Red Hat

Red Hat Data Grid 8.3

Data Grid Security Guide

Enable and configure Data Grid security

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Enable and configure Data Grid security

Legal Notice

Abstract

Protect your Data Grid deployments from network intruders. Restrict data access to authorized users.

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RED HAT DATA GRID

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

Schemaless data structure

Flexibility to store different objects as key-value pairs.

Grid-based data storage

Designed to distribute and replicate data across clusters.

Elastic scaling

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

Data interoperability

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

DATA GRID DOCUMENTATION

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

- Data Grid 8.3 Documentation
- Data Grid 8.3 Component Details
- Supported Configurations for Data Grid 8.3
- Data Grid 8 Feature Support
- Data Grid Deprecated Features and Functionality

DATA GRID DOWNLOADS

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

NOTE

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

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 .

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CHAPTER 1. CONFIGURING USER ROLES AND PERMISSIONS

Authorization is a security feature that requires users to have certain permissions before they can access caches or interact with Data Grid resources. You assign roles to users that provide different levels of permissions, from read-only access to full, super user privileges.

1.1. SECURITY AUTHORIZATION

Data Grid authorization secures your deployment by restricting user access.

User applications or clients must belong to a role that is assigned with sufficient permissions before they can perform operations on Cache Managers or caches.

For example, you configure authorization on a specific cache instance so that invoking **Cache.get()** requires an identity to be assigned a role with read permission while **Cache.put()** requires a role with write permission.

In this scenario, if a user application or client with the **io** role attempts to write an entry, Data Grid denies the request and throws a security exception. If a user application or client with the **writer** role sends a write request, Data Grid validates authorization and issues a token for subsequent operations.

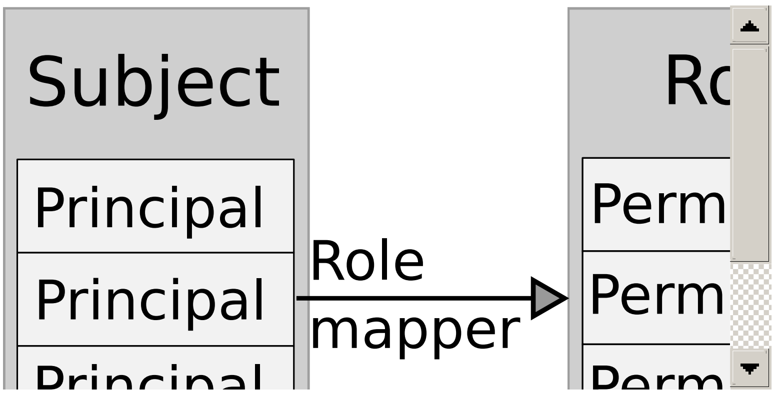
Identities

Identities are security Principals of type **java.security.Principal**. Subjects, implemented with the **javax.security.auth.Subject** class, represent a group of security Principals. In other words, a Subject represents a user and all groups to which it belongs.

Identities to roles

Data Grid uses role mappers so that security principals correspond to roles, which you assign one or more permissions.

The following image illustrates how security principals correspond to roles:



1.1.1. User roles and permissions

Data Grid includes a default set of roles that grant users with permissions to access data and interact with Data Grid resources.

ClusterRoleMapper is the default mechanism that Data Grid uses to associate security principals to authorization roles.

IMPORTANT

ClusterRoleMapper matches principal names to role names. A user named **admin** gets **admin** permissions automatically, a user named **deployer** gets **deployer** permissions, and so on.

Role	Permissions	Description
admin	ALL	Superuser with all permissions including control of the Cache Manager lifecycle.
deployer	ALL_READ, ALL_WRITE, LISTEN, EXEC, MONITOR, CREATE	Can create and delete Data Grid resources in addition to **application** permissions.
application	ALL_READ, ALL_WRITE, LISTEN, EXEC, MONITOR	Has read and write access to Data Grid resources in addition to **observer** permissions. Can also listen to events and execute server tasks and scripts.
observer	ALL_READ, MONITOR	Has read access to Data Grid resources in addition to **monitor** permissions.
monitor	MONITOR	Can view statistics via JMX and the **metrics** endpoint.

Reference

- org.infinispan.security.AuthorizationPermission Enumeration
- Data Grid configuration schema reference

1.1.2. Permissions

Authorization roles have different permissions with varying levels of access to Data Grid. Permissions let you restrict user access to both Cache Managers and caches.

1.1.2.1. Cache Manager permissions

Permission	Function	Description
CONFIGURATION	**defineConfiguration**	Defines new cache configurations.
LISTEN	**addListener**	Registers listeners against a Cache Manager.

Permission	Function	Description
LIFECYCLE	**stop**	Stops the Cache Manager.
CREATE	**createCache**, **removeCache**	Create and remove container resources such as caches, counters, schemas, and scripts.
MONITOR	**getStats**	Allows access to JMX statistics and the **metrics** endpoint.
ALL	-	Includes all Cache Manager permissions.

1.1.2.2. Cache permissions

Permission	Function	Description
READ	**get**, **contains**	Retrieves entries from a cache.
WRITE	**put**, **putIfAbsent**, **replace**, **remove**, **evict**	Writes, replaces, removes, evicts data in a cache.
EXEC	**distexec**, **streams**	Allows code execution against a cache.
LISTEN	**addListener**	Registers listeners against a cache.
BULK_READ	**keySet**, **values**, **entrySet**, **query**	Executes bulk retrieve operations.
BULK_WRITE	**clear**, **putAll**	Executes bulk write operations.
LIFECYCLE	**start**, **stop**	Starts and stops a cache.

Permission	Function	Description
ADMIN	**getVersion**, **addInterceptor***, **removeInterceptor**, **getInterceptorChain**, **getEvictionManager**, **getComponentRegistry**, **getDistributionManager**, **getAuthorizationManager**, **evict**, **getRpcManager**, **getCacheConfiguration**, **getCacheManager**, **getInvocationContextContainer**, **setAvailability**, **getDataContainer**, **getStats**, **getXAResource**	Allows access to underlying components and internal structures.
MONITOR	**getStats**	Allows access to JMX statistics and the **metrics** endpoint.
ALL	-	Includes all cache permissions.
ALL_READ	-	Combines the READ and BULK_READ permissions.
ALL_WRITE	-	Combines the WRITE and BULK_WRITE permissions.

Additional resources

- Data Grid Security API

1.1.3. Role mappers

Data Grid includes a **PrincipalRoleMapper** API that maps security Principals in a Subject to authorization roles that you can assign to users.

1.1.3.1. Cluster role mappers

ClusterRoleMapper uses a persistent replicated cache to dynamically store principal-to-role mappings for the default roles and permissions.

By default uses the Principal name as the role name and implements **org.infinispan.security.MutableRoleMapper** which exposes methods to change role mappings at runtime.

- Java class: **org.infinispan.security.mappers.ClusterRoleMapper**
- Declarative configuration: **<cluster-role-mapper />**

1.1.3.2. Identity role mappers

IdentityRoleMapper uses the Principal name as the role name.

- Java class: **org.infinispan.security.mappers.IdentityRoleMapper**
- Declarative configuration: **<identity-role-mapper />**

1.1.3.3. CommonName role mappers

CommonNameRoleMapper uses the Common Name (CN) as the role name if the Principal name is a Distinguished Name (DN).

For example this DN, **cn=managers,ou=people,dc=example,dc=com**, maps to the **managers** role.

- Java class: **org.infinispan.security.mappers.CommonRoleMapper**
- Declarative configuration: **<common-name-role-mapper />**

1.1.3.4. Custom role mappers

Custom role mappers are implementations of **org.infinispan.security.PrincipalRoleMapper**.

- Declarative configuration: **<custom-role-mapper class="my.custom.RoleMapper" />**

Additional resources

- Data Grid Security API
- org.infinispan.security.PrincipalRoleMapper

1.2. ACCESS CONTROL LIST (ACL) CACHE

Data Grid caches roles that you grant to users internally for optimal performance. Whenever you grant or deny roles to users, Data Grid flushes the ACL cache to ensure user permissions are applied correctly.

If necessary, you can disable the ACL cache or configure it with the **cache-size** and **cache-timeout** attributes.

XML

```xml
<infinispan>
  <cache-container name="acl-cache-configuration">
    <security cache-size="1000"
              cache-timeout="300000">
      <authorization/>
    </security>
  </cache-container>
</infinispan>
```

JSON

```json
{
  "infinispan" : {
    "cache-container" : {
      "name" : "acl-cache-configuration",
```

```
      "security" : {
        "cache-size" : "1000",
        "cache-timeout" : "300000",
        "authorization" : {}
      }
    }
  }
}
```

YAML

```
infinispan:
  cacheContainer:
    name: "acl-cache-configuration"
    security:
      cache-size: "1000"
      cache-timeout: "300000"
      authorization: ~
```

Additional resources

- Data Grid configuration schema reference

1.3. CUSTOMIZING ROLES AND PERMISSIONS

You can customize authorization settings in your Data Grid configuration to use role mappers with different combinations of roles and permissions.

Procedure

1. Declare a role mapper and a set of custom roles and permissions in the Cache Manager configuration.
2. Configure authorization for caches to restrict access based on user roles.

Custom roles and permissions configuration

XML

```
<infinispan>
  <cache-container name="custom-authorization">
    <security>
      <authorization>
        <!-- Declare a role mapper that associates a security principal
             to each role. -->
        <identity-role-mapper />
        <!-- Specify user roles and corresponding permissions. -->
        <role name="admin" permissions="ALL" />
        <role name="reader" permissions="READ" />
        <role name="writer" permissions="WRITE" />
        <role name="supervisor" permissions="READ WRITE EXEC"/>
      </authorization>
```

```
    </security>
  </cache-container>
</infinispan>
```

JSON

```
{
  "infinispan" : {
    "cache-container" : {
      "name" : "custom-authorization",
      "security" : {
        "authorization" : {
          "identity-role-mapper" : null,
          "roles" : {
            "reader" : {
              "role" : {
                "permissions" : "READ"
              }
            },
            "admin" : {
              "role" : {
                "permissions" : "ALL"
              }
            },
            "writer" : {
              "role" : {
                "permissions" : "WRITE"
              }
            },
            "supervisor" : {
              "role" : {
                "permissions" : "READ WRITE EXEC"
              }
            }
          }
        }
      }
    }
  }
}
```

YAML

```
infinispan:
  cacheContainer:
    name: "custom-authorization"
    security:
      authorization:
        identityRoleMapper: "null"
        roles:
          reader:
            role:
              permissions:
                - "READ"
```

```yaml
admin:
  role:
    permissions:
      - "ALL"
writer:
  role:
    permissions:
      - "WRITE"
supervisor:
  role:
    permissions:
      - "READ"
      - "WRITE"
      - "EXEC"
```

1.4. CONFIGURING CACHES WITH SECURITY AUTHORIZATION

Use authorization in your cache configuration to restrict user access. Before they can read or write cache entries, or create and delete caches, users must have a role with a sufficient level of permission.

Prerequisites

- Ensure the **authorization** element is included in the **security** section of the **cache-container** configuration.
  Data Grid enables security authorization in the Cache Manager by default and provides a global set of roles and permissions for caches.
- If necessary, declare custom roles and permissions in the Cache Manager configuration.

Procedure

1. Open your cache configuration for editing.
2. Add the **authorization** element to caches to restrict user access based on their roles and permissions.
3. Save the changes to your configuration.

