Red Hat Enterprise Linux 8

Deploying different types of servers

A guide to deploying different types of servers in Red Hat Enterprise Linux 8
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Abstract

This document describes how to configure and run different types of servers on Red Hat Enterprise Linux 8, including Apache HTTP web server, Samba server, NFS server, available database servers, and the CUPS server.
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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.
PROVIDING FEEDBACK ON RED HAT DOCUMENTATION

We appreciate your input on our documentation. Please let us know how we could make it better. To do so:

- For simple comments on specific passages:
  1. Make sure you are viewing the documentation in the *Multi-page HTML* format. In addition, ensure you see the **Feedback** button in the upper right corner of the document.
  2. Use your mouse cursor to highlight the part of text that you want to comment on.
  3. Click the **Add Feedback** pop-up that appears below the highlighted text.
  4. Follow the displayed instructions.

- For submitting more complex feedback, create a Bugzilla ticket:
  1. Go to the **Bugzilla** website.
  2. As the Component, use **Documentation**.
  3. Fill in the **Description** field with your suggestion for improvement. Include a link to the relevant part(s) of documentation.
  4. Click **Submit Bug**.
CHAPTER 1. SETTING UP THE APACHE HTTP WEB SERVER

1.1. INTRODUCTION TO THE APACHE HTTP WEB SERVER

A web server is a network service that serves content to a client over the web. This typically means web pages, but any other documents can be served as well. Web servers are also known as HTTP servers, as they use the hypertext transport protocol (HTTP).

The Apache HTTP Server, httpd, is an open source web server developed by the Apache Software Foundation.

If you are upgrading from a previous release of Red Hat Enterprise Linux, you will need to update the httpd service configuration accordingly. This section reviews some of the newly added features, and guides you through the update of prior configuration files.

1.1.1. Notable changes in the Apache HTTP Server

The Apache HTTP Server, has been updated from version 2.4.6 to version 2.4.37 between RHEL 7 and RHEL 8. This updated version includes several new features, but maintains backwards compatibility with the RHEL 7 version at the level of configuration and Application Binary Interface (ABI) of external modules.

New features include:

- HTTP/2 support is now provided by the mod_http2 package, which is a part of the httpd module.

- systemd socket activation is supported. See httpd.socket(8) man page for more details.

- Multiple new modules have been added:
  - mod_proxy_hcheck - a proxy health-check module
  - mod_proxy_uwsgi - a Web Server Gateway Interface (WSGI) proxy
  - mod_proxy_fdpass - provides support for the passing the socket of the client to another process
  - mod_cache_socache - an HTTP cache using, for example, memcache backend
  - mod_md - an ACME protocol SSL/TLS certificate service

- The following modules now load by default:
  - mod_request
  - mod_macro
  - mod_watchdog

- A new subpackage, httpd-filesystem, has been added, which contains the basic directory layout for the Apache HTTP Server including the correct permissions for the directories.

- Instantiated service support, httpd@.service has been introduced. See the httpd.service man page for more information.
A new `httpd-init.service` replaces the `%post` script to create a self-signed `mod_ssl` key pair.

Automated TLS certificate provisioning and renewal using the Automatic Certificate Management Environment (ACME) protocol is now supported with the `mod_md` package (for use with certificate providers such as Let’s Encrypt).

The Apache HTTP Server now supports loading TLS certificates and private keys from hardware security tokens directly from PKCS#11 modules. As a result, a `mod_ssl` configuration can now use PKCS#11 URLs to identify the TLS private key, and, optionally, the TLS certificate in the `SSLCertificateKeyFile` and `SSLCertificateFile` directives.

A new `ListenFree` directive in the `/etc/httpd/conf/httpd.conf` file is now supported. Similarly to the `Listen` directive, `ListenFree` provides information about IP addresses, ports, or IP address-and-port combinations that the server listens to. However, with `ListenFree`, the `IP_FREEBIND` socket option is enabled by default. Hence, `httpd` is allowed to bind to a nonlocal IP address or to an IP address that does not exist yet. This allows `httpd` to listen on a socket without requiring the underlying network interface or the specified dynamic IP address to be up at the time when `httpd` is trying to bind to it.

Note that the `ListenFree` directive is currently available only in RHEL 8.

For more details on `ListenFree`, see the following table:

**Table 1.1. ListenFree directive’s syntax, status, and modules**

<table>
<thead>
<tr>
<th>Syntax</th>
<th>Status</th>
<th>Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ListenFree [IP-address:]portnumber [protocol]</code></td>
<td>MPM</td>
<td>event, worker, prefork, mpm_winnt, mpm_netware, mpm_tls_os2</td>
</tr>
</tbody>
</table>

Other notable changes include:

- The following modules have been removed:
  - `mod_file_cache`
  - `mod_nss`
    Use `mod_ssl` as a replacement. For details about migrating from `mod_nss`, see Section 1.10, “Exporting a private key and certificates from an NSS database to use them in an Apache web server configuration”.
  - `mod_perl`

- The default type of the DBM authentication database used by the Apache HTTP Server in RHEL 8 has been changed from `SDBM` to `db5`.

- The `mod_wsgi` module for the Apache HTTP Server has been updated to Python 3. WSGI applications are now supported only with Python 3, and must be migrated from Python 2.

- The multi-processing module (MPM) configured by default with the Apache HTTP Server has changed from a multi-process, forked model (known as `prefork`) to a high-performance multi-threaded model, `event`. 
Any third-party modules that are not thread-safe need to be replaced or removed. To change the configured MPM, edit the `/etc/httpd/conf.modules.d/00-mpm.conf` file. See the `httpd.service(8)` man page for more information.

- The minimum UID and GID allowed for users by suEXEC are now 1000 and 500, respectively (previously 100 and 100).
- The `/etc/sysconfig/httpd` file is no longer a supported interface for setting environment variables for the httpd service. The `httpd.service(8)` man page has been added for the systemd service.
- Stopping the httpd service now uses a "graceful stop" by default.
- The `mod_auth_kerb` module has been replaced by the `mod_auth_gssapi` module.

1.1.2. Updating the configuration

To update the configuration files from the Apache HTTP Server version used in Red Hat Enterprise Linux 7, choose one of the following options:

- If `/etc/sysconfig/httpd` is used to set environment variables, create a systemd drop-in file instead.
- If any third-party modules are used, ensure they are compatible with a threaded MPM.
- If suexec is used, ensure user and group IDs meet the new minimums.

You can check the configuration for possible errors by using the following command:

```bash
# apachectl configtest
Syntax OK
```

1.2. THE APACHE CONFIGURATION FILES

When the httpd service is started, by default, it reads the configuration from locations that are listed in Table 1.2, "The httpd service configuration files".

Table 1.2. The httpd service configuration files

<table>
<thead>
<tr>
<th>Path</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>/etc/httpd/conf/httpd.conf</code></td>
<td>The main configuration file.</td>
</tr>
<tr>
<td><code>/etc/httpd/conf.d/</code></td>
<td>An auxiliary directory for configuration files that are included in the main configuration file.</td>
</tr>
<tr>
<td><code>/etc/httpd/conf.modules.d/</code></td>
<td>An auxiliary directory for configuration files which load installed dynamic modules packaged in Red Hat Enterprise Linux. In the default configuration, these configuration files are processed first.</td>
</tr>
</tbody>
</table>
Although, the default configuration is suitable for most situations, you can use also other configuration options. For any changes to take effect, restart the web server first. See Section 1.3, “Managing the httpd service” for more information on how to restart the httpd service.

To check the configuration for possible errors, type the following at a shell prompt:

```
# apachectl configtest
Syntax OK
```

To make the recovery from mistakes easier, make a copy of the original file before editing it.

