsystem for Red Hat Single Sign-On runs on the JGroups stack. Out of the box, the bind addresses for clustering are bound to a private network interface with 127.0.0.1 as default IP address. You have to edit your the standalone-ha.xml or domain.xml sections discussed in the Bind Address chapter.

private network config

```xml
  <interfaces>
    ...<interface name="private">
      <inet-address value="${jboss.bind.address.private:127.0.0.1}"/>
    </interface>
    ...<interface name="private">
      <inet-address value="${jboss.bind.address.private:127.0.0.1}"/>
    </interface>
    <socket-binding-group name="standard-sockets" default-interface="public" port-offset="${jboss.socket.binding.port-offset:0}">
      ...
      <socket-binding name="jgroups-mping" interface="private" port="0" multicast-address="${jboss.default.multicast.address:230.0.0.4}" multicast-port="45700"/>
      <socket-binding name="jgroups-tcp" interface="private" port="7600"/>
      <socket-binding name="jgroups-tcp-fd" interface="private" port="57600"/>
      <socket-binding name="jgroups-udp" interface="private" port="55200" multicast-address="${jboss.default.multicast.address:230.0.0.4}" multicast-port="45688"/>
      <socket-binding name="jgroups-udp-fd" interface="private" port="54200"/>
      <socket-binding name="modcluster" port="0" multicast-address="224.0.1.105" multicast-port="23364"/>
      ...
    </socket-binding-group>
```

Things you’ll want to configure are the jboss.bind.address.private and jboss.default.multicast.address as well as the ports of the services on the clustering stack.

**NOTE**

It is possible to cluster Red Hat Single Sign-On without IP Multicast, but this topic is beyond the scope of this guide. For more information, see JGroups in the JBoss EAP Configuration Guide.

9.6. SECURING CLUSTER COMMUNICATION

When cluster nodes are isolated on a private network it requires access to the private network to be able to join a cluster or to view communication in the cluster. In addition you can also enable authentication and encryption for cluster communication. As long as your private network is secure it is not necessary
to enable authentication and encryption. Red Hat Single Sign-On does not send very sensitive information on the cluster in either case.

If you want to enable authentication and encryption for clustering communication, see Securing a Cluster in the JBoss EAP Configuration Guide.

9.7. SERIALIZED CLUSTER STARTUP

Red Hat Single Sign-On cluster nodes are allowed to boot concurrently. When Red Hat Single Sign-On server instance boots up it may do some database migration, importing, or first time initializations. A DB lock is used to prevent start actions from conflicting with one another when cluster nodes boot up concurrently.

By default, the maximum timeout for this lock is 900 seconds. If a node is waiting on this lock for more than the timeout it will fail to boot. Typically you won’t need to increase/decrease the default value, but just in case it’s possible to configure it in standalone.xml, standalone-ha.xml, or domain.xml file in your distribution. The location of this file depends on your operating mode.

```xml
<spi name="dblock">
  <provider name="jpa" enabled="true">
    <properties>
      <property name="lockWaitTimeout" value="900"/>
    </properties>
  </provider>
</spi>
```

9.8. BOOTING THE CLUSTER

Booting Red Hat Single Sign-On in a cluster depends on your operating mode

**Standalone Mode**

$ bin/standalone.sh --server-config=standalone-ha.xml

**Domain Mode**

$ bin/domain.sh --host-config=host-master.xml
$ bin/domain.sh --host-config=host-slave.xml

You may need to use additional parameters or system properties. For example, the parameter `-b` for the binding host or the system property `jboss.node.name` to specify the name of the route, as described in Sticky Sessions section.

9.9. TROUBLESHOOTING

- Note that when you run a cluster, you should see message similar to this in the log of both cluster nodes:

```
INFO [org.infinispan.remoting.transport.jgroups.JGroupsTransport] (Incoming-10,shared=udp)
ISPN000094: Received new cluster view: [node1/keycloak] (2) [node1/keycloak, node2/keycloak]
```
If you see just one node mentioned, it’s possible that your cluster hosts are not joined together.

Usually it’s best practice to have your cluster nodes on private network without firewall for communication among them. Firewall could be enabled just on public access point to your network instead. If for some reason you still need to have firewall enabled on cluster nodes, you will need to open some ports. Default values are UDP port 55200 and multicast port 45688 with multicast address 230.0.0.4. Note that you may need more ports opened if you want to enable additional features like diagnostics for your JGroups stack. Red Hat Single Sign-On delegates most of the clustering work to Infinispan/JGroups. For more information, see JGroups in the JBoss EAP Configuration Guide.