Authorization configuration

The following configuration shows how to use implicit authorization configuration with default roles and permissions:

XML

```xml
<distributed-cache>
  <security>
    <!-- Inherit authorization settings from the cache-container. --> <authorization/>
  </security>
</distributed-cache>
```

JSON

```json
{
```

```
  "distributed-cache": {
    "security": {
      "authorization": {
        "enabled": true
      }
    }
  }
}
```

YAML

```
distributedCache:
  security:
    authorization:
      enabled: true
```

Custom roles and permissions

XML

```
<distributed-cache>
  <security>
    <authorization roles="admin supervisor"/>
  </security>
</distributed-cache>
```

JSON

```
{
  "distributed-cache": {
    "security": {
      "authorization": {
        "enabled": true,
        "roles": ["admin","supervisor"]
      }
    }
  }
}
```

YAML

```
distributedCache:
  security:
    authorization:
      enabled: true
      roles: ["admin","supervisor"]
```

1.5. DISABLING SECURITY AUTHORIZATION

In local development environments you can disable authorization so that users do not need roles and permissions. Disabling security authorization means that any user can access data and interact with Data Grid resources.

Procedure

1. Open your Data Grid configuration for editing.
2. Remove any **authorization** elements from the **security** configuration for the Cache Manager.
3. Remove any **authorization** configuration from your caches.
4. Save the changes to your configuration.

1.6. PROGRAMMATICALLY CONFIGURING AUTHORIZATION

When using embedded caches, you can configure authorization with the **GlobalSecurityConfigurationBuilder** and **ConfigurationBuilder** classes.

Procedure

1. Construct a **GlobalConfigurationBuilder** that enables authorization, specifies a role mapper, and defines a set of roles and permissions.

```
GlobalConfigurationBuilder global = new GlobalConfigurationBuilder();
global
  .security()
    .authorization().enable() (1)
      .principalRoleMapper(new IdentityRoleMapper()) (2)
      .role("admin") (3)
        .permission(AuthorizationPermission.ALL)
      .role("reader")
        .permission(AuthorizationPermission.READ)
      .role("writer")
        .permission(AuthorizationPermission.WRITE)
      .role("supervisor")
        .permission(AuthorizationPermission.READ)
        .permission(AuthorizationPermission.WRITE)
        .permission(AuthorizationPermission.EXEC);
```

(1) Enables Data Grid authorization for the Cache Manager.

(2) Specifies an implementation of **PrincipalRoleMapper** that maps Principals to roles.

(3) Defines roles and their associated permissions.

2. Enable authorization in the **ConfigurationBuilder** for caches to restrict access based on user roles.

```
ConfigurationBuilder config = new ConfigurationBuilder();
config
  .security()
    .authorization()
      .enable(); (1)
```

1 Implicitly adds all roles from the global configuration.

If you do not want to apply all roles to a cache, explicitly define the roles that are authorized for caches as follows:

```
ConfigurationBuilder config = new ConfigurationBuilder();
config
  .security()
    .authorization()
      .enable()
      .role("admin") 1
      .role("supervisor")
      .role("reader");
```

1 Defines authorized roles for the cache. In this example, users who have the **writer** role only are not authorized for the "secured" cache. Data Grid denies any access requests from those users.

Additional resources

- org.infinispan.configuration.global.GlobalSecurityConfigurationBuilder
- org.infinispan.configuration.cache.ConfigurationBuilder

1.7. CODE EXECUTION WITH SECURITY AUTHORIZATION

When you configure security authorization for embedded caches and then construct a **DefaultCacheManager**, it returns a **SecureCache** that checks the security context before invoking any operations. A **SecureCache** also ensures that applications cannot retrieve lower-level insecure objects such as **DataContainer**. For this reason, you must execute code with an identity that has the required authorization.

In Java, executing code with a specific identity usually means wrapping the code to be executed within a **PrivilegedAction** as follows:

```
import org.infinispan.security.Security;

Security.doAs(subject, new PrivilegedExceptionAction<Void>() {
public Void run() throws Exception {
    cache.put("key", "value");
}
});
```

With Java 8, you can simplify the preceding call as follows:

```
Security.doAs(mySubject, PrivilegedAction<String>() -> cache.put("key", "value"));
```

The preceding call uses the **Security.doAs()** method instead of **Subject.doAs()**. You can use either method with Data Grid, however **Security.doAs()** provides better performance.

If you need the current Subject, use the following call to retrieve it from the Data Grid context or from the AccessControlContext:

–

```
Security.getSubject();
```

CHAPTER 2. SECURITY REALMS

Security realms integrate Data Grid Server deployments with the network protocols and infrastructure in your environment that control access and verify user identities.

2.1. CREATING SECURITY REALMS

Add security realms to Data Grid Server configuration to control access to deployments. You can add one or more security realm to your configuration.

NOTE

When you add security realms to your configuration, Data Grid Server automatically enables the matching authentication mechanisms for the Hot Rod and REST endpoints.

Prerequisites

- Add socket bindings to your Data Grid Server configuration as required.
- Create keystores, or have a PEM file, to configure the security realm with TLS/SSL encryption. Data Grid Server can also generate keystores at startup.
- Provision the resources or services that the security realm configuration relies on.
  For example, if you add a token realm, you need to provision OAuth services.

This procedure demonstrates how to configure multiple property realms. Before you begin, you need to create properties files that add users and assign permissions with the Command Line Interface (CLI). Use the **user create** commands as follows:

```
user create <username> -p <changeme> -g <role> \
    --users-file=application-users.properties \
    --groups-file=application-groups.properties

user create <username> -p <changeme> -g <role> \
    --users-file=management-users.properties \
    --groups-file=management-groups.properties
```

TIP

Run **user create --help** for examples and more information.

NOTE

Adding credentials to a properties realm with the CLI creates the user only on the server instance to which you are connected. You must manually synchronize credentials in a properties realm to each node in the cluster.

Procedure

1. Open your Data Grid Server configuration for editing.
2. Use the **security-realms** element in the **security** configuration to contain create multiple security realms.

3. Add a security realm with the **security-realm** element and give it a unique name with the **name** attribute.

   IMPORTANT

   Do not add special characters, such as hyphens (**-**) or ampersands (**&**), to security realm names. Data Grid Server endpoints can become unreachable if security realm names contain special characters.

   To follow the example, create one security realm named **ApplicationRealm** and another named **ManagementRealm**.

4. Provide the TLS/SSL identify for Data Grid Server with the **server-identities** element and configure a keystore as required.

5. Specify the type of security realm by adding one the following elements or fields:

   - **properties-realm**
   - **ldap-realm**
   - **token-realm**
   - **truststore-realm**

6. Specify properties for the type of security realm you are configuring as appropriate.
   To follow the example, specify the ***.properties** files you created with the CLI using the **path** attribute on the **user-properties** and **group-properties** elements or fields.

7. If you add multiple different types of security realm to your configuration, include the **distributed-realm** element or field so that Data Grid Server uses the realms in combination with each other.

8. Configure Data Grid Server endpoints to use the security realm with the with the **security-realm** attribute.

9. Save the changes to your configuration.

Multiple property realms

The following configuration shows how you can configure multiple security realms in XML, JSON, or YAML format:

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="ApplicationRealm">
        <properties-realm groups-attribute="Roles">
          <user-properties path="application-users.properties"/>
          <group-properties path="application-groups.properties"/>
        </properties-realm>
      </security-realm>
      <security-realm name="ManagementRealm">
        <properties-realm groups-attribute="Roles">
```

```
      <user-properties path="management-users.properties"/>
      <group-properties path="management-groups.properties"/>
    </properties-realm>
   </security-realm>
  </security-realms>
 </security>
</server>
```

JSON

```
{
 "server": {
  "security": {
   "security-realms": [{
    "name": "ManagementRealm",
    "properties-realm": {
     "groups-attribute": "Roles",
     "user-properties": {
      "digest-realm-name": "ManagementRealm",
      "path": "management-users.properties"
     },
     "group-properties": {
      "path": "management-groups.properties"
     }
    }
   }, {
    "name": "ApplicationRealm",
    "properties-realm": {
     "groups-attribute": "Roles",
     "user-properties": {
      "digest-realm-name": "ApplicationRealm",
      "path": "application-users.properties"
     },
     "group-properties": {
      "path": "application-groups.properties"
     }
    }
   }]
  }
 }
}
```

YAML

```
server:
 security:
  securityRealms:
   - name: "ManagementRealm"
    propertiesRealm:
     groupsAttribute: "Roles"
     userProperties:
      digestRealmName: "ManagementRealm"
      path: "management-users.properties"
     groupProperties:
```

```
        path: "management-groups.properties"
  - name: "ApplicationRealm"
    propertiesRealm:
      groupsAttribute: "Roles"
      userProperties:
        digestRealmName: "ApplicationRealm"
        path: "application-users.properties"
      groupProperties:
        path: "application-groups.properties"
```

2.2. SETTING UP KERBEROS IDENTITIES

Add Kerberos identities to a security realm in your Data Grid Server configuration to use *keytab* files that contain service principal names and encrypted keys, derived from Kerberos passwords.

Prerequisites

- Have Kerberos service account principals.

> **NOTE**
>
> *keytab* files can contain both user and service account principals. However, Data Grid Server uses service account principals only which means it can provide identity to clients and allow clients to authenticate with Kerberos servers.

In most cases, you create unique principals for the Hot Rod and REST endpoints. For example, if you have a "datagrid" server in the "INFINISPAN.ORG" domain you should create the following service principals:

- **hotrod/datagrid@INFINISPAN.ORG** identifies the Hot Rod service.
- **HTTP/datagrid@INFINISPAN.ORG** identifies the REST service.

Procedure

1. Create keytab files for the Hot Rod and REST services.

   Linux

   ```
   ktutil
   ktutil:  addent -password -p datagrid@INFINISPAN.ORG -k 1 -e aes256-cts
   Password for datagrid@INFINISPAN.ORG: [enter your password]
   ktutil:  wkt http.keytab
   ktutil:  quit
   ```

   Microsoft Windows

   ```
   ktpass -princ HTTP/datagrid@INFINISPAN.ORG -pass * -mapuser
   INFINISPAN\USER_NAME
   ktab -k http.keytab -a HTTP/datagrid@INFINISPAN.ORG
   ```

2. Copy the keytab files to the **server/conf** directory of your Data Grid Server installation.

3. Open your Data Grid Server configuration for editing.

4. Add a **server-identities** definition to the Data Grid server security realm.

5. Specify the location of keytab files that provide service principals to Hot Rod and REST connectors.

6. Name the Kerberos service principals.

7. Save the changes to your configuration.

Kerberos identity configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="kerberos-realm">
        <server-identities>
          <!-- Specifies a keytab file that provides a Kerberos identity. -->
          <!-- Names the Kerberos service principal for the Hot Rod endpoint. -->
          <!-- The required="true" attribute specifies that the keytab file must be present when the server
starts. -->
          <kerberos keytab-path="hotrod.keytab"
                    principal="hotrod/datagrid@INFINISPAN.ORG"
                    required="true"/>
          <!-- Specifies a keytab file and names the Kerberos service principal for the REST endpoint. -->
          <kerberos keytab-path="http.keytab"
                    principal="HTTP/localhost@INFINISPAN.ORG"
                    required="true"/>
        </server-identities>
      </security-realm>
    </security-realms>
  </security>
  <endpoints>
    <endpoint socket-binding="default"
              security-realm="KerberosRealm">
     <hotrod-connector>
        <authentication>
          <sasl server-name="datagrid"
                server-principal="hotrod/datagrid@INFINISPAN.ORG"/>
        </authentication>
     </hotrod-connector>
     <rest-connector>
       <authentication server-principal="HTTP/localhost@INFINISPAN.ORG"/>
     </rest-connector>
   </endpoint>
  </endpoints>
</server>
```