1.3. MANAGING THE HTTPD SERVICE

This section describes how to start, stop, and restart the httpd service.

**Prerequisites**

- The Apache HTTP Server is installed.

**Procedure**

- To start the httpd service, enter:
  ```
  # systemctl start httpd
  ```

- To stop the httpd service, enter:
  ```
  # systemctl stop httpd
  ```

- To restart the httpd service, enter:
  ```
  # systemctl restart httpd
  ```

1.4. SETTING UP A SINGLE-INSTANCE APACHE HTTP SERVER

This section describes how to set up a single-instance Apache HTTP Server to serve static HTML content.

Follow the procedure in this section if the web server should provide the same content for all domains associated with the server. If you want to provide different content for different domains, set up name-based virtual hosts. For details, see Section 1.5, “Configuring Apache name-based virtual hosts”.

**Procedure**

1. Install the httpd package:
   ```
   # yum install httpd
   ```

2. Open the TCP port 80 in the local firewall:
   ```
   # firewall-cmd --permanent --add-port=80/tcp
   # firewall-cmd --reload
   ```
3. Enable and start the `httpd` service:

```
# systemctl enable --now httpd
```


**NOTE**

When adding content to `/var/www/html/`, files and directories must be readable by the user under which `httpd` runs by default. The content owner can be the either the `root` user and `root` user group, or another user or group of the administrator’s choice. If the content owner is the `root` user and `root` user group, the files must be readable by other users. The SELinux context for all the files and directories must be `httpd_sys_content_t`, which is applied by default to all content within the `/var/www` directory.

**Verification steps**

- Connect with a web browser to `http://server_IP_or_host_name/`

  If the `/var/www/html/` directory is empty or does not contain an `index.html` or `index.htm` file, Apache displays the Red Hat Enterprise Linux Test Page. If `/var/www/html/` contains HTML files with a different name, you can load them by entering the URL to that file, such as `http://server_IP_or_host_name/example.html`.

**Additional resources**

- For further details about configuring Apache and adapting the service to your environment, refer to the Apache manual. For details about installing the manual, see Section 1.8, “Installing the Apache HTTP Server manual”.

- For details about using or adjusting the `httpd systemd` service, see the `httpd.service(8)` man page.

### 1.5. CONFIGURING APACHE NAME-BASED VIRTUAL HOSTS

Name-based virtual hosts enable Apache to serve different content for different domains that resolve to the IP address of the server.

The procedure in this section describes setting up a virtual host for both the `example.com` and `example.net` domain with separate document root directories. Both virtual hosts serve static HTML content.

**Prerequisites**

- Clients and the web server resolve the `example.com` and `example.net` domain to the IP address of the web server.
  Note that you must manually add these entries to your DNS server.

**Procedure**

1. Install the `httpd` package:

```
# yum install httpd
```
2. Edit the `/etc/httpd/conf/httpd.conf` file:
   a. Append the following virtual host configuration for the `example.com` domain:

   ```
   <VirtualHost *:80>
   DocumentRoot "/var/www/example.com/"
   ServerName example.com
   CustomLog /var/log/httpd/example.com_access.log combined
   ErrorLog /var/log/httpd/example.com_error.log
   </VirtualHost>
   ```

   These settings configure the following:
   - All settings in the `<VirtualHost *:80>` directive are specific for this virtual host.
   - `DocumentRoot` sets the path to the web content of the virtual host.
   - `ServerName` sets the domains for which this virtual host serves content.
     To set multiple domains, add the `ServerAlias` parameter to the configuration and specify the additional domains separated with a space in this parameter.
   - `CustomLog` sets the path to the access log of the virtual host.
   - `ErrorLog` sets the path to the error log of the virtual host.

   **NOTE**
   Apache uses the first virtual host found in the configuration also for requests that do not match any domain set in the `ServerName` and `ServerAlias` parameters. This also includes requests sent to the IP address of the server.

3. Append a similar virtual host configuration for the `example.net` domain:

   ```
   <VirtualHost *:80>
   DocumentRoot "/var/www/example.net/"
   ServerName example.net
   CustomLog /var/log/httpd/example.net_access.log combined
   ErrorLog /var/log/httpd/example.net_error.log
   </VirtualHost>
   ```

4. Create the document roots for both virtual hosts:

   ```
   # mkdir /var/www/example.com/
   # mkdir /var/www/example.net/
   ```

5. If you set paths in the `DocumentRoot` parameters that are not within `/var/www/`, set the `httpd_sys_content_t` context on both document roots:

   ```
   # semanage fcontext -a -t httpd_sys_content_t "/srv/example.com(/.*)?"
   # restorecon -Rv /srv/example.com/
   # semanage fcontext -a -t httpd_sys_content_t "/srv/example.net(/.*)?"
   # restorecon -Rv /srv/example.net/
   ```
These commands set the httpd_sys_content_t context on the /srv/example.com/ and /srv/example.net/ directory.

Note that you must install the policycoreutils-python-utils package to run the restorecon command.

6. Open port 80 in the local firewall:

   # firewall-cmd --permanent --add-port=80/tcp
   # firewall-cmd --reload

7. Enable and start the httpd service:

   # systemctl enable --now httpd

**Verification steps**

1. Create a different example file in each virtual host's document root:

   # echo "vHost example.com" > /var/www/example.com/index.html
   # echo "vHost example.net" > /var/www/example.net/index.html

2. Use a browser and connect to http://example.com. The web server shows the example file from the example.com virtual host.

3. Use a browser and connect to http://example.net. The web server shows the example file from the example.net virtual host.

**Additional resources**

- For further details about configuring Apache virtual hosts, refer to the Virtual Hosts documentation in the Apache manual. For details about installing the manual, see Section 1.8, "Installing the Apache HTTP Server manual".

**1.6. CONFIGURING TLS ENCRYPTION ON AN APACHE HTTP SERVER**

By default, Apache provides content to clients using an unencrypted HTTP connection. This section describes how to enable TLS encryption and configure frequently used encryption-related settings on an Apache HTTP Server.

**Prerequisites**

- The Apache HTTP Server is installed and running.

**1.6.1. Adding TLS encryption to an Apache HTTP Server**

This section describes how to enable TLS encryption on an Apache HTTP Server for the example.com domain.

**Prerequisites**

- The Apache HTTP Server is installed and running.
The private key is stored in the /etc/pki/tls/private/example.com.key file. For details about creating a private key and certificate signing request (CSR), as well as how to request a certificate from a certificate authority (CA), see your CA’s documentation. Alternatively, if your CA supports the ACME protocol, you can use the mod_md module to automate retrieving and provisioning TLS certificates.

The TLS certificate is stored in the /etc/pki/tls/private/example.com.crt file. If you use a different path, adapt the corresponding steps of the procedure.

The CA certificate is stored in the /etc/pki/tls/private/ca.crt file. If you use a different path, adapt the corresponding steps of the procedure.

Clients and the web server resolve the host name of the server to the IP address of the web server.