- If you are interested in failover support (high availability), evictions, expiration and cache tuning, see Chapter 10, Server Cache Configuration.
CHAPTER 10. SERVER CACHE CONFIGURATION

Red Hat Single Sign-On has two types of caches. One type of cache sits in front of the database to decrease load on the DB and to decrease overall response times by keeping data in memory. Realm, client, role, and user metadata is kept in this type of cache. This cache is a local cache. Local caches do not use replication even if you are in the cluster with more Red Hat Single Sign-On servers. Instead, they only keep copies locally and if the entry is updated an invalidation message is sent to the rest of the cluster and the entry is evicted. There is separate replicated cache work, which task is to send the invalidation messages to the whole cluster about what entries should be evicted from local caches. This greatly reduces network traffic, makes things efficient, and avoids transmitting sensitive metadata over the wire.

The second type of cache handles managing user sessions, offline tokens, and keeping track of login failures so that the server can detect password phishing and other attacks. The data held in these caches is temporary, in memory only, but is possibly replicated across the cluster.

This chapter discusses some configuration options for these caches for both clustered and non-clustered deployments.

NOTE

More advanced configuration of these caches can be found in the Infinispan section of the JBoss EAP Configuration Guide.

10.1. EVICTION AND EXPIRATION

There are multiple different caches configured for Red Hat Single Sign-On. There is a realm cache that holds information about secured applications, general security data, and configuration options. There is also a user cache that contains user metadata. Both caches default to a maximum of 10000 entries and use a least recently used eviction strategy. Each of them is also tied to an object revisions cache that controls eviction in a clustered setup. This cache is created implicitly and has twice the configured size. The same applies for the authorization cache, which holds the authorization data. The keys cache holds data about external keys and does not need to have dedicated revisions cache. Rather it has expiration explicitly declared on it, so the keys are periodically expired and forced to be periodically downloaded from external clients or identity providers.

The eviction policy and max entries for these caches can be configured in the standalone.xml, standalone-ha.xml, or domain.xml depending on your operating mode. In the configuration file, there is the part with infinispan subsystem, which looks similar to this:

```xml
<subsystem xmlns="urn:jboss:domain:infinispan:12.0">
  <cache-container name="keycloak">
    <local-cache name="realms">
      <object-memory size="10000"/>
    </local-cache>
    <local-cache name="users">
      <object-memory size="10000"/>
    </local-cache>
  </cache-container>

  ... 

  <local-cache name="keys">
    <object-memory size="1000"/>
    <expiration max-idle="3600000"/>
  </local-cache>

  ...
</subsystem>
```
To limit or expand the number of allowed entries simply add or edit the `object` element or the `expiration` element of particular cache configuration.

In addition, there are also separate caches `sessions`, `clientSessions`, `offlineSessions`, `offlineClientSessions`, `loginFailures` and `actionTokens`. These caches are distributed in cluster environment and they are unbounded in size by default. If they are bounded, it would then be possible that some sessions will be lost. Expired sessions are cleared internally by Red Hat Single Sign-On itself to avoid growing the size of these caches without limit. If you see memory issues due to a large number of sessions, you can try to:

- Increase the size of cluster (more nodes in cluster means that sessions are spread more equally among nodes)
- Increase the memory for Red Hat Single Sign-On server process
- Decrease the number of owners to ensure that caches are saved in one single place. See Section 10.2, “Replication and Failover” for more details
- Disable l1-lifespan for distributed caches. See Infinispan documentation for more details
- Decrease session timeouts, which could be done individually for each realm in Red Hat Single Sign-On admin console. But this could affect usability for end users. See Timeouts for more details.

There is an additional replicated cache, `work`, which is mostly used to send messages among cluster nodes; it is also unbounded by default. However, this cache should not cause any memory issues as entries in this cache are very short-lived.

### 10.2. Replication and Failover

There are caches like `sessions`, `authenticationSessions`, `offlineSessions`, `loginFailures` and a few others (See Section 10.1, “Eviction and Expiration” for more details), which are configured as distributed caches when using a clustered setup. Entries are not replicated to every single node, but instead one or more nodes is chosen as an owner of that data. If a node is not the owner of a specific cache entry it queries the cluster to obtain it. What this means for failover is that if all the nodes that own a piece of data go down, that data is lost forever. By default, Red Hat Single Sign-On only specifies one owner for data. So if that one node goes down that data is lost. This usually means that users will be logged out and will have to login again.