JSON

```
{
  "server": {
```

```
    "security": {
      "security-realms": [{
        "name": "KerberosRealm",
        "server-identities": [{
          "kerberos": {
            "principal": "hotrod/datagrid@INFINISPAN.ORG",
            "keytab-path": "hotrod.keytab",
            "required": true
          },
          "kerberos": {
            "principal": "HTTP/localhost@INFINISPAN.ORG",
            "keytab-path": "http.keytab",
            "required": true
          }
        }]
      }]
    },
    "endpoints": {
      "endpoint": {
        "socket-binding": "default",
        "security-realm": "KerberosRealm",
        "hotrod-connector": {
          "authentication": {
            "security-realm": "kerberos-realm",
            "sasl": {
              "server-name": "datagrid",
              "server-principal": "hotrod/datagrid@INFINISPAN.ORG"
            }
          }
        },
        "rest-connector": {
          "authentication": {
            "server-principal": "HTTP/localhost@INFINISPAN.ORG"
          }
        }
      }
    }
  }
}
```

YAML

```
server:
  security:
    securityRealms:
      - name: "KerberosRealm"
        serverIdentities:
          - kerberos:
              principal: "hotrod/datagrid@INFINISPAN.ORG"
              keytabPath: "hotrod.keytab"
              required: "true"
          - kerberos:
              principal: "HTTP/localhost@INFINISPAN.ORG"
              keytabPath: "http.keytab"
              required: "true"
```

```
endpoints:
  endpoint:
    socketBinding: "default"
    securityRealm: "KerberosRealm"
    hotrodConnector:
      authentication:
        sasl:
          serverName: "datagrid"
          serverPrincipal: "hotrod/datagrid@INFINISPAN.ORG"
    restConnector:
      authentication:
        securityRealm: "KerberosRealm"
        serverPrincipal" : "HTTP/localhost@INFINISPAN.ORG"
```

2.3. PROPERTY REALMS

Property realms use property files to define users and groups.

- **users.properties** contains Data Grid user credentials. Passwords can be pre-digested with the **DIGEST-MD5** and **DIGEST** authentication mechanisms.
- **groups.properties** associates users with roles and permissions.

> **NOTE**
>
> Properties files contain headers that associate them with security realms in Data Grid Server configuration.

users.properties

```
myuser=a_password
user2=another_password
```

groups.properties

```
myuser=supervisor,reader,writer
user2=supervisor
```

Property realm configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="default">
        <!-- groups-attribute configures the "groups.properties" file to contain security authorization roles.
-->
        <properties-realm groups-attribute="Roles">
          <user-properties path="users.properties"
                           relative-to="infinispan.server.config.path"
                           plain-text="true"/>
          <group-properties path="groups.properties"
```

```
                    relative-to="infinispan.server.config.path"/>
        </properties-realm>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "default",
        "properties-realm": {
          "groups-attribute": "Roles",
          "user-properties": {
            "digest-realm-name": "default",
            "path": "users.properties",
            "relative-to": "infinispan.server.config.path",
            "plain-text": true
          },
          "group-properties": {
            "path": "groups.properties",
            "relative-to": "infinispan.server.config.path"
          }
        }
      }]
    }
  }
}
```

YAML

```
server:
  security:
    securityRealms:
      - name: "default"
        propertiesRealm:
          # groupsAttribute configures the "groups.properties" file
          # to contain security authorization roles.
          groupsAttribute: "Roles"
          userProperties:
            digestRealmName: "default"
            path: "users.properties"
            relative-to: 'infinispan.server.config.path'
            plainText: "true"
          groupProperties:
            path: "groups.properties"
            relative-to: 'infinispan.server.config.path'
```

2.4. LDAP REALMS

LDAP realms connect to LDAP servers, such as OpenLDAP, Red Hat Directory Server, Apache Directory Server, or Microsoft Active Directory, to authenticate users and obtain membership information.

> **NOTE**
>
> LDAP servers can have different entry layouts, depending on the type of server and deployment. It is beyond the scope of this document to provide examples for all possible configurations.

> **IMPORTANT**
>
> The principal for LDAP connections must have necessary privileges to perform LDAP queries and access specific attributes.

As an alternative to verifying user credentials with the **direct-verification** attribute, you can specify an LDAP attribute that validates passwords with the **user-password-mapper** element.

> **NOTE**
>
> You cannot use endpoint authentication mechanisms that perform hashing with the **direct-verification** attribute.
>
> Because Active Directory does not expose the **password** attribute you can use the **direct-verification** attribute only and not the **user-password-mapper** element. As a result you must use the **BASIC** authentication mechanism with the REST endpoint and **PLAIN** with the Hot Rod endpoint to integrate with Active Directory Server. A more secure alternative is to use Kerberos, which allows the **SPNEGO**, **GSSAPI**, and **GS2-KRB5** authentication mechanisms.

The **rdn-identifier** attribute specifies an LDAP attribute that finds the user entry based on a provided identifier, which is typically a username; for example, the **uid** or **sAMAccountName** attribute. Add **search-recursive="true"** to the configuration to search the directory recursively. By default, the search for the user entry uses the **(rdn_identifier={0})** filter. Specify a different filter with the **filter-name** attribute.

The **attribute-mapping** element retrieves all the groups of which the user is a member. There are typically two ways in which membership information is stored:

- Under group entries that usually have class **groupOfNames** in the **member** attribute. In this case, you can use an attribute filter as in the preceding example configuration. This filter searches for entries that match the supplied filter, which locates groups with a **member** attribute equal to the user's DN. The filter then extracts the group entry's CN as specified by **from**, and adds it to the user's **Roles**.
- In the user entry in the **memberOf** attribute. In this case you should use an attribute reference such as the following:
  <attribute-reference reference="memberOf" from="cn" to="Roles" />

  This reference gets all **memberOf** attributes from the user's entry, extracts the CN as specified by **from**, and adds them to the user's **Roles**.

LDAP realm configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="LdapRealm">
        <!-- Specifies connection properties. -->
        <ldap-realm url="ldap://my-ldap-server:10389"
                    principal="uid=admin,ou=People,dc=infinispan,dc=org"
                    credential="strongPassword"
                    connection-timeout="3000"
                    read-timeout="30000"
                    connection-pooling="true"
                    referral-mode="ignore"
                    page-size="30"
                    direct-verification="true">
          <!-- Defines how principals are mapped to LDAP entries. -->
          <identity-mapping rdn-identifier="uid"
                            search-dn="ou=People,dc=infinispan,dc=org"
                            search-recursive="false">
            <!-- Retrieves all the groups of which the user is a member. -->
            <attribute-mapping>
              <attribute from="cn" to="Roles"
                         filter="(&amp;(objectClass=groupOfNames)(member={1}))"
                         filter-dn="ou=Roles,dc=infinispan,dc=org"/>
            </attribute-mapping>
          </identity-mapping>
        </ldap-realm>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "LdapRealm",
        "ldap-realm": {
          "url": "ldap://my-ldap-server:10389",
          "principal": "uid=admin,ou=People,dc=infinispan,dc=org",
          "credential": "strongPassword",
          "connection-timeout": "3000",
          "read-timeout": "30000",
          "connection-pooling": "true",
          "referral-mode": "ignore",
          "page-size": "30",
          "direct-verification": "true",
          "identity-mapping": {
            "rdn-identifier": "uid",
            "search-dn": "ou=People,dc=infinispan,dc=org",
            "search-recursive": "false",
            "attribute-mapping": [{
              "from": "cn",
              "to": "Roles",
```

```
            "filter": "(&(objectClass=groupOfNames)(member={1}))",
            "filter-dn": "ou=Roles,dc=infinispan,dc=org"
          }]
        }
      }
    }]
  }
 }
}
```

YAML

```
server:
  security:
    securityRealms:
      - name: LdapRealm
        ldapRealm:
          url: 'ldap://my-ldap-server:10389'
          principal: 'uid=admin,ou=People,dc=infinispan,dc=org'
          credential: strongPassword
          connectionTimeout: '3000'
          readTimeout: '30000'
          connectionPooling: true
          referralMode: ignore
          pageSize: '30'
          directVerification: true
          identityMapping:
            rdnIdentifier: uid
            searchDn: 'ou=People,dc=infinispan,dc=org'
            searchRecursive: false
            attributeMapping:
              - filter: '(&(objectClass=groupOfNames)(member={1}))'
                filterDn: 'ou=Roles,dc=infinispan,dc=org'
                from: cn
                to: Roles
```

2.4.1. LDAP realm principal re-writing

SASL authentication mechanisms such as **GSSAPI**, **GS2-KRB5** and **Negotiate** include a username that needs to be *cleaned up* before you can use it to search LDAP directories.

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="LdapRealm">
        <ldap-realm url="ldap://${org.infinispan.test.host.address}:10389"
                    principal="uid=admin,ou=People,dc=infinispan,dc=org"
                    credential="strongPassword">
          <name-rewriter>
            <!-- Defines a rewriter that extracts the username from the principal using a regular
expression. -->
            <regex-principal-transformer name="domain-remover"
```

```
                    pattern="(.*)@INFINISPAN\.ORG"
                    replacement="$1"/>
        </name-rewriter>
        <identity-mapping rdn-identifier="uid"
                  search-dn="ou=People,dc=infinispan,dc=org">
          <attribute-mapping>
            <attribute from="cn" to="Roles"
                  filter="(&amp;(objectClass=groupOfNames)(member={1}))"
                  filter-dn="ou=Roles,dc=infinispan,dc=org"/>
          </attribute-mapping>
          <user-password-mapper from="userPassword"/>
        </identity-mapping>
      </ldap-realm>
    </security-realm>
  </security-realms>
 </security>
</server>
```

JSON

```
{
 "server": {
  "security": {
   "security-realms": [{
    "name": "LdapRealm",
    "ldap-realm": {
     "principal": "uid=admin,ou=People,dc=infinispan,dc=org",
     "url": "ldap://${org.infinispan.test.host.address}:10389",
     "credential": "strongPassword",
     "name-rewriter": {
      "regex-principal-transformer": {
       "pattern": "(.*)@INFINISPAN\\.ORG",
       "replacement": "$1"
      }
     },
     "identity-mapping": {
      "rdn-identifier": "uid",
      "search-dn": "ou=People,dc=infinispan,dc=org",
      "attribute-mapping": {
       "attribute": {
        "filter": "(&(objectClass=groupOfNames)(member={1}))",
        "filter-dn": "ou=Roles,dc=infinispan,dc=org",
        "from": "cn",
        "to": "Roles"
       }
      },
      "user-password-mapper": {
       "from": "userPassword"
      }
     }
    }
   }]
  }
 }
}
```

YAML