Procedure

1. Install the mod_ssl package:

   # dnf install mod_ssl

2. Edit the /etc/httpd/conf.d/ssl.conf file and add the following settings to the <VirtualHost _default_:443> directive:

   a. Set the server name:

   ServerName example.com

   IMPORTANT

   The server name must match the entry set in the Common Name field of the certificate.

   b. Optional: If the certificate contains additional host names in the Subject Alt Names (SAN) field, you can configure mod_ssl to provide TLS encryption also for these host names. To configure this, add the ServerAlias parameter with corresponding names:

   ServerAlias www.example.com server.example.com

   c. Set the paths to the private key, the server certificate, and the CA certificate:

   SSLCertificateKeyFile "/etc/pki/tls/private/example.com.key"
   SSLCertificateFile "/etc/pki/tls/certs/example.com.crt"
   SSLCACertificateFile "/etc/pki/tls/certs/ca.crt"

3. For security reasons, configure that only the root user can access the private key file:

   # chown root:root /etc/pki/tls/private/example.com.key
   # chmod 600 /etc/pki/tls/private/example.com.key
4. Open port 443 in the local firewall:

```
# firewall-cmd --permanent --add-port=443
# firewall-cmd --reload
```

5. Restart the `httpd` service:

```
# systemctl restart httpd
```

**NOTE**

If you protected the private key file with a password, you must enter this password each time when the `httpd` service starts.

**Verification steps**

- Use a browser and connect to `https://example.com`.

**Additional resources**

- For further details about configuring TLS, refer to the **SSL/TLS Encryption** documentation in the Apache manual. For details about installing the manual, see Section 1.8, “Installing the Apache HTTP Server manual”.

**1.6.2. Setting the supported TLS protocol versions on an Apache HTTP Server**

By default, the Apache HTTP Server on RHEL 8 uses the system-wide crypto policy that defines safe default values, which are also compatible with recent browsers. For example, the `DEFAULT` policy defines that only the `TLSv1.2` and `TLSv1.3` protocol versions are enabled in Apache.

This section describes how to manually configure which TLS protocol versions your Apache HTTP Server supports. Follow the procedure if your environment requires to enable only specific TLS protocol versions, for example:

- If your environment requires that clients can also use the weak `TLSv1` (TLSv1.0) or `TLSv1.1` protocol.
- If you want to configure that Apache only supports the `TLSv1.2` or `TLSv1.3` protocol.

**Prerequisites**

- TLS encryption is enabled on the server as described in Section 1.6.1, “Adding TLS encryption to an Apache HTTP Server”.
Procedure

1. Edit the `/etc/httpd/conf/httpd.conf` file, and add the following setting to the `<VirtualHost>` directive for which you want to set the TLS protocol version. For example, to enable only the **TLSv1.3** protocol:

   ```
   SSLProtocol -All TLSv1.3
   ```

2. Restart the **httpd** service:

   ```
   # systemctl restart httpd
   ```

Verification steps

1. Use the following command to verify that the server supports **TLSv1.3**:

   ```
   # openssl s_client -connect example.com:443 -tls1_3
   ```

2. Use the following command to verify that the server does not support **TLSv1.2**:

   ```
   # openssl s_client -connect example.com:443 -tls1_2
   ```

   If the server does not support the protocol, the command returns an error:

   ```
   14011160609088:error:1409442E:SSL routines:ssl3_read_bytes:tlsv1 alert protocol version:ssl/record/rec_layer_s3.c:1543:SSL alert number 70
   ```

3. Optional: Repeat the command for other TLS protocol versions.

Additional resources

- For further details about the system-wide crypto policy, see the `update-crypto-policies(8)` man page and [Using system-wide cryptographic policies](#).

- For further details about the `SSLProtocol` parameter, refer to the `mod_ssl` documentation in the Apache manual. For details about installing the manual, see [Section 1.8, "Installing the Apache HTTP Server manual"](#).

### 1.6.3. Setting the supported ciphers on an Apache HTTP Server

By default, the Apache HTTP Server on RHEL 8 uses the system-wide crypto policy that defines safe default values, which are also compatible with recent browsers. For the list of ciphers the system-wide crypto allows, see the `/etc/crypto-policies/back-ends/openssl.config` file.

This section describes how to manually configure which ciphers your Apache HTTP Server supports. Follow the procedure if your environment requires specific ciphers.

**Prerequisites**

- TLS encryption is enabled on the server as described in [Section 1.6.1, "Adding TLS encryption to an Apache HTTP Server"](#).

**Procedure**
1. Edit the `/etc/httpd/conf/httpd.conf` file, and add the `SSLCipherSuite` parameter to the `<VirtualHost>` directive for which you want to set the TLS ciphers:

   ```
   SSLCipherSuite
   "EECDH+AESGCM:EDH+AESGCM:AES256+EECDH:AES256+EDH:!SHA1:!SHA256"
   ```

   This example enables only the **EECDH+AESGCM**, **EDH+AESGCM**, **AES256+EECDH**, and **AES256+EDH** ciphers and disables all ciphers which use the **SHA1** and **SHA256** message authentication code (MAC).

2. Restart the `httpd` service:

   ```
   # systemctl restart httpd
   ```

Verification steps

1. To display the list of ciphers the Apache HTTP Server supports:

   a. Install the `nmap` package:

      ```
      # yum install nmap
      ```

   b. Use the `nmap` utility to display the supported ciphers:

      ```
      # nmap --script ssl-enum-ciphers -p 443 example.com
      ... 
      PORT    STATE SERVICE
      443/tcp open  https
      | ssl-enum-ciphers:
      |   TLSv1.2:
      |     ciphers:
      |       TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384 (ecdh_x25519) - A
      |       TLS_DHE_RSA_WITH_AES_256_GCM_SHA384 (dh 2048) - A
      |       TLS_ECDHE_RSA_WITH_CHACHA20_POLY1305_SHA256 (ecdh_x25519) - A
      |     cipher:
      |     DHE_RSA_WITH_AES_256_CBC_SHA256 (dh 2048) - A
      |     DHE_RSA_WITH_AES_256_CBC_SHA (dh 2048) - A
      |     DHE_RSA_WITH_AES_256_CBC_SHA (dh 2048) - A
      |     DHE_RSA_WITH_AES_128_CBC_SHA256 (dh 2048) - A
      |     DHE_RSA_WITH_AES_128_CBC_SHA (dh 2048) - A
      |     DHE_RSA_WITH_3DES_EDE_CBC_SHA (dh 2048) - A
      |     DHE_RSA_WITH_AES_128_CBC_SHA (dh 2048) - A
      ... 
      ```

Additional resources


- For further details about the `SSLCipherSuite` parameter, refer to the `mod_ssl` documentation in the Apache manual. For details about installing the manual, see [Section 1.8, “Installing the Apache HTTP Server manual”](https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/8/html/deploying_different_types_of_servers/installing_the_apache_http_server). 

### 1.7. CONFIGURING TLS CLIENT CERTIFICATE AUTHENTICATION

Client certificate authentication enables administrators to allow only users who authenticate using a certificate to access resources on the web server. This section describes how to configure client certificate authentication for the `/var/www/html/Example/` directory.

If the Apache HTTP Server uses the TLS 1.3 protocol, certain clients require additional configuration. For example, in Firefox, set the `security.tls.enable_post_handshake_auth` parameter in the `about:config` menu to `true`. For further details, see [Transport Layer Security version 1.3 in Red Hat](https://access.redhat.com/documentation/en-us/red_hat_enterprise_linux/8/html/deploying_different_types_of_servers/transport_layer_security_version_1_3).
Enterprise Linux 8.

Prerequisites

- TLS encryption is enabled on the server as described in Section 1.6.1, “Adding TLS encryption to an Apache HTTP Server”.

Procedure

1. Edit the /etc/httpd/conf/httpd.conf file and add the following settings to the <VirtualHost> directive for which you want to configure client authentication:

   ```
   <Directory "/var/www/html/Example/">
   SSLVerifyClient require
   </Directory>
   ```

   The SSLVerifyClient require setting defines that the server must successfully validate the client certificate before the client can access the content in the /var/www/html/Example/ directory.