You can change the number of nodes that replicate a piece of data by change the `owners` attribute in the `distributed-cache` declaration.

```xml
<subsystem xmlns="urn:jboss:domain:infinispan:12.0">
  <cache-container name="keycloak">
    <distributed-cache name="sessions" owners="2"/>
  </cache-container>
</subsystem>
```

Here we’ve changed it so at least two nodes will replicate one specific user login session.
TIP

The number of owners recommended is really dependent on your deployment. If you do not care if users are logged out when a node goes down, then one owner is good enough and you will avoid replication.

TIP

It is generally wise to configure your environment to use loadbalancer with sticky sessions. It is beneficial for performance as Red Hat Single Sign-On server, where the particular request is served, will be usually the owner of the data from the distributed cache and will therefore be able to look up the data locally. See Section 9.4, “Sticky sessions” for more details.

10.3. DISABLING CACHING

To disable the realm or user cache, you must edit the standalone.xml, standalone-ha.xml, or domain.xml file in your distribution. The location of this file depends on your operating mode. Here’s what the config looks like initially.

```xml
<spi name="userCache">
  <provider name="default" enabled="true"/>
</spi>

<spi name="realmCache">
  <provider name="default" enabled="true"/>
</spi>
```

To disable the cache set the enabled attribute to false for the cache you want to disable. You must reboot your server for this change to take effect.

10.4. CLEARING CACHES AT RUNTIME

To clear the realm or user cache, go to the Red Hat Single Sign-On admin console Realm Settings→Cache Config page. On this page you can clear the realm cache, the user cache or cache of external public keys.

NOTE

The cache will be cleared for all realms!
CHAPTER 11. RED HAT SINGLE SIGN-ON OPERATOR

The Red Hat Single Sign-On Operator automates Red Hat Single Sign-On administration in Openshift. You use this Operator to create custom resources (CRs), which automate administrative tasks. For example, instead of creating a client or a user in the Red Hat Single Sign-On admin console, you can create custom resources to perform those tasks. A custom resource is a YAML file that defines the parameters for the administrative task.

You can create custom resources to perform the following tasks:

- Install Red Hat Single Sign-On
- Create realms
- Create clients
- Create users
- Connect to an external database
- Schedule database backups
- Install extensions and themes

**NOTE**

After you create custom resources for realms, clients, and users, you can manage them by using the Red Hat Single Sign-On admin console or as custom resources using the `oc` command. However, you cannot use both methods, because the Operator performs a one way sync for custom resources that you modify. For example, if you modify a realm custom resource, the changes show up in the admin console. However, if you modify the realm using the admin console, those changes have no effect on the custom resource.

Begin using the Operator by installing the Red Hat Single Sign-On Operator on a cluster.

11.1. INSTALLING THE RED HAT SINGLE SIGN-ON OPERATOR ON A CLUSTER

To install the Red Hat Single Sign-On Operator, you can use:

- The Operator Lifecycle Manager (OLM)

11.1.1. Installing using the Operator Lifecycle Manager

**Prerequisites**

- You have cluster-admin permission or an equivalent level of permissions granted by an administrator.

**Procedure**

Perform this procedure on an OpenShift cluster.

1. Open the OpenShift Container Platform web console.
2. In the left column, click **Operators, OperatorHub**.


**OperatorHub tab in OpenShift**

```
Administrators  ▼
Home
Operators  ▼
OperatorHub
Installed Operators
Workloads  ▼
Networking  ▼
Storage  ▼
Builds  ▼
Monitoring  ▼
Compute  ▼
User Management  ▼
Administration  ▼
```

**OperatorHub**

Discover Operators from the Kubernetes community and Red Hat partners, curated by Red Hat. Operators on your clusters to provide optional add-ons and shared services to your developers, providing a self-service experience.

```
All Items
AI/Machine Learning
Application Runtime
Big Data
Cloud Provider
Database
Developer Tools
Integration & Delivery
Logging & Tracing
Monitoring
Networking
OpenShift Optional
```

**Security**

```
single sign-on operator
```


**Operator Install page on OpenShift**

```
Red Hat Single Sign-On Operator
7.4.0 provided by Red Hat
```

5. Click **Install**.

6. Select a namespace and click Subscribe.
Namespace selection in OpenShift

**Installation Mode**

- All namespaces on the cluster (default)
  
  This mode is not supported by this Operator

- A specific namespace on the cluster
  
  Operator will be available in a single namespace only.