```yaml
server:
  security:
    securityRealms:
      - name: "LdapRealm"
        ldapRealm:
          principal: "uid=admin,ou=People,dc=infinispan,dc=org"
          url: "ldap://${org.infinispan.test.host.address}:10389"
          credential: "strongPassword"
          nameRewriter:
            regexPrincipalTransformer:
              pattern: (.*)@INFINISPAN\.ORG
              replacement: "$1"
          identityMapping:
            rdnIdentifier: "uid"
            searchDn: "ou=People,dc=infinispan,dc=org"
            attributeMapping:
              attribute:
                filter: "(&(objectClass=groupOfNames)(member={1}))"
                filterDn: "ou=Roles,dc=infinispan,dc=org"
                from: "cn"
                to: "Roles"
            userPasswordMapper:
              from: "userPassword"
```

2.5. TOKEN REALMS

Token realms use external services to validate tokens and require providers that are compatible with RFC-7662 (OAuth2 Token Introspection), such as Red Hat SSO.

Token realm configuration

XML

```xml
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="TokenRealm">
        <!-- Specifies the URL of the authentication server. -->
        <token-realm name="token"
                     auth-server-url="https://oauth-server/auth/">
          <!-- Specifies the URL of the token introspection endpoint. -->
          <oauth2-introspection introspection-url="https://oauth-
server/auth/realms/infinispan/protocol/openid-connect/token/introspect"
                                client-id="infinispan-server"
                                client-secret="1fdca4ec-c416-47e0-867a-3d471af7050f"/>
        </token-realm>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON


```
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "TokenRealm",
        "token-realm": {
          "auth-server-url": "https://oauth-server/auth/",
          "oauth2-introspection": {
            "client-id": "infinispan-server",
            "client-secret": "1fdca4ec-c416-47e0-867a-3d471af7050f",
            "introspection-url": "https://oauth-server/auth/realms/infinispan/protocol/openid-connect/token/introspect"
          }
        }
      }]
    }
  }
}
```


YAML


```
server:
  security:
    securityRealms:
      - name: "TokenRealm"
        tokenRealm:
          authServerUrl: 'https://oauth-server/auth/'
          oauth2Introspection:
            clientId: infinispan-server
            clientSecret: '1fdca4ec-c416-47e0-867a-3d471af7050f'
            introspectionUrl: 'https://oauth-server/auth/realms/infinispan/protocol/openid-connect/token/introspect'
```


2.6. TRUST STORE REALMS

Trust store realms use certificates, or certificates chains, that verify Data Grid Server and client identities when they negotiate connections.

Keystores

Contain server certificates that provide a Data Grid Server identity to clients. If you configure a keystore with server certificates, Data Grid Server encrypts traffic using industry standard SSL/TLS protocols.

Trust stores

Contain client certificates, or certificate chains, that clients present to Data Grid Server. Client trust stores are optional and allow Data Grid Server to perform client certificate authentication.

Client certificate authentication

You must add the **require-ssl-client-auth="true"** attribute to the endpoint configuration if you want Data Grid Server to validate or authenticate client certificates.

Trust store realm configuration

XML

```xml
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="TrustStoreRealm">
        <server-identities>
          <ssl>
            <!-- Provides an SSL/TLS identity with a keystore that contains server certificates. -->
            <keystore path="server.p12"
                      relative-to="infinispan.server.config.path"
                      keystore-password="secret"
                      alias="server"/>
            <!-- Configures a trust store that contains client certificates or part of a certificate chain. -->
            <truststore path="trust.p12"
                        relative-to="infinispan.server.config.path"
                        password="secret"/>
          </ssl>
        </server-identities>
        <!-- Authenticates client certificates against the trust store. If you configure this, the trust store
must contain the public certificates for all clients. -->
        <truststore-realm/>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```json
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "TrustStoreRealm",
        "server-identities": {
          "ssl": {
            "keystore": {
              "path": "server.p12",
              "relative-to": "infinispan.server.config.path",
              "keystore-password": "secret",
              "alias": "server"
            },
            "truststore": {
              "path": "trust.p12",
              "relative-to": "infinispan.server.config.path",
              "password": "secret"
            }
          }
        },
        "truststore-realm": {}
      }]
```

```
      }
    }
  }
```

YAML

```
server:
  security:
    securityRealms:
      - name: "TrustStoreRealm"
        serverIdentities:
          ssl:
            keystore:
              path: "server.p12"
              relative-to: "infinispan.server.config.path"
              keystore-password: "secret"
              alias: "server"
            truststore:
              path: "trust.p12"
              relative-to: "infinispan.server.config.path"
              password: "secret"
        truststoreRealm: ~
```

2.7. DISTRIBUTED SECURITY REALMS

Distributed realms combine multiple different types of security realms. When users attempt to access the Hot Rod or REST endpoints, Data Grid Server uses each security realm in turn until it finds one that can perform the authentication.

Distributed realm configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="DistributedRealm">
        <ldap-realm url="ldap://my-ldap-server:10389"
                    principal="uid=admin,ou=People,dc=infinispan,dc=org"
                    credential="strongPassword">
          <identity-mapping rdn-identifier="uid"
                            search-dn="ou=People,dc=infinispan,dc=org"
                            search-recursive="false">
            <attribute-mapping>
              <attribute from="cn" to="Roles"
                         filter="(&amp;(objectClass=groupOfNames)(member={1}))"
                         filter-dn="ou=Roles,dc=infinispan,dc=org"/>
            </attribute-mapping>
          </identity-mapping>
        </ldap-realm>
        <properties-realm groups-attribute="Roles">
          <user-properties path="users.properties"
                           relative-to="infinispan.server.config.path"/>
```

```
        <group-properties path="groups.properties"
                          relative-to="infinispan.server.config.path"/>
      </properties-realm>
      <distributed-realm/>
    </security-realm>
  </security-realms>
 </security>
</server>
```

JSON

```
{
 "server": {
  "security": {
   "security-realms": [{
    "name": "DistributedRealm",
    "ldap-realm": {
     "principal": "uid=admin,ou=People,dc=infinispan,dc=org",
     "url": "ldap://my-ldap-server:10389",
     "credential": "strongPassword",
     "identity-mapping": {
      "rdn-identifier": "uid",
      "search-dn": "ou=People,dc=infinispan,dc=org",
      "search-recursive": false,
      "attribute-mapping": {
       "attribute": {
        "filter": "(&(objectClass=groupOfNames)(member={1}))",
        "filter-dn": "ou=Roles,dc=infinispan,dc=org",
        "from": "cn",
        "to": "Roles"
       }
      }
     }
    },
    "properties-realm": {
     "groups-attribute": "Roles",
     "user-properties": {
      "digest-realm-name": "DistributedRealm",
      "path": "users.properties"
     },
     "group-properties": {
      "path": "groups.properties"
     }
    },
    "distributed-realm": {}
   }]
  }
 }
}
```

YAML

```
server:
 security:
```

```yaml
securityRealms:
  - name: "DistributedRealm"
    ldapRealm:
      principal: "uid=admin,ou=People,dc=infinispan,dc=org"
      url: "ldap://my-ldap-server:10389"
      credential: "strongPassword"
      identityMapping:
        rdnIdentifier: "uid"
        searchDn: "ou=People,dc=infinispan,dc=org"
        searchRecursive: "false"
        attributeMapping:
          attribute:
            filter: "(&(objectClass=groupOfNames)(member={1}))"
            filterDn: "ou=Roles,dc=infinispan,dc=org"
            from: "cn"
            to: "Roles"
    propertiesRealm:
      groupsAttribute: "Roles"
      userProperties:
        digestRealmName: "DistributedRealm"
        path: "users.properties"
      groupProperties:
        path: "groups.properties"
    distributedRealm: ~
```

CHAPTER 3. ENDPOINT AUTHENTICATION MECHANISMS

Data Grid Server can use custom SASL and HTTP authentication mechanisms for Hot Rod and REST endpoints.

3.1. DATA GRID SERVER AUTHENTICATION

Authentication restricts user access to endpoints as well as the Data Grid Console and Command Line Interface (CLI).

Data Grid Server includes a "default" security realm that enforces user authentication. Default authentication uses a property realm with user credentials stored in the **server/conf/users.properties** file. Data Grid Server also enables security authorization by default so you must assign users with permissions stored in the **server/conf/groups.properties** file.

TIP

Use the **user create** command with the Command Line Interface (CLI) to add users and assign permissions. Run **user create --help** for examples and more information.

3.2. CONFIGURING DATA GRID SERVER AUTHENTICATION MECHANISMS

You can explicitly configure Hot Rod and REST endpoints to use specific authentication mechanisms. Configuring authentication mechanisms is required only if you need to explicitly override the default mechanisms for a security realm.

> **NOTE**
>
> Each **endpoint** section in your configuration must include **hotrod-connector** and **rest-connector** elements or fields. For example, if you explicitly declare a **hotrod-connector** you must also declare a **rest-connector** even if it does not configure an authentication mechanism.

Prerequisites

- Add security realms to your Data Grid Server configuration as required.

Procedure

1. Open your Data Grid Server configuration for editing.
2. Add an **endpoint** element or field and specify the security realm that it uses with the **security-realm** attribute.
3. Add a **hotrod-connector** element or field to configure the Hot Rod endpoint.
    a. Add an **authentication** element or field.
    b. Specify SASL authentication mechanisms for the Hot Rod endpoint to use with the **sasl mechanisms** attribute.
    c. If applicable, specify SASL quality of protection settings with the **qop** attribute.

d. Specify the Data Grid Server identity with the **server-name** attribute if necessary.

4. Add a **rest-connector** element or field to configure the REST endpoint.

   a. Add an **authentication** element or field.

   b. Specify HTTP authentication mechanisms for the REST endpoint to use with the **mechanisms** attribute.

5. Save the changes to your configuration.

Authentication mechanism configuration

The following configuration specifies SASL mechanisms for the Hot Rod endpoint to use for authentication:

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <endpoints>
    <endpoint socket-binding="default"
              security-realm="my-realm">
      <hotrod-connector>
        <authentication>
          <sasl mechanisms="SCRAM-SHA-512 SCRAM-SHA-384 SCRAM-SHA-256
                            SCRAM-SHA-1 DIGEST-SHA-512 DIGEST-SHA-384
                            DIGEST-SHA-256 DIGEST-SHA DIGEST-MD5 PLAIN"
                server-name="infinispan"
                qop="auth"/>
        </authentication>
      </hotrod-connector>
      <rest-connector>
        <authentication mechanisms="DIGEST BASIC"/>
      </rest-connector>
    </endpoint>
  </endpoints>
</server>
```

JSON

```
{
  "server": {
    "endpoints": {
      "endpoint": {
        "socket-binding": "default",
        "security-realm": "my-realm",
        "hotrod-connector": {
          "authentication": {
            "security-realm": "default",
            "sasl": {
              "server-name": "infinispan",
              "mechanisms": ["SCRAM-SHA-512", "SCRAM-SHA-384", "SCRAM-SHA-256", "SCRAM-
SHA-1", "DIGEST-SHA-512", "DIGEST-SHA-384", "DIGEST-SHA-256", "DIGEST-SHA", "DIGEST-
MD5", "PLAIN"],
              "qop": ["auth"]
            }
```

```
          }
        },
        "rest-connector": {
          "authentication": {
            "mechanisms": ["DIGEST", "BASIC"],
            "security-realm": "default"
          }
        }
      }
    }
  }
}
```

YAML

```
server:
  endpoints:
    endpoint:
      socketBinding: "default"
      securityRealm: "my-realm"
      hotrodConnector:
        authentication:
          securityRealm: "default"
          sasl:
            serverName: "infinispan"
            mechanisms:
              - "SCRAM-SHA-512"
              - "SCRAM-SHA-384"
              - "SCRAM-SHA-256"
              - "SCRAM-SHA-1"
              - "DIGEST-SHA-512"
              - "DIGEST-SHA-384"
              - "DIGEST-SHA-256"
              - "DIGEST-SHA"
              - "DIGEST-MD5"
              - "PLAIN"
            qop:
              - "auth"
      restConnector:
        authentication:
          mechanisms:
            - "DIGEST"
            - "BASIC"
          securityRealm: "default"
```

3.2.1. Disabling authentication

In local development environments or on isolated networks you can configure Data Grid to allow unauthenticated client requests. When you disable user authentication you should also disable authorization in your Data Grid security configuration.