2. Restart the httpd service:

   ```
   # systemctl restart httpd
   ```

Verification steps

1. Use the curl utility to access the https://example.com/Example/ URL without client authentication:

   ```
   $ curl https://example.com/Example/
   curl: (56) OpenSSL SSL_read: error:1409445C:SSL routines:ssl3_read_bytes:tlsv13 alert certificate required, errno 0
   ```

   The error indicates that the web server requires a client certificate authentication.

2. Pass the client private key and certificate, as well as the CA certificate to curl to access the same URL with client authentication:

   ```
   $ curl --cacert ca.crt --key client.key --cert client.crt https://example.com/Example/
   ```

   If the request succeeds, curl displays the index.html file stored in the /var/www/html/Example/ directory.

Additional resources

- For further details about client authentication, see the mod_ssl Configuration How-To documentation in the Apache manual. For details about installing the manual, see Section 1.8, “Installing the Apache HTTP Server manual”.

1.8. INSTALLING THE APACHE HTTP SERVER MANUAL

This section describes how to install the Apache HTTP Server manual. This manual provides a detailed documentation of, for example:
Prerequisites

- The Apache HTTP Server is installed and running.

Procedure

1. Install the `httpd-manual` package:

   ```bash
   # yum install httpd-manual
   ```

2. Optional: By default, all clients connecting to the Apache HTTP Server can display the manual. To restrict access to a specific IP range, such as the 192.0.2.0/24 subnet, edit the `/etc/httpd/conf.d/manual.conf` file and add the `Require ip 192.0.2.0/24` setting to the `<Directory "/usr/share/httpd/manual">` directive:

   ```
   <Directory "/usr/share/httpd/manual"/>
   ...
   Require ip 192.0.2.0/24
   ...
   </Directory>
   ```

3. Restart the `httpd` service:

   ```bash
   # systemctl restart httpd
   ```

Verification steps

1. To display the Apache HTTP Server manual, connect with a web browser to `http://host_name_or_IP_address/manual/`

1.9. WORKING WITH MODULES

Being a modular application, the `httpd` service is distributed along with a number of Dynamic Shared Objects (DSOs), which can be dynamically loaded or unloaded at runtime as necessary. These modules are located in the `/usr/lib64/httpd/modules/` directory.

1.9.1. Loading a module
To load a particular DSO module, use the `LoadModule` directive. Note that modules provided by a separate package often have their own configuration file in the `/etc/httpd/conf.modules.d/` directory.

**Example 1.1. Loading the mod_ssl DSO**

LoadModule ssl_module modules/mod_ssl.so

After loading the module, restart the web server to reload the configuration. See Section 1.3, “Managing the httpd service” for more information on how to restart the `httpd` service.

### 1.9.2. Writing a module

To create a new DSO module, make sure you have the `httpd-devel` package installed. To do so, enter the following command as `root`:

```bash
# yum install httpd-devel
```

This package contains the include files, the header files, and the Apache eXtenSion (apxs) utility required to compile a module.

Once written, you can build the module with the following command:

```bash
# apxs -i -a -c module_name.c
```

If the build was successful, you should be able to load the module the same way as any other module that is distributed with the Apache HTTP Server.

### 1.10. EXPORTING A PRIVATE KEY AND CERTIFICATES FROM AN NSS DATABASE TO USE THEM IN AN APACHE WEB SERVER CONFIGURATION

RHEL 8 no longer provides the `mod_nss` module for the Apache web server, and Red Hat recommends using the `mod_ssl` module. If you store your private key and certificates in a Network Security Services (NSS) database, for example, because you migrated the web server from RHEL 7 to RHEL 8, follow this procedure to extract the key and certificates in Privacy Enhanced Mail (PEM) format. You can then use the files in the `mod_ssl` configuration as described in Section 1.6, “Configuring TLS encryption on an Apache HTTP Server”.

This procedure assumes that the NSS database is stored in `/etc/httpd/alias/` and that you store the exported private key and certificates in the `/etc/pki/tls/` directory.

**Prerequisites**

- The private key, the certificate, and the certificate authority (CA) certificate are stored in an NSS database.

**Procedure**

1. List the certificates in the NSS database:

   ```bash
   # certutil -d /etc/httpd/alias/ -L
   ```
You need the nicknames of the certificates in the next steps.

2. To extract the private key, you must temporarily export the key to a PKCS #12 file:
   a. Use the nickname of the certificate associated with the private key, to export the key to a PKCS #12 file:

   ```
   # pk12util -o /etc/pki/tls/private/export.p12 -d /etc/httpd/alias/ -n "Example Server Certificate"
   Enter password for PKCS12 file: password
   Re-enter password: password
   pk12util: PKCS12 EXPORT SUCCESSFUL
   ```

   Note that you must set a password on the PKCS #12 file. You need this password in the next step.

   b. Export the private key from the PKCS #12 file:

   ```
   # openssl pkcs12 -in /etc/pki/tls/private/export.p12 -out /etc/pki/tls/private/server.key -nocerts -nodes
   Enter Import Password: password
   MAC verified OK
   ```

   c. Delete the temporary PKCS #12 file:

   ```
   # rm /etc/pki/tls/private/export.p12
   ```

3. Set the permissions on `/etc/pki/tls/private/server.key` to ensure that only the `root` user can access this file:

   ```
   # chown root:root /etc/pki/tls/private/server.key
   # chmod 0600 /etc/pki/tls/private/server.key
   ```

4. Use the nickname of the server certificate in the NSS database to export the CA certificate:

   ```
   # certutil -d /etc/httpd/alias/ -L -n "Example Server Certificate" -a -o /etc/pki/tls/certs/server.crt
   ```

5. Set the permissions on `/etc/pki/tls/certs/server.crt` to ensure that only the `root` user can access this file:

   ```
   # chown root:root /etc/pki/tls/certs/server.crt
   # chmod 0600 /etc/pki/tls/certs/server.crt
   ```

6. Use the nickname of the CA certificate in the NSS database to export the CA certificate:

   ```
   # certutil -d /etc/httpd/alias/ -L -n "Example CA" -a -o /etc/pki/tls/certs/ca.crt
   ```
7. Follow Section 1.6, “Configuring TLS encryption on an Apache HTTP Server” to configure the Apache web server, and:

- Set the `SSLCertificateKeyFile` parameter to `/etc/pki/tls/private/server.key`.
- Set the `SSLCertificateFile` parameter to `/etc/pki/tls/certs/server.crt`.
- Set the `SSLCACertificateFile` parameter to `/etc/pki/tls/certs/ca.crt`.

Additional resources

- The `certutil(1)` man page
- The `pk12util(1)` man page
- The `pkcs12(1ssl)` man page

1.11. ADDITIONAL RESOURCES

- `httpd(8)` — The manual page for the `httpd` service containing the complete list of its command-line options.
- `httpd.service(8)` — The manual page for the `httpd.service` unit file, describing how to customize and enhance the service.
- `httpd.conf(5)` — The manual page for `httpd` configuration, describing the structure and location of the `httpd` configuration files.
- `apachectl(8)` — The manual page for the Apache HTTP Server Control Interface.
CHAPTER 2. SETTING UP AND CONFIGURING NGINX

NGINX is a high performance and modular server that you can use, for example, as a:

- Web server
- Reverse proxy
- Load balancer

This section describes how to NGINX in these scenarios.

2.1. INSTALLING AND PREPARING NGINX

Red Hat uses Application Streams to provide different versions of NGINX. This section describes how to:

- Select a stream and install NGINX
- Open the required ports in the firewall
- Enable and start the nginx service

Using the default configuration, NGINX runs as a web server on port 80 and provides content from the /usr/share/nginx/html/ directory.

Prerequisites

- RHEL 8 is installed.
- The host is subscribed to the Red Hat Customer Portal.
- The firewalld service is enabled and started.