**Installed Namespace**

- keycloak

**Update Channel**

- alpha

**Approval Strategy**

- Automatic

- Manual

---

The Operator starts installing.

**Additional resources**

- When the Operator installation completes, you are ready to create your first custom resource. See [Red Hat Single Sign-On installation using a custom resource](#).

- For more information on OpenShift Operators, see the [OpenShift Operators guide](#).

**Additional resources**

- When the Operator installation completes, you are ready to create your first custom resource. See [Red Hat Single Sign-On installation using a custom resource](#).

- For more information on OpenShift Operators, see the [OpenShift Operators guide](#).
11.2. USING THE RED HAT SINGLE SIGN-ON OPERATOR IN PRODUCTION ENVIRONMENT

- The usage of embedded DB is not supported in a production environment.
- Backup CRD is deprecated and not supported in a production environment.
- We fully support using the rest of the CRDs in production, despite the `v1alpha1` version. We do not plan to make any breaking changes in this CRDs version.

11.3. RED HAT SINGLE SIGN-ON INSTALLATION USING A CUSTOM RESOURCE

You can use the Operator to automate the installation of Red Hat Single Sign-On by creating a Keycloak custom resource. When you use a custom resource to install Red Hat Single Sign-On, you create the components and services that are described here and illustrated in the graphic that follows.

- **keycloak-db-secret** - Stores properties such as the database username, password, and external address (if you connect to an external database)

- **credentials-<CR-Name>** - Admin username and password to log into the Red Hat Single Sign-On admin console (the `<CR-Name>` is based on the Keycloak custom resource name)

- **keycloak** - Keycloak deployment specification that is implemented as a StatefulSet with high availability support

- **keycloak-postgresql** - Starts a PostgreSQL database installation

- **keycloak-discovery** Service - Performs JDBC PING discovery

- **keycloak** Service - Connects to Red Hat Single Sign-On through HTTPS (HTTP is not supported)

- **keycloak-postgresql** Service - Connects an internal and external, if used, database instance

- **keycloak** Route - The URL for accessing the Red Hat Single Sign-On admin console from OpenShift

How Operator components and services interact
11.3.1. The Keycloak custom resource

The Keycloak custom resource is a YAML file that defines the parameters for installation. This file contains three properties.

- **instances** - controls the number of instances running in high availability mode.
- **externalAccess** - if the enabled is True, the Operator creates a route for OpenShift for the Red Hat Single Sign-On cluster.
- **externalDatabase** - in order to connect to an externally hosted database. That topic is covered in the external database section of this guide. Setting it to false should be used only for testing purposes and will install an embedded PostgreSQL database. Be aware that externalDatabase:false is NOT supported in production environments.

Example YAML file for a Keycloak custom resource

```yaml
apiVersion: keycloak.org/v1alpha1
kind: Keycloak
metadata:
  name: example-sso
  labels:
    app: sso
spec:
  instances: 1
  externalAccess:
    enabled: True
```

**NOTE**

You can update the YAML file and the changes appear in the Red Hat Single Sign-On admin console, however changes to the admin console do not update the custom resource.

11.3.2. Creating a Keycloak custom resource on OpenShift
On OpenShift, you use the custom resource to create a route, which is the URL of the admin console, and find the secret, which holds the username and password for the admin console.

**Prerequisites**

- You have a YAML file for this custom resource.
- You have cluster-admin permission or an equivalent level of permissions granted by an administrator.

**Procedure**

1. Create a route using your YAML file: `oc create -f <filename>.yaml -n <namespace>`. For example:

   ```shell
   $ oc create -f sso.yaml -n sso
   keycloak.keycloak.org/example-sso created
   ```

   A route is created in OpenShift.

2. Log into the OpenShift web console.

3. Select **Networking, Routes** and search for Keycloak.

   **Routes screen in OpenShift web console**

   ![Routes screen in OpenShift web console]

   4. On the screen with the Keycloak route, click the URL under **Location**. The Red Hat Single Sign-On admin console login screen appears.

   **Admin console login screen**
5. Locate the username and password for the admin console in the OpenShift web console; under Workloads, click Secrets and search for Keycloak.

Secrets screen in OpenShift web console

6. Enter the username and password into the admin console login screen.

Admin console login screen
Red Hat Single Sign-On master realm

7. Check the status of the custom resource:

   $ oc describe keycloak <CR-name>

Results

After the Operator processes the custom resource, view the status with this command:

   $ oc describe keycloak <CR-name>

Keycloak custom resource Status
Once the installation of Red Hat Single Sign-On completes, you are ready to create a realm custom resource.