Procedure

1. Open your Data Grid Server configuration for editing.

2. Remove the **security-realm** attribute from the **endpoints** element or field.

3. Remove any **authorization** elements from the **security** configuration for the **cache-container** and each cache configuration.

4. Save the changes to your configuration.

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <endpoints socket-binding="default"/>
</server>
```

JSON

```
{
  "server": {
    "endpoints": {
      "endpoint": {
        "socket-binding": "default"
      }
    }
  }
}
```

YAML

```
server:
  endpoints:
    endpoint:
      socketBinding: "default"
```

3.3. DATA GRID SERVER AUTHENTICATION MECHANISMS

Data Grid Server automatically configures endpoints with authentication mechanisms that match your security realm configuration. For example, if you add a Kerberos security realm then Data Grid Server enables the **GSSAPI** and **GS2-KRB5** authentication mechanisms for the Hot Rod endpoint.

Hot Rod endpoints

Data Grid Server enables the following SASL authentication mechanisms for Hot Rod endpoints when your configuration includes the corresponding security realm:

Security realm	SASL authentication mechanism
Property realms and LDAP realms	SCRAM-*, DIGEST-*, **SCRAM-***
Token realms	OAUTHBEARER
Trust realms	EXTERNAL

Security realm	SASL authentication mechanism
Kerberos identities	GSSAPI, GS2-KRB5
SSL/TLS identities	PLAIN

REST endpoints

Data Grid Server enables the following HTTP authentication mechanisms for REST endpoints when your configuration includes the corresponding security realm:

Security realm	HTTP authentication mechanism
Property realms and LDAP realms	DIGEST
Token realms	BEARER_TOKEN
Trust realms	CLIENT_CERT
Kerberos identities	SPNEGO
SSL/TLS identities	BASIC

3.3.1. SASL authentication mechanisms

Data Grid Server supports the following SASL authentications mechanisms with Hot Rod endpoints:

Authentication mechanism	Description	Security realm type	Related details
PLAIN	Uses credentials in plain-text format. You should use **PLAIN** authentication with encrypted connections only.	Property realms and LDAP realms	Similar to the **BASIC** HTTP mechanism.
DIGEST-*	Uses hashing algorithms and nonce values. Hot Rod connectors support **DIGEST-MD5**, **DIGEST-SHA**, **DIGEST-SHA-256**, **DIGEST-SHA-384**, and **DIGEST-SHA-512** hashing algorithms, in order of strength.	Property realms and LDAP realms	Similar to the **Digest** HTTP mechanism.

Authentication mechanism	Description	Security realm type	Related details
SCRAM-*	Uses *salt* values in addition to hashing algorithms and nonce values. Hot Rod connectors support **SCRAM-SHA**, **SCRAM-SHA-256**, **SCRAM-SHA-384**, and **SCRAM-SHA-512** hashing algorithms, in order of strength.	Property realms and LDAP realms	Similar to the **Digest** HTTP mechanism.
GSSAPI	Uses Kerberos tickets and requires a Kerberos Domain Controller. You must add a corresponding **kerberos** server identity in the realm configuration. In most cases, you also specify an **ldap-realm** to provide user membership information.	Kerberos realms	Similar to the **SPNEGO** HTTP mechanism.
GS2-KRB5	Uses Kerberos tickets and requires a Kerberos Domain Controller. You must add a corresponding **kerberos** server identity in the realm configuration. In most cases, you also specify an **ldap-realm** to provide user membership information.	Kerberos realms	Similar to the **SPNEGO** HTTP mechanism.
EXTERNAL	Uses client certificates.	Trust store realms	Similar to the **CLIENT_CERT** HTTP mechanism.
OAUTHBEARER	Uses OAuth tokens and requires a **token-realm** configuration.	Token realms	Similar to the **BEARER_TOKEN** HTTP mechanism.

3.3.2. SASL quality of protection (QoP)

If SASL mechanisms support integrity and privacy protection (QoP) settings, you can add them to your Hot Rod endpoint configuration with the **qop** attribute.

QoP setting	Description
auth	Authentication only.
auth-int	Authentication with integrity protection.
auth-conf	Authentication with integrity and privacy protection.

3.3.3. SASL policies

SASL policies provide fine-grain control over Hot Rod authentication mechanisms.

TIP

Data Grid cache authorization restricts access to caches based on roles and permissions. Configure cache authorization and then set **<no-anonymous value=false />** to allow anonymous login and delegate access logic to cache authorization.

Policy	Description	Default value
forward-secrecy	Use only SASL mechanisms that support forward secrecy between sessions. This means that breaking into one session does not automatically provide information for breaking into future sessions.	false
pass-credentials	Use only SASL mechanisms that require client credentials.	false
no-plain-text	Do not use SASL mechanisms that are susceptible to simple plain passive attacks.	false
no-active	Do not use SASL mechanisms that are susceptible to active, non-dictionary, attacks.	false
no-dictionary	Do not use SASL mechanisms that are susceptible to passive dictionary attacks.	false
no-anonymous	Do not use SASL mechanisms that accept anonymous logins.	true

SASL policy configuration

In the following configuration the Hot Rod endpoint uses the **GSSAPI** mechanism for authentication because it is the only mechanism that complies with all SASL policies:

XML

```xml
<server xmlns="urn:infinispan:server:13.0">
  <endpoints>
    <endpoint socket-binding="default"
              security-realm="default">
      <hotrod-connector>
        <authentication>
          <sasl mechanisms="PLAIN DIGEST-MD5 GSSAPI EXTERNAL"
                server-name="infinispan"
                qop="auth"
                policy="no-active no-plain-text"/>
        </authentication>
      </hotrod-connector>
      <rest-connector/>
    </endpoint>
  </endpoints>
</server>
```

JSON

```json
{
  "server": {
    "endpoints" : {
      "endpoint" : {
        "socket-binding" : "default",
        "security-realm" : "default",
        "hotrod-connector" : {
          "authentication" : {
            "sasl" : {
              "server-name" : "infinispan",
              "mechanisms" : [ "PLAIN","DIGEST-MD5","GSSAPI","EXTERNAL" ],
              "qop" : [ "auth" ],
              "policy" : [ "no-active","no-plain-text" ]
            }
          }
        },
        "rest-connector" : ""
      }
    }
  }
}
```

YAML

```yaml
server:
  endpoints:
    endpoint:
      socketBinding: "default"
```

```
      securityRealm: "default"
      hotrodConnector:
        authentication:
          sasl:
            serverName: "infinispan"
            mechanisms:
              - "PLAIN"
              - "DIGEST-MD5"
              - "GSSAPI"
              - "EXTERNAL"
            qop:
              - "auth"
            policy:
              - "no-active"
              - "no-plain-text"
      restConnector: ~
```

3.3.4. HTTP authentication mechanisms

Data Grid Server supports the following HTTP authentication mechanisms with REST endpoints:

Authentication mechanism	Description	Security realm type	Related details
BASIC	Uses credentials in plain-text format. You should use **BASIC** authentication with encrypted connections only.	Property realms and LDAP realms	Corresponds to the **Basic** HTTP authentication scheme and is similar to the **PLAIN** SASL mechanism.
DIGEST	Uses hashing algorithms and nonce values. REST connectors support **SHA-512**, **SHA-256** and **MD5** hashing algorithms.	Property realms and LDAP realms	Corresponds to the **Digest** HTTP authentication scheme and is similar to **DIGEST-*** SASL mechanisms.
SPNEGO	Uses Kerberos tickets and requires a Kerberos Domain Controller. You must add a corresponding **kerberos** server identity in the realm configuration. In most cases, you also specify an **ldap-realm** to provide user membership information.	Kerberos realms	Corresponds to the **Negotiate** HTTP authentication scheme and is similar to the **GSSAPI** and **GS2-KRB5** SASL mechanisms.

Authentication mechanism	Description	Security realm type	Related details
BEARER_TOKEN	Uses OAuth tokens and requires a **token-realm** configuration.	Token realms	Corresponds to the **Bearer** HTTP authentication scheme and is similar to **OAUTHBEARER** SASL mechanism.
CLIENT_CERT	Uses client certificates.	Trust store realms	Similar to the **EXTERNAL** SASL mechanism.

CHAPTER 4. CONFIGURING TLS/SSL ENCRYPTION

You can secure Data Grid Server connections using SSL/TLS encryption by configuring a keystore that contains public and private keys for Data Grid. You can also configure client certificate authentication if you require mutual TLS.

4.1. CONFIGURING DATA GRID SERVER KEYSTORES

Add keystores to Data Grid Server and configure it to present SSL/TLS certificates that verify its identity to clients. If a security realm contains TLS/SSL identities, it encrypts any connections to Data Grid Server endpoints that use that security realm.

Prerequisites

- Create a keystore that contains certificates, or certificate chains, for Data Grid Server.

Data Grid Server supports the following keystore formats: JKS, JCEKS, PKCS12/PFX and PEM. BKS, BCFKS, and UBER are also supported if the Bouncy Castle library is present.

IMPORTANT

In production environments, server certificates should be signed by a trusted Certificate Authority, either Root or Intermediate CA.

TIP

You can use PEM files as keystores if they contain both of the following:

- A private key in PKCS#1 or PKCS#8 format.
- One or more certificates.

You should also configure PEM file keystores with an empty password (**password=""**).

Procedure

1. Open your Data Grid Server configuration for editing.
2. Add the keystore that contains SSL/TLS identities for Data Grid Server to the **$RHDG_HOME/server/conf** directory.
3. Add a **server-identities** definition to the Data Grid Server security realm.
4. Specify the keystore file name with the **path** attribute.
5. Provide the keystore password and certificate alias with the **keystore-password** and **alias** attributes.
6. Save the changes to your configuration.

Next steps

Configure clients with a trust store so they can verify SSL/TLS identities for Data Grid Server.

Keystore configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="default">
        <server-identities>
          <ssl>
            <!-- Adds a keystore that contains server certificates that provide SSL/TLS identities to clients.
-->
            <keystore path="server.p12"
                      relative-to="infinispan.server.config.path"
                      password="secret"
                      alias="my-server"/>
          </ssl>
        </server-identities>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "default",
        "server-identities": {
          "ssl": {
            "keystore": {
              "alias": "my-server",
              "path": "server.p12",
              "password": "secret"
            }
          }
        }
      }]
    }
  }
}
```

YAML

```
server:
  security:
    securityRealms:
      - name: "default"
        serverIdentities:
          ssl:
            keystore:
              alias: "my-server"
              path: "server.p12"
              password: "secret"
```

Additional resources

- Configuring Hot Rod client encryption

4.1.1. Generating Data Grid Server keystores

Configure Data Grid Server to automatically generate keystores at startup.