Procedure

1. Display the available NGINX module streams:

```
# yum module list nginx
Red Hat Enterprise Linux 8 for x86_64 - AppStream (RPMs)
Name Stream Profiles Summary
nginx  1.14 [d] common [d]   nginx webserver
nginx  1.16       common [d]   nginx webserver
...  
```

   Hint: [d]efault, [e]nabled, [x]disabled, [i]nstalled

2. If you want to install a different stream than the default, select the stream:

   ```
   # yum module enable nginx:stream_version
   ```

3. Install the nginx package:

   ```
   # yum install nginx
   ```
4. Open the ports on which NGINX should provide its service in the firewall. For example, to open the default ports for HTTP (port 80) and HTTPS (port 443) in firewalld, enter:

```
# firewall-cmd --permanent --add-port=80/tcp,443/tcp
# firewall-cmd --reload
```

5. Enable the nginx service to start automatically when the system boots:

```
# systemctl enable nginx
```

6. Optionally, start the nginx service:

```
# systemctl start nginx
```

If you do not want to use the default configuration, skip this step, and configure NGINX accordingly before you start the service.

Verification steps

1. Use the yum utility to verify that the nginx package is installed:

```
# yum list installed nginx
```

2. Ensure that the ports on which NGINX should provide its service are opened in the firewalld:

```
# firewall-cmd --list-ports
```

80/tcp 443/tcp

3. Verify that the nginx service is enabled:

```
# systemctl is-enabled nginx
```

enabled

Additional resources

- For details about Subscription Manager, see the Using and Configuring Subscription Manager guide.
- For further details about Application Streams, modules, and installing packages, see the Installing, managing, and removing user-space components guide.
- For details about configuring firewalls, see the Securing networks guide.

### 2.2. CONFIGURING NGINX AS A WEB SERVER THAT PROVIDES DIFFERENT CONTENT FOR DIFFERENT DOMAINS

By default, NGINX acts as a web server that provides the same content to clients for all domain names associated with the IP addresses of the server. This procedure explains how to configure NGINX:
To serve requests to the example.com domain with content from the /var/www/example.com/ directory

To serve requests to the example.net domain with content from the /var/www/example.net/ directory

To serve all other requests, for example, to the IP address of the server or to other domains associated with the IP address of the server, with content from the /usr/share/nginx/html/ directory

**Prerequisites**

- NGINX is installed as described in Section 2.1, “Installing and preparing NGINX”.
- Clients and the web server resolve the example.com and example.net domain to the IP address of the web server.
  Note that you must manually add these entries to your DNS server.

**Procedure**

1. Edit the /etc/nginx/nginx.conf file:
   
   a. By default, the /etc/nginx/nginx.conf file already contains a catch-all configuration. If you have deleted this part from the configuration, re-add the following server block to the http block in the /etc/nginx/nginx.conf file:

   ```
   server {
     listen 80 default_server;
     listen [::]:80 default_server;
     server_name _;
     root /usr/share/nginx/html;
   }
   ```

   These settings configure the following:
   - The listen directive define which IP address and ports the service listens. In this case, NGINX listens on port 80 on both all IPv4 and IPv6 addresses. The default_server parameter indicates that NGINX uses this server block as the default for requests matching the IP addresses and ports.
   - The server_name parameter defines the host names for which this server block is responsible. Setting server_name to _ configures NGINX to accept any host name for this server block.
   - The root directive sets the path to the web content for this server block.

   b. Append a similar server block for the example.com domain to the http block:

   ```
   server {
     server_name example.com;
     root /var/www/example.com/;
     access_log /var/log/nginx/example.com/access.log;
     error_log /var/log/nginx/example.com/error.log;
   }
   ```

   - The access_log directive defines a separate access log file for this domain.
• The `error_log` directive defines a separate error log file for this domain.

c. Append a similar `server` block for the `example.net` domain to the `http` block:

```plaintext
server {
  server_name  example.net;
  root         /var/www/example.net/;
  access_log   /var/log/nginx/example.net/access.log;
  error_log    /var/log/nginx/example.net/error.log;
}
```

2. Create the root directories for both domains:

```plaintext
# mkdir -p /var/www/example.com/
# mkdir -p /var/www/example.net/
```

3. Set the `httpd_sys_content_t` context on both root directories:

```plaintext
# semanage fcontext -a -t httpd_sys_content_t "/var/www/example.com(/.*)?"
# restorecon -Rv /var/www/example.com/
# semanage fcontext -a -t httpd_sys_content_t "/var/www/example.net(/.*)?"
# restorecon -Rv /var/www/example.net/
```

These commands set the `httpd_sys_content_t` context on the `/var/www/example.com/` and `/var/www/example.net/` directories.

Note that you must install the `policycoreutils-python-utils` package to run the `restorecon` commands.

4. Create the log directories for both domains:

```plaintext
# mkdir /var/log/nginx/example.com/
# mkdir /var/log/nginx/example.net/
```

5. Restart the `nginx` service:

```plaintext
# systemctl restart nginx
```

Verification steps

1. Create a different example file in each virtual host’s document root:

```plaintext
# echo "Content for example.com" > /var/www/example.com/index.html
# echo "Content for example.net" > /var/www/example.net/index.html
# echo "Catch All content" > /usr/share/nginx/html/index.html
```

2. Use a browser and connect to `http://example.com`. The web server shows the example content from the `/var/www/example.com/index.html` file.

3. Use a browser and connect to `http://example.net`. The web server shows the example content from the `/var/www/example.net/index.html` file.

4. Use a browser and connect to `http://IP_address_of_the_server`. The web server shows the example content from the `/usr/share/nginx/html/index.html` file.
2.3. ADDING TLS ENCRYPTION TO AN NGINX WEB SERVER

This section describes how to enable TLS encryption on an NGINX web server for the example.com domain.

Prerequisites

- NGINX is installed as described in Section 2.1, “Installing and preparing NGINX”.
- The private key is stored in the /etc/pki/tls/private/example.com.key file. For details about creating a private key and certificate signing request (CSR), as well as how to request a certificate from a certificate authority (CA), see your CA’s documentation.
- The TLS certificate is stored in the /etc/pki/tls/certs/example.com.crt file. If you use a different path, adapt the corresponding steps of the procedure.
- The CA certificate has been appended to the TLS certificate file of the server.
- Clients and the web server resolve the host name of the server to the IP address of the web server.
- Port 443 is open in the local firewall.

Procedure

1. Edit the /etc/nginx/nginx.conf file, and add the following server block to the http block in the configuration:

   ```
   server {
   listen 443 ssl;
   server_name example.com;
   root /usr/share/nginx/html;
   ssl_certificate /etc/pki/tls/certs/example.com.crt;
   ssl_certificate_key /etc/pki/tls/private/example.com.key;
   }
   ```

2. For security reasons, configure that only the root user can access the private key file:

   ```
   # chown root:root /etc/pki/tls/private/example.com.key
   # chmod 600 /etc/pki/tls/private/example.com.key
   ```

   **WARNING**
   
   If the private key was accessed by unauthorized users, revoke the certificate, create a new private key, and request a new certificate. Otherwise, the TLS connection is no longer secure.