An external database is the supported option and needs to be enabled in the Keycloak custom resource. You can disable this option only for testing and enable it when you switch to a production environment. See Connecting to an external database.

11.4. CREATING A REALM CUSTOM RESOURCE

You can use the Operator to create realms in Red Hat Single Sign-On as defined by a custom resource. You define the properties of the realm custom resource in a YAML file.
NOTE
You can update the YAML file and changes appear in the Red Hat Single Sign-On admin console, however changes to the admin console do not update the custom resource.

Example YAML file for a Realm custom resource

```yaml
apiVersion: keycloak.org/v1alpha1
kind: KeycloakRealm
metadata:
  name: test
  labels:
    app: sso
spec:
  realm:
    id: "basic"
    realm: "basic"
    enabled: True
displayName: "Basic Realm"
instanceSelector:
  matchLabels:
    app: sso
```

Prerequisites

- You have a YAML file for this custom resource.
- In the YAML file, the `app` under `instanceSelector` matches the label of a Keycloak custom resource. Matching these values ensures that you create the realm in the right instance of Red Hat Single Sign-On.
- You have cluster-admin permission or an equivalent level of permissions granted by an administrator.

Procedure

1. Use this command on the YAML file that you created: `oc create -f <realm-name>.yaml`. For example:
   ```bash
   $ oc create -f initial_realm.yaml
   keycloak.keycloak.org/test created
   ```
2. Log into the admin console for the related instance of Red Hat Single Sign-On.
3. Click Select Realm and locate the realm that you created.
   The new realm opens.

   **Admin console master realm**
Results

After the Operator processes the custom resource, view the status with this command:

```
$ oc describe keycloak <CR-name>
```

**Realm custom resource status**

Name: example-keycloakrealm
Namespace: keycloak
Labels: app=sso
Annotations: <none>
API Version: keycloak.org/v1alpha1
Kind: KeycloakRealm
Metadata:
  Creation Timestamp: 2019-12-03T09:46:02Z
  Finalizers: realm.cleanup
  Generation: 1
  Resource Version: 804596
  Self Link: /apis/keycloak.org/v1alpha1/namespaces/keycloak/keycloakrealms/example-keycloakrealm
  UID: b7b2f883-15b1-11ea-91e6-02cb885627a6
Spec:
  Instance Selector:
    Match Labels:
      App: sso
  Realm:
    Display Name: Basic Realm
    Enabled: true
    Id: basic
    Realm: basic
Status:
  Login URL:
  Message:
    Phase: reconciling
    Ready: true
  Events: <none>
Additional resources

- When the realm creation completes, you are ready to create a client custom resource.

### 11.5. CREATING A CLIENT CUSTOM RESOURCE

You can use the Operator to create clients in Red Hat Single Sign-On as defined by a custom resource. You define the properties of the realm in a YAML file.

**NOTE**

You can update the YAML file and changes appear in the Red Hat Single Sign-On admin console, however changes to the admin console do not update the custom resource.

**Example YAML file for a Client custom resource**

```yaml
apiVersion: keycloak.org/v1alpha1
kind: KeycloakClient
metadata:
  name: example-client
  labels:
    app: sso
spec:
  realmSelector:
    matchLabels:
      app: <matching labels for KeycloakRealm custom resource>
  client:
    # auto-generated if not supplied
    #id: 123
  clientId: client-secret
  secret: client-secret
  # ...
  # other properties of Keycloak Client
```

**Prerequisites**

- You have a YAML file for this custom resource.
- You have cluster-admin permission or an equivalent level of permissions granted by an administrator.

**Procedure**

1. Use this command on the YAML file that you created: `oc create -f <client-name>.yaml`. For example:

   ```bash
   $ oc create -f initial_client.yaml
   keycloak.keycloak.org/example-client created
   ```