> **IMPORTANT**
>
> Automatically generated keystores:
>
> - Should not be used in production environments.
> - Are generated whenever necessary; for example, while obtaining the first connection from a client.
> - Contain certificates that you can use directly in Hot Rod clients.

Procedure

1. Open your Data Grid Server configuration for editing.
2. Include the **generate-self-signed-certificate-host** attribute for the **keystore** element in the server configuration.
3. Specify a hostname for the server certificate as the value.
4. Save the changes to your configuration.

Generated keystore configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="GeneratedKeystore">
        <server-identities>
          <ssl>
            <!-- Generates a keystore that includes a self-signed certificate with the specified hostname. --
>
            <keystore path="server.p12"
                      relative-to="infinispan.server.config.path"
                      password="secret"
                      alias="server"
                      generate-self-signed-certificate-host="localhost"/>
          </ssl>
        </server-identities>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```json
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "GeneratedKeystore",
        "server-identities": {
          "ssl": {
            "keystore": {
              "alias": "server",
              "generate-self-signed-certificate-host": "localhost",
              "path": "server.p12",
              "password": "secret"
            }
          }
        }
      }]
    }
  }
}
```

YAML

```yaml
server:
  security:
    securityRealms:
      - name: "GeneratedKeystore"
        serverIdentities:
          ssl:
            keystore:
              alias: "server"
              generateSelfSignedCertificateHost: "localhost"
              path: "server.p12"
              password: "secret"
```

4.1.2. Configuring TLS versions and cipher suites

When using SSL/TLS encryption to secure your deployment, you can configure Data Grid Server to use specific versions of the TLS protocol as well as specific cipher suites within the protocol.

Procedure

1. Open your Data Grid Server configuration for editing.
2. Add the **engine** element to the SSL configuration for Data Grid Server.
3. Configure Data Grid to use one or more TLS versions with the **enabled-protocols** attribute. Data Grid Server supports TLS version 1.2 and 1.3 by default. If appropriate you can set **TLSv1.3** only to restrict the security protocol for client connections. Data Grid does not recommend enabling **TLSv1.1** because it is an older protocol with limited support and provides weak security. You should never enable any version of TLS older than 1.1.

> **WARNING**
>
> If you modify the SSL **engine** configuration for Data Grid Server you must explicitly configure TLS versions with the **enabled-protocols** attribute. Omitting the **enabled-protocols** attribute allows any TLS version.
>
> ```
> <engine enabled-protocols="TLSv1.3 TLSv1.2" />
> ```

4. Configure Data Grid to use one or more cipher suites with the **enabled-ciphersuites** attribute (for TLSv1.2 and below) and the **enabled-ciphersuites-tls13** attribute (for TLSv1.3).
   You must ensure that you set a cipher suite that supports any protocol features you plan to use; for example **HTTP/2 ALPN**.

5. Save the changes to your configuration.

SSL engine configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="default">
        <server-identities>
          <ssl>
            <keystore path="server.p12"
                      relative-to="infinispan.server.config.path"
                      password="secret"
                      alias="server"/>
            <!-- Configures Data Grid Server to use specific TLS versions and cipher suites. -->
            <engine enabled-protocols="TLSv1.3 TLSv1.2"
                    enabled-ciphersuites="TLS_AES_256_GCM_SHA384,TLS_AES_128_GCM_SHA256"
                    enabled-ciphersuites-tls13="TLS_AES_256_GCM_SHA384"/>
          </ssl>
        </server-identities>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "default",
        "server-identities": {
          "ssl": {
            "keystore": {
```

```
          "alias": "server",
          "path": "server.p12",
          "password": "secret"
        },
        "engine": {
          "enabled-protocols": ["TLSv1.3"],
          "enabled-ciphersuites": "TLS_AES_256_GCM_SHA384,TLS_AES_128_GCM_SHA256",
          "enabled-ciphersuites-tls13": "TLS_AES_256_GCM_SHA384"
        }
      }
    }
   }]
  }
 }
}
```

YAML

```
server:
  security:
    securityRealms:
      - name: "default"
        serverIdentities:
          ssl:
            keystore:
              alias: "server"
              path: "server.p12"
              password: "secret"
            engine:
              enabledProtocols:
                - "TLSv1.3"
              enabledCiphersuites: "TLS_AES_256_GCM_SHA384,TLS_AES_128_GCM_SHA256"
              enabledCiphersuitesTls13: "TLS_AES_256_GCM_SHA384"
```

4.2. CONFIGURING DATA GRID SERVER ON A SYSTEM WITH FIPS 140-2 COMPLIANT CRYPTOGRAPHY

FIPS (Federal Information Processing Standards) are standards and guidelines for US federal computer systems. Although FIPS are developed for use by the US federal government, many in the private sector voluntarily use these standards.

FIPS 140-2 defines security requirements for cryptographic modules. You can configure your Data Grid Server to use encryption ciphers that adhere to the FIPS 140-2 specification by using alternative JDK security providers.

Additional resources

- Java PKCS#11 cryptographic provider
- The Legion of the Bouncy Castle cryptographic provider

4.2.1. Configuring the PKCS11 cryptographic provider

You can configure the PKCS11 cryptographic provider by specifying the PKCS11 keystore with the **SunPKCS11-NSS-FIPS** provider.

Prerequisites

- Configure your system for FIPS mode. You can check if your system has FIPS Mode enabled by issuing the **fips-mode-setup --check** command in your Data Grid command-line Interface (CLI)
- Initialize the system-wide NSS database by using the **certutil** tool.
- Install the JDK with the **java.security** file configured to enable the **SunPKCS11** provider. This provider points to the NSS database and the SSL provider.
- Install a certificate in the NSS database.

> **NOTE**
>
> The OpenSSL provider requires a private key, but you cannot retrieve a private key from the PKCS#11 store. FIPS blocks the export of unencrypted keys from a FIPS-compliant cryptographic module, so you cannot use the OpenSSL provider for TLS when in FIPS mode. You can disable the OpenSSL provider at startup with the **-Dorg.infinispan.openssl=false** argument.

Procedure

1. Open your Data Grid Server configuration for editing.
2. Add a **server-identities** definition to the Data Grid Server security realm.
3. Specify the PKCS11 keystore with the **SunPKCS11-NSS-FIPS** provider.
4. Save the changes to your configuration.

Keystore configuration

XML

```xml
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="default">
        <server-identities>
          <ssl>
            <!-- Adds a keystore that reads certificates from the NSS database. -->
            <keystore provider="SunPKCS11-NSS-FIPS" type="PKCS11"/>
          </ssl>
        </server-identities>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```json
{
```

```
  "server": {
    "security": {
      "security-realms": [{
        "name": "default",
        "server-identities": {
          "ssl": {
            "keystore": {
              "provider": "SunPKCS11-NSS-FIPS",
              "type": "PKCS11"
            }
          }
        }
      }]
    }
  }
}
```


YAML


```
server:
  security:
    securityRealms:
      - name: "default"
        serverIdentities:
          ssl:
            keystore:
              provider: "SunPKCS11-NSS-FIPS"
              type: "PKCS11"
```


4.2.2. Configuring the Bouncy Castle FIPS cryptographic provider

You can configure the Bouncy Castle FIPS (Federal Information Processing Standards) cryptographic provider in your Data Grid server's configuration.

Prerequisites

- Configure your system for FIPS mode. You can check if your system has FIPS Mode enabled by issuing the **fips-mode-setup --check** command in your Data Grid command-line Interface (CLI).
- Create a keystore in BCFKS format that contains a certificate.

Procedure

1. Download the Bouncy Castle FIPS JAR file, and add the file to the **server/lib** directory of your Data Grid Server installation.
2. To install Bouncy Castle, issue the **install** command:

   ```
   [disconnected]> install org.bouncycastle:bc-fips:1.0.2.3
   ```

3. Open your Data Grid Server configuration for editing.
4. Add a **server-identities** definition to the Data Grid Server security realm.

5. Specify the BCFKS keystore with the **BCFIPS** provider.

6. Save the changes to your configuration.

Keystore configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="default">
        <server-identities>
          <ssl>
            <!-- Adds a keystore that reads certificates from the BCFKS keystore. -->
            <keystore path="server.bcfks" password="secret" alias="server" provider="BCFIPS"
type="BCFKS"/>
          </ssl>
        </server-identities>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```
{
  "server": {
    "security": {
      "security-realms": [{
        "name": "default",
        "server-identities": {
          "ssl": {
            "keystore": {
              "path": "server.bcfks",
              "password": "secret",
              "alias": "server",
              "provider": "BCFIPS",
              "type": "BCFKS"
            }
          }
        }
      }]
    }
  }
}
```

YAML

```
server:
  security:
    securityRealms:
      - name: "default"
        serverIdentities:
          ssl:
```

```
keystore:
  path: "server.bcfks"
  password: "secret"
  alias: "server"
  provider: "BCFIPS"
  type: "BCFKS"
```

4.3. CONFIGURING CLIENT CERTIFICATE AUTHENTICATION

Configure Data Grid Server to use mutual TLS to secure client connections.

You can configure Data Grid to verify client identities from certificates in a trust store in two ways:

- Require a trust store that contains only the signing certificate, which is typically a Certificate Authority (CA). Any client that presents a certificate signed by the CA can connect to Data Grid.
- Require a trust store that contains all client certificates in addition to the signing certificate. Only clients that present a signed certificate that is present in the trust store can connect to Data Grid.

TIP

Alternatively to providing trust stores you can use shared system certificates.

Prerequisites

- Create a client trust store that contains either the CA certificate or all public certificates.
- Create a keystore for Data Grid Server and configure an SSL/TLS identity.

NOTE

PEM files can be used as trust stores provided they contain one or more certificates. These trust stores should be configured with an empty password: **password=""**.

Procedure

1. Open your Data Grid Server configuration for editing.
2. Add the **require-ssl-client-auth="true"** parameter to your **endpoints** configuration.
3. Add the client trust store to the **$RHDG_HOME/server/conf** directory.
4. Specify the **path** and **password** attributes for the **truststore** element in the Data Grid Server security realm configuration.
5. Add the **<truststore-realm/>** element to the security realm if you want Data Grid Server to authenticate each client certificate.
6. Save the changes to your configuration.

Next steps

- Set up authorization with client certificates in the Data Grid Server configuration if you control access with security roles and permissions.

- Configure clients to negotiate SSL/TLS connections with Data Grid Server.

Client certificate authentication configuration

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="TrustStoreRealm">
        <server-identities>
          <ssl>
            <!-- Provides an SSL/TLS identity with a keystore that
                 contains server certificates. -->
            <keystore path="server.p12"
                      relative-to="infinispan.server.config.path"
                      keystore-password="secret"
                      alias="server"/>
            <!-- Configures a trust store that contains client certificates
                 or part of a certificate chain. -->
            <truststore path="trust.p12"
                        relative-to="infinispan.server.config.path"
                        password="secret"/>
          </ssl>
        </server-identities>
        <!-- Authenticates client certificates against the trust store. If you configure this, the trust store
must contain the public certificates for all clients. -->
        <truststore-realm/>
      </security-realm>
    </security-realms>
  </security>
  <endpoints>
    <endpoint socket-binding="default"
              security-realm="trust-store-realm"
              require-ssl-client-auth="true">
      <hotrod-connector>
        <authentication>
          <sasl mechanisms="EXTERNAL"
                server-name="infinispan"
                qop="auth"/>
        </authentication>
      </hotrod-connector>
      <rest-connector>
        <authentication mechanisms="CLIENT_CERT"/>
      </rest-connector>
    </endpoint>
  </endpoints>
</server>
```