3. Restart the nginx service:

   ```
2.4. CONFIGURING NGINX AS A REVERSE PROXY FOR THE HTTP TRAFFIC

You can configure the NGINX web server to act as a reverse proxy for HTTP traffic. For example, you can use this functionality to forward requests to a specific subdirectory on a remote server. From the client perspective, the client loads the content from the host it accesses. However, NGINX loads the actual content from the remote server and forwards it to the client.

This procedure explains how to forward traffic to the /example directory on the web server to the URL https://example.com.

Prerequisites

- NGINX is installed as described in Section 2.1, “Installing and preparing NGINX”.
- Optional: TLS encryption is enabled on the reverse proxy.

Procedure

1. Edit the /etc/nginx/nginx.conf file and add the following settings to the server block that should provide the reverse proxy:

   ```
   location /example {
     proxy_pass https://example.com;
   }
   ```

   The location block defines that NGINX passes all requests in the /example directory to https://example.com.

2. Set the httpd_can_network_connect SELinux boolean parameter to 1 to configure that SELinux allows NGINX to forward traffic:

   ```
   # setsebool -P httpd_can_network_connect 1
   ```

3. Restart the nginx service:

   ```
   # systemctl restart nginx
   ```

Verification steps

- Use a browser and connect to http://host_name/example and the content of https://example.com is shown.

2.5. CONFIGURING NGINX AS AN HTTP LOAD BALANCER

You can use the NGINX reverse proxy feature to load-balance traffic. This procedure describes how to
configure NGINX as an HTTP load balancer that sends requests to different servers, based on which of them has the least number of active connections. If both servers are not available, the procedure also defines a third host for fallback reasons.

**Prerequisites**

- NGINX is installed as described in Section 2.1, “Installing and preparing NGINX”.

**Procedure**

1. Edit the `/etc/nginx/nginx.conf` file and add the following settings:

```plaintext
http {
  upstream backend {
    least_conn;
    server server1.example.com;
    server server2.example.com;
    server server3.example.com backup;
  }
  server {
    location / {
      proxy_pass http://backend;
    }
  }
}
```

The `least_conn` directive in the host group named `backend` defines that NGINX sends requests to `server1.example.com` or `server2.example.com`, depending on which host has the least number of active connections. NGINX uses `server3.example.com` only as a backup in case that the other two hosts are not available.

With the `proxy_pass` directive set to `http://backend`, NGINX acts as a reverse proxy and uses the `backend` host group to distribute requests based on the settings of this group.

Instead of the `least_conn` load balancing method, you can specify:

- No method to use round robin and distribute requests evenly across servers.
- `ip_hash` to send requests from one client address to the same server based on a hash calculated from the first three octets of the IPv4 address or the whole IPv6 address of the client.
- `hash` to determine the server based on a user-defined key, which can be a string, a variable, or a combination of both. The `consistent` parameter configures that NGINX distributes requests across all servers based on the user-defined hashed key value.
- `random` to send requests to a randomly selected server.

2. Restart the `nginx` service:

```
# systemctl restart nginx
```

**2.6. ADDITIONAL RESOURCES**
For the official NGINX documentation see https://nginx.org/en/docs/. Note that Red Hat does not maintain this documentation and that it might not work with the NGINX version you have installed.
CHAPTER 3. USING SAMBA AS A SERVER

Samba implements the Server Message Block (SMB) protocol in Red Hat Enterprise Linux. The SMB protocol is used to access resources on a server, such as file shares and shared printers. Additionally, Samba implements the Distributed Computing Environment Remote Procedure Call (DCE RPC) protocol used by Microsoft Windows.

You can run Samba as:

- An Active Directory (AD) or NT4 domain member
- A standalone server
- An NT4 Primary Domain Controller (PDC) or Backup Domain Controller (BDC)

**NOTE**

Red Hat supports the PDC and BDC modes only in existing installations with Windows versions which support NT4 domains. Red Hat recommends not setting up a new Samba NT4 domain, because Microsoft operating systems later than Windows 7 and Windows Server 2008 R2 do not support NT4 domains.

Red Hat does not support running Samba as an AD domain controller (DC).

Independently of the installation mode, you can optionally share directories and printers. This enables Samba to act as a file and print server.

3.1. UNDERSTANDING THE DIFFERENT SAMBA SERVICES AND MODES

This section describes the different services included in Samba and the different modes you can configure.

3.1.1. The Samba services

Samba provides the following services:

**smbd**

This service provides file sharing and printing services using the SMB protocol. Additionally, the service is responsible for resource locking and for authenticating connecting users. The `smbd` system service starts and stops the `smbd` daemon.

To use the `smbd` service, install the `samba` package.

**nmbd**

This service provides host name and IP resolution using the NetBIOS over IPv4 protocol. Additionally to the name resolution, the `nmbd` service enables browsing the SMB network to locate domains, work groups, hosts, file shares, and printers. For this, the service either reports this information directly to the broadcasting client or forwards it to a local or master browser. The `nmbd` system service starts and stops the `nmbd` daemon.

Note that modern SMB networks use DNS to resolve clients and IP addresses.

To use the `nmbd` service, install the `samba` package.
**winbindd**

This service provides an interface for the Name Service Switch (NSS) to use AD or NT4 domain users and groups on the local system. This enables, for example, domain users to authenticate to services hosted on a Samba server or to other local services. The **winbind systemd** service starts and stops the **winbindd** daemon.

If you set up Samba as a domain member, **winbindd** must be started before the **smbd** service. Otherwise, domain users and groups are not available to the local system.

To use the **winbindd** service, install the **samba-winbind** package.

---

**IMPORTANT**

Red Hat only supports running Samba as a server with the **winbindd** service to provide domain users and groups to the local system. Due to certain limitations, such as missing Windows access control list (ACL) support and NT LAN Manager (NTLM) fallback, SSSD is not supported.

### 3.1.2. The Samba security services

The **security** parameter in the **[global]** section in the **/etc/samba/smb.conf** file manages how Samba authenticates users that are connecting to the service. Depending on the mode you install Samba in, the parameter must be set to different values:

**On an AD domain member, setsecurity = ads**

In this mode, Samba uses Kerberos to authenticate AD users.

For details about setting up Samba as a domain member, see Section 3.5, “Setting up Samba as an AD domain member server”.

**On a standalone server, setsecurity = user**

In this mode, Samba uses a local database to authenticate connecting users.

For details about setting up Samba as a standalone server, see Section 3.3, “Setting up Samba as a standalone server”.

**On an NT4 PDC or BDC, setsecurity = user**

In this mode, Samba authenticates users to a local or LDAP database.

**On an NT4 domain member, setsecurity = domain**

In this mode, Samba authenticates connecting users to an NT4 PDC or BDC. You cannot use this mode on AD domain members.

For details about setting up Samba as a domain member, see Section 3.5, “Setting up Samba as an AD domain member server”.

**Additional resources**

- See the description of the **security** parameter in the **smb.conf(5)** man page.

### 3.1.3. Scenarios when Samba services and Samba client utilities load and reload their configuration

The following describes when Samba services and utilities load and reload their configuration:
Samba services reload their configuration:

- Automatically every 3 minutes
- On manual request, for example, when you run the `smbcontrol all reload-config` command.

Samba client utilities read their configuration only when you start them.

Note that certain parameters, such as `security` require a restart of the `smb` service to take effect and a reload is not sufficient.

### Additional resources

- The **How configuration changes are applied** section in the `smb.conf(5)` man page
- The `smbd(8), nmbd(8), and winbindd(8)` man pages

### 3.1.4. Editing the Samba configuration in a save way

Samba services automatically reload their configuration every 3 minutes. This procedure describes how to edit the Samba configuration in a way that prevents the services reload the changes before you have verified the configuration using the `testparm` utility.

#### Prerequisites

- Samba is installed.

#### Procedure

1. Create a copy of the `/etc/samba/smb.conf` file:
   
   ```
   # cp /etc/samba/smb.conf /etc/samba/samba.conf.copy
   ```

2. Edit the copied file and make the desired changes.

3. Verify the configuration in the `/etc/samba/samba.conf.copy` file:
   
   ```
   # testparm -s /etc/samba/samba.conf.copy
   