3. Click Clients.
The new client appears in the list of clients.

<table>
<thead>
<tr>
<th>Client ID</th>
<th>Enabled</th>
<th>Base URL</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>account</td>
<td>True</td>
<td><a href="http://localhost:8080/auth/realms/master/accounts/">http://localhost:8080/auth/realms/master/accounts/</a></td>
<td>Edit</td>
</tr>
<tr>
<td>account-console</td>
<td>True</td>
<td><a href="http://localhost:8080/auth/realms/master/accounts/">http://localhost:8080/auth/realms/master/accounts/</a></td>
<td>Edit</td>
</tr>
<tr>
<td>admin-cli</td>
<td>True</td>
<td>Not defined</td>
<td>Edit</td>
</tr>
<tr>
<td>broker</td>
<td>True</td>
<td>Not defined</td>
<td>Edit</td>
</tr>
<tr>
<td>master-realm</td>
<td>True</td>
<td>Not defined</td>
<td>Edit</td>
</tr>
<tr>
<td>security-admin-console</td>
<td>True</td>
<td><a href="http://localhost:8080/auth/admin/master/console/">http://localhost:8080/auth/admin/master/console/</a></td>
<td>Edit</td>
</tr>
</tbody>
</table>

Results

After a client is created, the Operator creates a Secret containing the Client ID and the client’s secret using the following naming pattern: `keycloak-client-secret-<custom resource name>`. For example:

**Client’s Secret**

```yaml
apiVersion: v1
data:
  CLIENT_ID: <base64 encoded Client ID>
  CLIENT_SECRET: <base64 encoded Client Secret>

kind: Secret
```

After the Operator processes the custom resource, view the status with this command:

```
$ oc describe keycloak <CR-name>
```

**Client custom resource Status**

```
Name:    client-secret
Namespace: keycloak
Labels:  app=sso
API Version: keycloak.org/v1alpha1
Kind:    KeycloakClient
Spec:
  Client:
    Client Authenticator Type:  client-secret
    Client Id:                  client-secret
    Id:                        keycloak-client-secret
  Realm Selector:             
    Match Labels:
      App: sso
Status:
  Message:  
  Phase:    reconciling
  Ready:    true
Secondary Resources:
  Secret:
    keycloak-client-secret-client-secret
Events:  <none>
```
Additional resources

- When the client creation completes, you are ready to create a user custom resource.

11.6. CREATING A USER CUSTOM RESOURCE

You can use the Operator to create users in Red Hat Single Sign-On as defined by a custom resource. You define the properties of the user custom resource in a YAML file.

**NOTE**

You can update properties, except for the password, in the YAML file and changes appear in the Red Hat Single Sign-On admin console, however changes to the admin console do not update the custom resource.

Example YAML file for a user custom resource

```yaml
apiVersion: keycloak.org/v1alpha1
customResource:
name: example-user
spec:
user:
  username: "realm_user"
  firstName: "John"
  lastName: "Doe"
  email: "user@example.com"
  enabled: True
  emailVerified: False
  realmRoles:
  - "offline_access"
  clientRoles:
    account:
      - "manage-account"
    realm-management:
      - "manage-users"
  realmSelector:
    matchLabels:
      app: sso
```

Prerequisites

- You have a YAML file for this custom resource.
- The **realmSelector** matches the labels of an existing realm custom resource.
- You have cluster-admin permission or an equivalent level of permissions granted by an administrator.

Procedure

1. Use this command on the YAML file that you created: `oc create -f <user_cr>.yaml`. For example:
2. Log into the admin console for the related instance of Red Hat Single Sign-On.

3. Click Users.

4. Search for the user that you defined in the YAML file. You may need to switch to a different realm to find the user.

Results

After a user is created, the Operator creates a Secret containing the both username and password using the following naming pattern: `credential-<realm name>-<username>-<namespace>`. Here’s an example:

KeycloakUser Secret

```
kind: Secret
apiVersion: v1
data:
  password: <base64 encoded password>
  username: <base64 encoded username>
type: Opaque
```

Once the Operator processes the custom resource, view the status with this command:

```
$ oc describe keycloak <CR-name>
```

User custom resource Status

```
Name:          example-realm-user
Namespace:     keycloak
Labels:        app=sso
API Version:   keycloak.org/v1alpha1
Kind:          KeycloakUser
Spec:
  Realm Selector:
    Match Labels:
      App: sso
User:
  Email:        realm_user@redhat.com
  Credentials:
    Type: password
```
If you have an external database, you can modify the Keycloak custom resource to support it. See Connecting to an external database.

To back up your database using custom resources, see schedule database backups.

11.7. CONNECTING TO AN EXTERNAL DATABASE

You can use the Operator to connect to an external PostgreSQL database by creating a `keycloak-db-secret` YAML file and setting Keycloak CR externalDatabase property to enabled. Note that values are Base64 encoded.