JSON

```
{
  "server": {
    "security": {
```

```
    "security-realms": [{
      "name": "TrustStoreRealm",
      "server-identities": {
        "ssl": {
          "keystore": {
            "path": "server.p12",
            "relative-to": "infinispan.server.config.path",
            "keystore-password": "secret",
            "alias": "server"
          },
          "truststore": {
            "path": "trust.p12",
            "relative-to": "infinispan.server.config.path",
            "password": "secret"
          }
        }
      },
      "truststore-realm": {}
    }]
  },
  "endpoints": [{
    "socket-binding": "default",
    "security-realm": "TrustStoreRealm",
    "require-ssl-client-auth": "true",
    "connectors": {
      "hotrod": {
        "hotrod-connector": {
          "authentication": {
            "sasl": {
              "mechanisms": "EXTERNAL",
              "server-name": "infinispan",
              "qop": "auth"
            }
          }
        },
        "rest": {
          "rest-connector": {
            "authentication": {
              "mechanisms": "CLIENT_CERT"
            }
          }
        }
      }
    }
  }]
 }
}
```

YAML

```
server:
  security:
    securityRealms:
      - name: "TrustStoreRealm"
        serverIdentities:
```

```
          ssl:
            keystore:
              path: "server.p12"
              relative-to: "infinispan.server.config.path"
              keystore-password: "secret"
              alias: "server"
            truststore:
              path: "trust.p12"
              relative-to: "infinispan.server.config.path"
              password: "secret"
        truststoreRealm: ~
    endpoints:
      socketBinding: "default"
      securityRealm: "trust-store-realm"
      requireSslClientAuth: "true"
      connectors:
        - hotrod:
            hotrodConnector:
              authentication:
                sasl:
                  mechanisms: "EXTERNAL"
                  serverName: "infinispan"
                  qop: "auth"
        - rest:
            restConnector:
              authentication:
                mechanisms: "CLIENT_CERT"
```

Additional resources

- Configuring Hot Rod client encryption
- Using Shared System Certificates (Red Hat Enterprise Linux 7 Security Guide)

4.4. CONFIGURING AUTHORIZATION WITH CLIENT CERTIFICATES

Enabling client certificate authentication means you do not need to specify Data Grid user credentials in client configuration, which means you must associate roles with the Common Name (CN) field in the client certificate(s).

Prerequisites

- Provide clients with a Java keystore that contains either their public certificates or part of the certificate chain, typically a public CA certificate.
- Configure Data Grid Server to perform client certificate authentication.

Procedure

1. Open your Data Grid Server configuration for editing.
2. Enable the **common-name-role-mapper** in the security authorization configuration.
3. Assign the Common Name (**CN**) from the client certificate a role with the appropriate permissions.

4. Save the changes to your configuration.

Client certificate authorization configuration

XML

```xml
<infinispan>
  <cache-container name="certificate-authentication" statistics="true">
    <security>
      <authorization>
        <!-- Declare a role mapper that associates the common name (CN) field in client certificate trust stores with authorization roles. -->
        <common-name-role-mapper/>
        <!-- In this example, if a client certificate contains `CN=Client1` then clients with matching certificates get ALL permissions. -->
        <role name="Client1" permissions="ALL"/>
      </authorization>
    </security>
  </cache-container>
</infinispan>
```

JSON

```json
{
  "infinispan": {
    "cache-container": {
      "name": "certificate-authentication",
      "security": {
        "authorization": {
          "common-name-role-mapper": null,
          "roles": {
            "Client1": {
              "role": {
                "permissions": "ALL"
              }
            }
          }
        }
      }
    }
  }
}
```

YAML

```yaml
infinispan:
  cacheContainer:
    name: "certificate-authentication"
    security:
      authorization:
        commonNameRoleMapper: ~
        roles:
          Client1:
```

```
role:
  permissions:
    - "ALL"
```

CHAPTER 5. STORING DATA GRID SERVER CREDENTIALS IN KEYSTORES

External services require credentials to authenticate with Data Grid Server. To protect sensitive text strings such as passwords, add them to a credential keystore rather than directly in Data Grid Server configuration files.

You can then configure Data Grid Server to decrypt passwords for establishing connections with services such as databases or LDAP directories.

IMPORTANT

Plain-text passwords in **$RHDG_HOME/server/conf** are unencrypted. Any user account with read access to the host filesystem can view plain-text passwords.

While credential keystores are password-protected store encrypted passwords, any user account with write access to the host filesystem can tamper with the keystore itself.

To completely secure Data Grid Server credentials, you should grant read-write access only to user accounts that can configure and run Data Grid Server.

5.1. SETTING UP CREDENTIAL KEYSTORES

Create keystores that encrypt credential for Data Grid Server access.

A credential keystore contains at least one alias that is associated with an encrypted password. After you create a keystore, you specify the alias in a connection configuration such as a database connection pool. Data Grid Server then decrypts the password for that alias from the keystore when the service attempts authentication.

You can create as many credential keystores with as many aliases as required.

Procedure

1. Open a terminal in **$RHDG_HOME**.
2. Create a keystore and add credentials to it with the **credentials** command.

   #### TIP

   By default, keystores are of type PKCS12. Run **help credentials** for details on changing keystore defaults.

   The following example shows how to create a keystore that contains an alias of "dbpassword" for the password "changeme". When you create a keystore you also specify a password for the keystore with the **-p** argument.

   #### Linux

   ```
   bin/cli.sh credentials add dbpassword -c changeme -p "secret1234!"
   ```

   #### Microsoft Windows

   ```
   bin\cli.bat credentials add dbpassword -c changeme -p "secret1234!"
   ```

```
bin\cli.bat credentials add dbpassword -c changeme -p "secret1234!"
```

3. Check that the alias is added to the keystore.

```
bin/cli.sh credentials ls -p "secret1234!"
dbpassword
```

4. Configure Data Grid to use the credential keystore.
   a. Specify the name and location of the credential keystore in the **credential-stores** configuration.
   b. Provide the credential keystore and alias in the **credential-reference** configuration.

   TIP

   Attributes in the **credential-reference** configuration are optional.

   - **store** is required only if you have multiple keystores.
   - **alias** is required only if the keystore contains multiple aliases.

5.2. CREDENTIAL KEYSTORE CONFIGURATION

This topic provides examples of credential keystores in Data Grid Server configuration.

Credential keystores

XML

```xml
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <!-- Uses a keystore to manage server credentials. -->
    <credential-stores>
      <!-- Specifies the name and filesystem location of a keystore. -->
      <credential-store name="credentials" path="credentials.pfx">
        <!-- Specifies the password for the credential keystore. -->
        <clear-text-credential clear-text="secret1234!"/>
      </credential-store>
    </credential-stores>
  </security>
</server>
```

JSON

```json
{
  "server": {
    "security": {
      "credential-stores": [{
        "name": "credentials",
        "path": "credentials.pfx",
        "clear-text-credential": {
          "clear-text": "secret1234!"
```

```
        }
      }]
    }
  }
}
```

YAML

```
server:
  security:
    credentialStores:
      - name: credentials
        path: credentials.pfx
        clearTextCredential:
          clearText: "secret1234!"
```

Datasource connections

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <data-sources>
    <data-source name="postgres"
                 jndi-name="jdbc/postgres">
      <!-- Specifies the database username in the connection factory. -->
      <connection-factory driver="org.postgresql.Driver"
                          username="dbuser"
                          url="${org.infinispan.server.test.postgres.jdbcUrl}">
        <!-- Specifies the credential keystore that contains an encrypted password and the alias for it. --
>
        <credential-reference store="credentials"
                              alias="dbpassword"/>
      </connection-factory>
      <connection-pool max-size="10"
                       min-size="1"
                       background-validation="1000"
                       idle-removal="1"
                       initial-size="1"
                       leak-detection="10000"/>
    </data-source>
  </data-sources>
</server>
```

JSON

```
{
  "server": {
    "data-sources": [{
      "name": "postgres",
      "jndi-name": "jdbc/postgres",
      "connection-factory": {
        "driver": "org.postgresql.Driver",
        "username": "dbuser",
```

```
          "url": "${org.infinispan.server.test.postgres.jdbcUrl}",
          "credential-reference": {
            "store": "credentials",
            "alias": "dbpassword"
          }
        }
      }]
    }
}
```

YAML

```
server:
  dataSources:
    - name: postgres
      jndiName: jdbc/postgres
      connectionFactory:
        driver: org.postgresql.Driver
        username: dbuser
        url: '${org.infinispan.server.test.postgres.jdbcUrl}'
        credentialReference:
          store: credentials
          alias: dbpassword
```

LDAP connections

XML

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <credential-stores>
      <credential-store name="credentials"
                        path="credentials.pfx">
        <clear-text-credential clear-text="secret1234!"/>
      </credential-store>
    </credential-stores>
    <security-realms>
      <security-realm name="default">
        <!-- Specifies the LDAP principal in the connection factory. -->
        <ldap-realm name="ldap"
                    url="ldap://my-ldap-server:10389"
                    principal="uid=admin,ou=People,dc=infinispan,dc=org">
          <!-- Specifies the credential keystore that contains an encrypted password and the alias for it. -
->
          <credential-reference store="credentials"
                                alias="ldappassword"/>
        </ldap-realm>
      </security-realm>
    </security-realms>
  </security>
</server>
```

JSON

```json
{
  "server": {
    "security": {
      "credential-stores": [{
        "name": "credentials",
        "path": "credentials.pfx",
        "clear-text-credential": {
          "clear-text": "secret1234!"
        }
      }],
      "security-realms": [{
        "name": "default",
        "ldap-realm": {
          "name": "ldap",
          "url": "ldap://my-ldap-server:10389",
          "principal": "uid=admin,ou=People,dc=infinispan,dc=org",
          "credential-reference": {
            "store": "credentials",
            "alias": "ldappassword"
          }
        }
      }]
    }
  }
}
```

YAML

```yaml
server:
  security:
    credentialStores:
      - name: credentials
        path: credentials.pfx
        clearTextCredential:
          clearText: "secret1234!"
    securityRealms:
      - name: "default"
        ldapRealm:
          name: ldap
          url: 'ldap://my-ldap-server:10389'
          principal: 'uid=admin,ou=People,dc=infinispan,dc=org'
          credentialReference:
            store: credentials
            alias: ldappassword
```

CHAPTER 6. ENCRYPTING CLUSTER TRANSPORT

Secure cluster transport so that nodes communicate with encrypted messages. You can also configure Data Grid clusters to perform certificate authentication so that only nodes with valid identities can join.

6.1. SECURING CLUSTER TRANSPORT WITH TLS IDENTITIES

Add SSL/TLS identities to a Data Grid Server security realm and use them to secure cluster transport. Nodes in the Data Grid Server cluster then exchange SSL/TLS certificates to encrypt JGroups messages, including RELAY messages if you configure cross-site replication.

Prerequisites

- Install a Data Grid Server cluster.

Procedure

1. Create a TLS keystore that contains a single certificate to identify Data Grid Server.
   You can also use a PEM file if it contains a private key in PKCS#1 or PKCS#8 format, a certificate, and has an empty password: **password=""**.

   > **NOTE**
   >
   > If the certificate in the keystore is not signed by a public certificate authority (CA) then you must also create a trust store that contains either the signing certificate or the public key.