   If `testparm` reports errors, fix them and run the command again.
   ```

4. Override the `/etc/samba/smb.conf` file with the new configuration:
   
   ```
   # mv /etc/samba/samba.conf.copy /etc/samba/smb.conf
   ```

5. Wait until the Samba services automatically reload their configuration or manually reload the configuration:
   
   ```
   # smbcontrol all reload-config
   ```

### Additional resources
3.2. VERIFYING THE SAMBA CONFIGURATION

Red Hat recommends that you verify the Samba configuration each time you update the /etc/samba/smb.conf file. This section provides details about that.

3.2.1. Verifying the smb.conf file by using the testparm utility

The testparm utility verifies that the Samba configuration in the /etc/samba/smb.conf file is correct. The utility detects invalid parameters and values, but also incorrect settings, such as for ID mapping. If testparm reports no problem, the Samba services will successfully load the /etc/samba/smb.conf file. Note that testparm cannot verify that the configured services will be available or work as expected.

IMPORTANT

Red Hat recommends that you verify the /etc/samba/smb.conf file by using testparm after each modification of this file.

Prerequisites

- You installed Samba.
- The /etc/samba/smb.conf file exits.

Procedure

1. Run the testparm utility as the root user:

```bash
# testparm
Load smb config files from /etc/samba/smb.conf
rlimit_max: increasing rlimit_max (1024) to minimum Windows limit (16384)
Unknown parameter encountered: "log levell"
Processing section "[example_share]"
Loaded services file OK.
ERROR: The idmap range for the domain * (tdb) overlaps with the range of DOMAIN (ad)!

Server role: ROLE_DOMAIN_MEMBER

Press enter to see a dump of your service definitions

# Global parameters
[global]
...

[example_share]
...
```

The previous example output reports a non-existent parameter and an incorrect ID mapping configuration.
2. If `testparm` reports incorrect parameters, values, or other errors in the configuration, fix the problem and run the utility again.

### 3.3. SETTING UP SAMBA AS A STANDALONE SERVER

You can set up Samba as a server that is not a member of a domain. In this installation mode, Samba authenticates users to a local database instead of to a central DC. Additionally, you can enable guest access to allow users to connect to one or multiple services without authentication.

#### 3.3.1. Setting up the server configuration for the standalone server

This section describes how to set up the server configuration for a Samba standalone server.

**Procedure**

1. Install the `samba` package:
   ```
   # yum install samba
   ```

2. Edit the `/etc/samba/smb.conf` file and set the following parameters:
   ```
   [global]
   workgroup = Example-WG
   netbios name = Server
   security = user
   log file = /var/log/samba/%m.log
   log level = 1
   ```

   This configuration defines a standalone server named **Server** within the **Example-WG** work group. Additionally, this configuration enables logging on a minimal level (1) and log files will be stored in the `/var/log/samba/` directory. Samba will expand the `%m` macro in the `log file` parameter to the NetBIOS name of connecting clients. This enables individual log files for each client.

3. Optionally, configure file or printer sharing. See:
   - Section 3.7, “Setting up a Samba file share that uses POSIX ACLs”
   - Section 3.9, “Setting up a share that uses Windows ACLs”
   - Section 3.15, “Setting up Samba as a print server”

4. Verify the `/etc/samba/smb.conf` file:
   ```
   # testparm
   ```

5. If you set up shares that require authentication, create the user accounts. For details, see Section 3.3.2, “Creating and enabling local user accounts”.

6. Open the required ports and reload the firewall configuration by using the `firewall-cmd` utility:
   ```
   # firewall-cmd --permanent --add-port={139/tcp,445/tcp}
   # firewall-cmd --reload
   ```
7. Enable and start the `smb` service:

```
# systemctl enable --now smb
```

Additional resources

- For further details about the parameters used in the procedure, see the descriptions of the parameters in the `smb.conf(5)` man page.

### 3.3.2. Creating and enabling local user accounts

To enable users to authenticate when they connect to a share, you must create the accounts on the Samba host both in the operating system and in the Samba database. Samba requires the operating system account to validate the Access Control Lists (ACL) on file system objects and the Samba account to authenticate connecting users.

If you use the `passdb backend = tdbsam` default setting, Samba stores user accounts in the `/var/lib/samba/private/passdb.tdb` database.

The procedure in this section describes how to create a local Samba user named `example`.

**Prerequisites**

- Samba is installed configured as a standalone server.

**Procedure**

1. Create the operating system account:

```
# useradd -M -s /sbin/nologin example
```

This command adds the `example` account without creating a home directory. If the account is only used to authenticate to Samba, assign the `/sbin/nologin` command as shell to prevent the account from logging in locally.

2. Set a password to the operating system account to enable it:

```
# passwd example
```

Enter new UNIX password: `password`
Retype new UNIX password: `password`
passwd: password updated successfully

Samba does not use the password set on the operating system account to authenticate. However, you need to set a password to enable the account. If an account is disabled, Samba denies access if this user connects.

3. Add the user to the Samba database and set a password to the account:

```
# smbpasswd -a example
```

New SMB password: `password`
Retype new SMB password: `password`
Added user example.

Use this password to authenticate when using this account to connect to a Samba share.
4. Enable the Samba account:

```bash
# smbpasswd -e example
Enabled user example.
```

### 3.4. UNDERSTANDING AND CONFIGURING SAMBA ID MAPPING

Windows domains distinguish users and groups by unique Security Identifiers (SID). However, Linux requires unique UIDs and GIDs for each user and group. If you run Samba as a domain member, the `winbindd` service is responsible for providing information about domain users and groups to the operating system.

To enable the `winbindd` service to provide unique IDs for users and groups to Linux, you must configure ID mapping in the `/etc/samba/smb.conf` file for:

- The local database (default domain)
- The AD or NT4 domain the Samba server is a member of
- Each trusted domain from which users must be able to access resources on this Samba server

Samba provides different ID mapping back ends for specific configurations. The most frequently used back ends are:

<table>
<thead>
<tr>
<th>Back end</th>
<th>Use case</th>
</tr>
</thead>
<tbody>
<tr>
<td>tdb</td>
<td>The * default domain only</td>
</tr>
<tr>
<td>ad</td>
<td>AD domains only</td>
</tr>
<tr>
<td>rid</td>
<td>AD and NT4 domains</td>
</tr>
<tr>
<td>autorid</td>
<td>AD, NT4, and the * default domain</td>
</tr>
</tbody>
</table>

#### 3.4.1. Planning Samba ID ranges

Regardless of whether you store the Linux UIDs and GIDs in AD or if you configure Samba to generate them, each domain configuration requires a unique ID range that must not overlap with any of the other domains.

**WARNING**

If you set overlapping ID ranges, Samba fails to work correctly.

---

**Example 3.1. Unique ID Ranges**
The following shows non-overlapping ID mapping ranges for the default (*), AD-DOM, and the TRUST-DOM domains.