Example YAML file for `keycloak-db-secret`

```yaml
apiVersion: v1
kind: Secret
metadata:
  name: keycloak-db-secret
  namespace: keycloak
stringData:
  POSTGRES_DATABASE: <Database Name>
  POSTGRES_EXTERNAL_ADDRESS: <External Database IP or URL (resolvable by K8s)>
  POSTGRES_EXTERNAL_PORT: <External Database Port>
  POSTGRES_PASSWORD: <Database Password>
  POSTGRES_SUPERUSER: true
  POSTGRES_USERNAME: <Database Username>
type: Opaque
```

The following properties set the hostname or IP address and port of the database.

- **POSTGRES_EXTERNAL_ADDRESS** - an IP address or a hostname of the external database.
- **POSTGRES_EXTERNAL_PORT** - (Optional) A database port.

The other properties work in the same way for a hosted or external database. Set them as follows:

- **POSTGRES_DATABASE** - Database name to be used.
- **POSTGRES_USERNAME** - Database username
- **POSTGRES_PASSWORD** - Database password
• **POSTGRES_SUPERUSER** - Indicates whether backups should run as super user. Typically true.

The Operator will create a Service named `keycloak-postgresql`. This Service is configured by the Operator to expose the external database based on the content of `POSTGRES_EXTERNAL_ADDRESS`. Red Hat Single Sign-On uses this Service to connect to the Database, which means it does not connect to the Database directly but rather through this Service.

The Keycloak custom resource requires updates to enable external database support.

**Example YAML file for Keycloak custom resource that supports an external database**

```yaml
apiVersion: keycloak.org/v1alpha1
kind: Keycloak
metadata:
  labels:
    app: sso
  name: example-keycloak
  namespace: keycloak
spec:
  externalDatabase:
    enabled: true
  instances: 1
```

**Prerequisites**

- You have a YAML file for `keycloak-db-secret`.
- You have modified the Keycloak custom resource to set `externalDatabase` to `true`.
- You have cluster-admin permission or an equivalent level of permissions granted by an administrator.

**Procedure**

1. Locate the secret for your PostgreSQL database: `oc get secret <secret_for_db> -o yaml`. For example:

   ```
   $ oc get secret keycloak-db-secret -o yaml
   apiVersion: v1
   data
   POSTGRES_DATABASE: cm9vdA==
   POSTGRES_EXTERNAL_ADDRESS: MTcyLjE3LjAuMw==
   POSTGRES_EXTERNAL_PORT: NTQzMg==
   $ echo "MTcyLjE3LjAuMw==" | base64 -decode
   192.0.2.3
   
   The `POSTGRES_EXTERNAL_ADDRESS` is in Base64 format.
   
   2. Decode the value for the secret: `echo "<encoded_secret>" | base64 -decode`. For example:

   ```
   $ echo "MTcyLjE3LjAuMw==" | base64 -decode
   192.0.2.3
   
   3. Confirm that the decoded value matches the IP address for your database:

   ```
   $ oc get pods -o wide
   ```
Confirm that `keycloak-postgresql` appears in a list of running services:

```bash
$ oc get svc
NAME                 TYPE       CLUSTER-IP     EXTERNAL-IP  PORT(S)   AGE
keycloak             ClusterIP  203.0.113.0    <none>       8443/TCP  27m
keycloak-discovery   ClusterIP  None           <none>       8080/TCP  27m
keycloak-postgresql  ClusterIP  203.0.113.1    <none>       5432/TCP  27m
```

The `keycloak-postgresql` service sends requests to a set of IP addresses in the backend. These IP addresses are called endpoints.

View the endpoints used by the `keycloak-postgresql` service to confirm that they use the IP addresses for your database:

```bash
$ oc get endpoints keycloak-postgresql
NAME                  ENDPOINTS         AGE
keycloak-postgresql   192.0.2.3.5432    27m
```

Confirm that Red Hat Single Sign-On is running with the external database. This example shows that everything is running:

```bash
$ oc get pods
NAME                        READY  STATUS    RESTARTS   AGE   IP
keycloak-0                  1/1    Running   0          26m   192.0.2.0
keycloak-postgresql-c8vv27m 1/1    Running   0          36m   192.0.2.3
```

### 11.8. SCHEDULING DATABASE BACKUPS

**WARNING**

Backup CR is deprecated and could be removed in future releases.

You can use the Operator to schedule automatic backups of the database as defined by custom resources. The custom resource triggers a backup job and reports back its status.

You can use Operator to create a backup job that performs a one-time backup to a local Persistent Volume.