2. Add the keystore to the **$RHDG_HOME/server/conf** directory.

3. Add the keystore to a new security realm in your Data Grid Server configuration.

   > **IMPORTANT**
   >
   > You should create dedicated keystores and security realms so that Data Grid Server endpoints do not use the same security realm as cluster transport.

```
<server xmlns="urn:infinispan:server:13.0">
  <security>
    <security-realms>
      <security-realm name="cluster-transport">
        <server-identities>
          <ssl>
            <!-- Adds a keystore that contains a certificate that provides SSL/TLS identity to encrypt cluster transport. -->
            <keystore path="server.pfx"
                      relative-to="infinispan.server.config.path"
                      password="secret"
                      alias="server"/>
          </ssl>
        </server-identities>
      </security-realm>
```

```
    </security-realms>
  </security>
</server>
```

4. Configure cluster transport to use the security realm by specifying the name of the security realm with the **server:security-realm** attribute.

```
<infinispan>
  <cache-container>
    <transport server:security-realm="cluster-transport"/>
  </cache-container>
</infinispan>
```

Verification

When you start Data Grid Server, the following log message indicates that the cluster is using the security realm for cluster transport:

```
[org.infinispan.SERVER] ISPN080060: SSL Transport using realm <security_realm_name>
```

6.2. JGROUPS ENCRYPTION PROTOCOLS

To secure cluster traffic, you can configure Data Grid nodes to encrypt JGroups message payloads with secret keys.

Data Grid nodes can obtain secret keys from either:

- The coordinator node (asymmetric encryption).
- A shared keystore (symmetric encryption).

Retrieving secret keys from coordinator nodes

You configure asymmetric encryption by adding the **ASYM_ENCRYPT** protocol to a JGroups stack in your Data Grid configuration. This allows Data Grid clusters to generate and distribute secret keys.

> **IMPORTANT**
>
> When using asymmetric encryption, you should also provide keystores so that nodes can perform certificate authentication and securely exchange secret keys. This protects your cluster from man-in-the-middle (MitM) attacks.

Asymmetric encryption secures cluster traffic as follows:

1. The first node in the Data Grid cluster, the coordinator node, generates a secret key.
2. A joining node performs certificate authentication with the coordinator to mutually verify identity.
3. The joining node requests the secret key from the coordinator node. That request includes the public key for the joining node.
4. The coordinator node encrypts the secret key with the public key and returns it to the joining node.

5. The joining node decrypts and installs the secret key.

6. The node joins the cluster, encrypting and decrypting messages with the secret key.

Retrieving secret keys from shared keystores

You configure symmetric encryption by adding the **SYM_ENCRYPT** protocol to a JGroups stack in your Data Grid configuration. This allows Data Grid clusters to obtain secret keys from keystores that you provide.

1. Nodes install the secret key from a keystore on the Data Grid classpath at startup.

2. Node join clusters, encrypting and decrypting messages with the secret key.

Comparison of asymmetric and symmetric encryption

ASYM_ENCRYPT with certificate authentication provides an additional layer of encryption in comparison with **SYM_ENCRYPT**. You provide keystores that encrypt the requests to coordinator nodes for the secret key. Data Grid automatically generates that secret key and handles cluster traffic, while letting you specify when to generate secret keys. For example, you can configure clusters to generate new secret keys when nodes leave. This ensures that nodes cannot bypass certificate authentication and join with old keys.

SYM_ENCRYPT, on the other hand, is faster than **ASYM_ENCRYPT** because nodes do not need to exchange keys with the cluster coordinator. A potential drawback to **SYM_ENCRYPT** is that there is no configuration to automatically generate new secret keys when cluster membership changes. Users are responsible for generating and distributing the secret keys that nodes use to encrypt cluster traffic.

6.3. SECURING CLUSTER TRANSPORT WITH ASYMMETRIC ENCRYPTION

Configure Data Grid clusters to generate and distribute secret keys that encrypt JGroups messages.

Procedure

1. Create a keystore with certificate chains that enables Data Grid to verify node identity.

2. Place the keystore on the classpath for each node in the cluster.
   For Data Grid Server, you put the keystore in the $RHDG_HOME directory.

3. Add the **SSL_KEY_EXCHANGE** and **ASYM_ENCRYPT** protocols to a JGroups stack in your Data Grid configuration, as in the following example:

```
<infinispan>
  <jgroups>
    <!-- Creates a secure JGroups stack named "encrypt-tcp" that extends the default TCP
stack. -->
    <stack name="encrypt-tcp" extends="tcp">
      <!-- Adds a keystore that nodes use to perform certificate authentication. -->
      <!-- Uses the stack.combine and stack.position attributes to insert
SSL_KEY_EXCHANGE into the default TCP stack after VERIFY_SUSPECT. -->
      <SSL_KEY_EXCHANGE keystore_name="mykeystore.jks"
                        keystore_password="changeit"
                        stack.combine="INSERT_AFTER"
                        stack.position="VERIFY_SUSPECT"/>
      <!-- Configures ASYM_ENCRYPT -->
```

```
    <!-- Uses the stack.combine and stack.position attributes to insert ASYM_ENCRYPT into the default TCP stack before pbcast.NAKACK2. -->
    <!-- The use_external_key_exchange = "true" attribute configures nodes to use the `SSL_KEY_EXCHANGE` protocol for certificate authentication. -->
    <ASYM_ENCRYPT asym_keylength="2048"
            asym_algorithm="RSA"
            change_key_on_coord_leave = "false"
            change_key_on_leave = "false"
            use_external_key_exchange = "true"
            stack.combine="INSERT_BEFORE"
            stack.position="pbcast.NAKACK2"/>
  </stack>
 </jgroups>
 <cache-container name="default" statistics="true">
  <!-- Configures the cluster to use the JGroups stack. -->
  <transport cluster="${infinispan.cluster.name}"
         stack="encrypt-tcp"
         node-name="${infinispan.node.name:}"/>
 </cache-container>
</infinispan>
```

Verification

When you start your Data Grid cluster, the following log message indicates that the cluster is using the secure JGroups stack:

```
[org.infinispan.CLUSTER] ISPN000078: Starting JGroups channel cluster with stack <encrypted_stack_name>
```

Data Grid nodes can join the cluster only if they use **ASYM_ENCRYPT** and can obtain the secret key from the coordinator node. Otherwise the following message is written to Data Grid logs:

```
[org.jgroups.protocols.ASYM_ENCRYPT] <hostname>: received message without encrypt header from <hostname>; dropping it
```

Additional resources

- JGroups 4 Manual
- JGroups 4.2 Schema

6.4. SECURING CLUSTER TRANSPORT WITH SYMMETRIC ENCRYPTION

Configure Data Grid clusters to encrypt JGroups messages with secret keys from keystores that you provide.

Procedure

1. Create a keystore that contains a secret key.
2. Place the keystore on the classpath for each node in the cluster.
   For Data Grid Server, you put the keystore in the $RHDG_HOME directory.

3. Add the **SYM_ENCRYPT** protocol to a JGroups stack in your Data Grid configuration.

```
<infinispan>
  <jgroups>
    <!-- Creates a secure JGroups stack named "encrypt-tcp" that extends the default TCP stack. -->
    <stack name="encrypt-tcp" extends="tcp">
      <!-- Adds a keystore from which nodes obtain secret keys. -->
      <!-- Uses the stack.combine and stack.position attributes to insert SYM_ENCRYPT into the
default TCP stack after VERIFY_SUSPECT. -->
      <SYM_ENCRYPT keystore_name="myKeystore.p12"
                   keystore_type="PKCS12"
                   store_password="changeit"
                   key_password="changeit"
                   alias="myKey"
                   stack.combine="INSERT_AFTER"
                   stack.position="VERIFY_SUSPECT"/>
    </stack>
  </jgroups>
  <cache-container name="default" statistics="true">
    <!-- Configures the cluster to use the JGroups stack. -->
    <transport cluster="${infinispan.cluster.name}"
               stack="encrypt-tcp"
               node-name="${infinispan.node.name:}"/>
  </cache-container>
</infinispan>
```

Verification

When you start your Data Grid cluster, the following log message indicates that the cluster is using the secure JGroups stack:

```
[org.infinispan.CLUSTER] ISPN000078: Starting JGroups channel cluster with stack
<encrypted_stack_name>
```

Data Grid nodes can join the cluster only if they use **SYM_ENCRYPT** and can obtain the secret key from the shared keystore. Otherwise the following message is written to Data Grid logs:

```
[org.jgroups.protocols.SYM_ENCRYPT] <hostname>: received message without encrypt header from
<hostname>; dropping it
```

Additional resources

- JGroups 4 Manual
- JGroups 4.2 Schema

CHAPTER 7. DATA GRID PORTS AND PROTOCOLS

As Data Grid distributes data across your network and can establish connections for external client requests, you should be aware of the ports and protocols that Data Grid uses to handle network traffic.

If run Data Grid as a remote server then you might need to allow remote clients through your firewall. Likewise, you should adjust ports that Data Grid nodes use for cluster communication to prevent conflicts or network issues.

7.1. DATA GRID SERVER PORTS AND PROTOCOLS

Data Grid Server provides network endpoints that allow client access with different protocols.

Port	Protocol	Description
11222	TCP	Hot Rod and REST
11221	TCP	Memcached (disabled by default)

Single port

Data Grid Server exposes multiple protocols through a single TCP port, **11222**. Handling multiple protocols with a single port simplifies configuration and reduces management complexity when deploying Data Grid clusters. Using a single port also enhances security by minimizing the attack surface on the network.

Data Grid Server handles HTTP/1.1, HTTP/2, and Hot Rod protocol requests from clients via the single port in different ways.

HTTP/1.1 upgrade headers

Client requests can include the **HTTP/1.1 upgrade** header field to initiate HTTP/1.1 connections with Data Grid Server. Client applications can then send the **Upgrade: protocol** header field, where **protocol** is a server endpoint.

Application-Layer Protocol Negotiation (ALPN)/Transport Layer Security (TLS)

Client requests include Server Name Indication (SNI) mappings for Data Grid Server endpoints to negotiate protocols over a TLS connection.

> **NOTE**
>
> Applications must use a TLS library that supports the ALPN extension. Data Grid uses WildFly OpenSSL bindings for Java.

Automatic Hot Rod detection

Client requests that include Hot Rod headers automatically route to Hot Rod endpoints.

7.1.1. Configuring network firewalls for Data Grid traffic

Adjust firewall rules to allow traffic between Data Grid Server and client applications.

Procedure

On Red Hat Enterprise Linux (RHEL) workstations, for example, you can allow traffic to port **11222** with firewalld as follows:

```
# firewall-cmd --add-port=11222/tcp --permanent
success
# firewall-cmd --list-ports | grep 11222
11222/tcp
```

To configure firewall rules that apply across a network, you can use the nftables utility.

Reference

- Using and configuring firewalld
- Getting started with nftables

7.2. TCP AND UDP PORTS FOR CLUSTER TRAFFIC

Data Grid uses the following ports for cluster transport messages:

Default Port	Protocol	Description
7800	TCP/UDP	JGroups cluster bind port
46655	UDP	JGroups multicast

Cross-site replication

Data Grid uses the following ports for the JGroups RELAY2 protocol:

7900

For Data Grid clusters running on OpenShift.

7800

If using UDP for traffic between nodes and TCP for traffic between clusters.

7801

If using TCP for traffic between nodes and TCP for traffic between clusters.