**Example YAML file for a Backup custom resource**

```yaml
apiVersion: keycloak.org/v1alpha1
kind: KeycloakBackup
metadata:
  name: test-backup
```
Prerequisites

- You have a YAML file for this custom resource.
- You have a `PersistentVolume` with a `claimRef` to reserve it only for a `PersistentVolumeClaim` created by the Red Hat Single Sign-On Operator.

Procedure

1. Create a backup job: `oc create -f <backup_crname>`. For example:

   ```bash
   $ oc create -f one-time-backup.yaml
   keycloak.keycloak.org/test-backup
   
   The Operator creates a `PersistentVolumeClaim` with the following naming scheme: `Keycloak-backup<CR-name>`.
   
2. View a list of volumes:

   ```bash
   $ oc get pvc
   NAME                          STATUS   VOLUME
   keycloak-backup-test-backup   Bound    pvc-e242-ew022d5-093q-3134n-41-adff
   keycloak-postgresql-claim     Bound    pvc-e242-vs29202-9bcd7-093q-31-zadj
   
3. View a list of backup jobs:

   ```bash
   $ oc get jobs
   NAME           COMPLETIONS     DURATION     AGE
   test-backup    0/1             6s           6s
   
4. View the list of executed backup jobs:

   ```bash
   $ oc get pods
   NAME                               READY    STATUS       RESTARTS    AGE
   test-backup-5b4rf                  0/1      Completed    0           24s
   keycloak-0                         1/1      Running      0           52m
   keycloak-postgresql-c824c6-vv27m   1/1      Running      0           71m
   
5. View the log of your completed backup job:

   ```bash
   $ oc logs test-backup-5b4rf
   ==> Component data dump completed
   .
   .
   .
   
Additional resources

- For more details on persistent volumes, see Understanding persistent storage.

11.9. INSTALLING EXTENSIONS AND THEMES
You can use the operator to install extensions and themes that you need for your company or organization. The extension or theme can be anything that Red Hat Single Sign-On can consume. For example, you can add a metrics extension. You add the extension or theme to the Keycloak custom resource.

Example YAML file for a Keycloak custom resource

```
apiVersion: keycloak.org/v1alpha1
kind: Keycloak
metadata:
  name: example-keycloak
labels:
  app: sso
spec:
  instances: 1
  extensions:
  - <url_for_extension_or_theme>
externalAccess:
  enabled: True
```

You can package and deploy themes in the same way as any other extensions. See Deploying Themes manual entry for more information.

**Prerequisites**

- You have a YAML file for the Keycloak custom resource.
- You have cluster-admin permission or an equivalent level of permissions granted by an administrator.

**Procedure**

1. Edit the YAML file for the Keycloak custom resource: `oc edit <CR-name>`
2. Add a line called `extensions: after the `instances` line.
3. Add a URL to a JAR file for your custom extension or theme.
4. Save the file.

The Operator downloads the extension or theme and installs it.

**11.10. COMMAND OPTIONS FOR MANAGING CUSTOM RESOURCES**

After you create a custom request, you can edit it or delete using the `oc` command.

- To edit a custom request, use this command: `oc edit <CR-name>`
- To delete a custom request, use this command: `oc delete <CR-name>`

For example, to edit a realm custom request named test-realm, use this command:

```
$ oc edit test-realm
```

A window opens where you can make changes.
NOTE

You can update the YAML file and changes appear in the Red Hat Single Sign-On admin console, however changes to the admin console do not update the custom resource.

11.11. UPGRADE STRATEGY

You can configure how the operator performs Red Hat Single Sign-On upgrades. You can choose from the following upgrade strategies.

- **recreate**: This is the default strategy. The operator removes all Red Hat Single Sign-On replicas, optionally creates a backup and then creates the replicas based on a newer Red Hat Single Sign-On image. This strategy is suitable for major upgrades as a single Red Hat Single Sign-On version is accessing the underlying database. The downside is Red Hat Single Sign-On needs to be shut down during the upgrade.

- **rolling**: The operator removes one replica at a time and creates it again based on a newer Red Hat Single Sign-On image. This ensures a zero-downtime upgrade but is more suitable for minor version upgrades that do not require database migration since the database is accessed by multiple Red Hat Single Sign-On versions concurrently. Automatic backups are not supported with this strategy.

Example YAML file for a Keycloak custom resource

```yaml
apiVersion: keycloak.org/v1alpha1
kind: Keycloak
metadata:
  name: example-keycloak
labels:
  app: sso
spec:
  instances: 2
migration:
  strategy: recreate
  backups:
    enabled: True
externalAccess:
  enabled: True
```