```plaintext
[global]
...
idmap config * : backend = tdb
idmap config * : range = 10000-999999

idmap config AD-DOM:backend = rid
idmap config AD-DOM:range = 2000000-2999999

idmap config TRUST-DOM:backend = rid
idmap config TRUST-DOM:range = 4000000-4999999
```

**IMPORTANT**

You can only assign one range per domain. Therefore, leave enough space between the domains ranges. This enables you to extend the range later if your domain grows.

If you later assign a different range to a domain, the ownership of files and directories previously created by these users and groups will be lost.

3.4.2. The * default domain

In a domain environment, you add one ID mapping configuration for each of the following:

- The domain the Samba server is a member of
- Each trusted domain that should be able to access the Samba server

However, for all other objects, Samba assigns IDs from the default domain. This includes:

- Local Samba users and groups
- Samba built-in accounts and groups, such as `BUILTIN\Administrators`

**IMPORTANT**

You must configure the default domain as described in this section to enable Samba to operate correctly.

The default domain back end must be writable to permanently store the assigned IDs.

For the default domain, you can use one of the following back ends:

**tdb**

When you configure the default domain to use the `tdb` back end, set an ID range that is big enough to include objects that will be created in the future and that are not part of a defined domain ID mapping configuration.

For example, set the following in the `[global]` section in the `/etc/samba/smb.conf` file:

```plaintext
idmap config * : backend = tdb
idmap config * : range = 10000-999999
```
For further details, see Section 3.4.3, “Using the tdb ID mapping back end”.

**autorid**

When you configure the default domain to use the **autorid** back end, adding additional ID mapping configurations for domains is optional. For example, set the following in the [global] section in the `/etc/samba/smb.conf` file:

```
idmap config * : backend = autorid
idmap config * : range = 10000-999999
```

For further details, see Section 3.4.6, “Using the autorid ID mapping back end”.

### 3.4.3. Using the tdb ID mapping back end

The **winbindd** service uses the writable **tdb** ID mapping back end by default to store Security Identifier (SID), UID, and GID mapping tables. This includes local users, groups, and built-in principals.

Use this back end only for the * default domain. For example:

```
idmap config * : backend = tdb
idmap config * : range = 10000-999999
```

**Additional resources**

- Section 3.4.2, “The * default domain”.

### 3.4.4. Using the ad ID mapping back end

This section describes how to configure a Samba AD member to use the **ad** ID mapping back end.

The **ad** ID mapping back end implements a read-only API to read account and group information from AD. This provides the following benefits:

- All user and group settings are stored centrally in AD.
- User and group IDs are consistent on all Samba servers that use this back end.
- The IDs are not stored in a local database which can corrupt, and therefore file ownerships cannot be lost.

**NOTE**

The **ad** ID mapping back end does not support Active Directory domains with one-way trusts. If you configure a domain member in an Active Directory with one-way trusts, use instead one of the following ID mapping back ends: **tdb**, **rid**, or **autorid**.

The ad back end reads the following attributes from AD:
<table>
<thead>
<tr>
<th>AD attribute name</th>
<th>Object type</th>
<th>Mapped to</th>
</tr>
</thead>
<tbody>
<tr>
<td>sAMAccountName</td>
<td>User and group</td>
<td>User or group name, depending on the object</td>
</tr>
<tr>
<td>uidNumber</td>
<td>User</td>
<td>User ID (UID)</td>
</tr>
<tr>
<td>gidNumber</td>
<td>Group</td>
<td>Group ID (GID)</td>
</tr>
<tr>
<td>loginShell</td>
<td>User</td>
<td>Path to the shell of the user</td>
</tr>
<tr>
<td>unixHomeDirectory</td>
<td>User</td>
<td>Path to the home directory of the user</td>
</tr>
<tr>
<td>primaryGroupID</td>
<td>User</td>
<td>Primary group ID</td>
</tr>
</tbody>
</table>

[a] Samba only reads this attribute if you set `idmap config DOMAIN:unix_nss_info = yes.`

[b] Samba only reads this attribute if you set `idmap config DOMAIN:unix_primary_group = yes.`

Prerequisites

- Both users and groups must have unique IDs set in AD, and the IDs must be within the range configured in the `/etc/samba/smb.conf` file. Objects whose IDs are outside of the range will not be available on the Samba server.

- Users and groups must have all required attributes set in AD. If required attributes are missing, the user or group will not be available on the Samba server. The required attributes depend on your configuration.

- You installed Samba.

- The Samba configuration, except ID mapping, exists in the `/etc/samba/smb.conf` file.

Procedure

1. Edit the `[global]` section in the `/etc/samba/smb.conf` file:
   a. Add an ID mapping configuration for the default domain (*) if it does not exist. For example:

   ```
   idmap config * : backend = tdb
   idmap config * : range = 10000-999999
   ```

   b. Enable the `ad` ID mapping back end for the AD domain:

   ```
   idmap config DOMAIN : backend = ad
   ```

   c. Set the range of IDs that is assigned to users and groups in the AD domain. For example:

   ```
   idmap config DOMAIN : range = 2000000-2999999
   ```
IMPORTANT

The range must not overlap with any other domain configuration on this server. Additionally, the range must be set big enough to include all IDs assigned in the future. For further details, see Section 3.4.1, “Planning Samba ID ranges”.

d. Set that Samba uses the RFC 2307 schema when reading attributes from AD:

```bash
idmap config DOMAIN: schema_mode = rfc2307
```

e. To enable Samba to read the login shell and the path to the users home directory from the corresponding AD attribute, set:

```bash
idmap config DOMAIN: unix_nss_info = yes
```

Alternatively, you can set a uniform domain-wide home directory path and login shell that is applied to all users. For example:

```bash
template shell = /bin/bash
template homedir = /home/%U
```

f. By default, Samba uses the primaryGroupID attribute of a user object as the user’s primary group on Linux. Alternatively, you can configure Samba to use the value set in the gidNumber attribute instead:

```bash
idmap config DOMAIN: unix_primary_group = yes
```

2. Verify the `/etc/samba/smb.conf` file:

```bash
# testparm
```

3. Reload the Samba configuration:

```bash
# smbcontrol all reload-config
```

Additional resources

- Section 3.4.2, “The * default domain”
- For further details about the parameters used in the procedure, see the `smb.conf(5)` and `idmap_ad(8)` man pages.
- For details about variable substitution, see the VARIABLE SUBSTITUTIONS section in the `smb.conf(5)` man page.

### 3.4.5. Using the rid ID mapping back end

This section describes how to configure a Samba domain member to use the rid ID mapping back end.

Samba can use the relative identifier (RID) of a Windows SID to generate an ID on Red Hat Enterprise Linux.
NOTE

The RID is the last part of a SID. For example, if the SID of a user is `S-1-5-21-5421822485-1151247151-421485315-30014`, then `30014` is the corresponding RID.

The **rid** ID mapping back end implements a read-only API to calculate account and group information based on an algorithmic mapping scheme for AD and NT4 domains. When you configure the back end, you must set the lowest and highest RID in the `idmap config DOMAIN : range` parameter. Samba will not map users or groups with a lower or higher RID than set in this parameter.

**IMPORTANT**

As a read-only back end, **rid** cannot assign new IDs, such as for **BUILTIN** groups. Therefore, do not use this back end for the * default domain.

Benefits of using the **rid** back end

- All domain users and groups that have an RID within the configured range are automatically available on the domain member.
- You do not need to manually assign IDs, home directories, and login shells.

Drawbacks of using the **rid** back end

- All domain users get the same login shell and home directory assigned. However, you can use variables.
- User and group IDs are only the same across Samba domain members if all use the **rid** back end with the same ID range settings.
- You cannot exclude individual users or groups from being available on the domain member. Only users and groups outside of the configured range are excluded.
- Based on the formulas the **winbindd** service uses to calculate the IDs, duplicate IDs can occur in multi-domain environments if objects in different domains have the same RID.

Prerequisites

- You installed Samba.
- The Samba configuration, except ID mapping, exists in the `/etc/samba/smb.conf` file.

Procedure

1. Edit the `[global]` section in the `/etc/samba/smb.conf` file:
   a. Add an ID mapping configuration for the default domain (*) if it does not exist. For example:
      ```
      idmap config * : backend = tdb
      idmap config * : range = 10000-999999
      ```
   b. Enable the **rid** ID mapping back end for the domain:
      ```
      idmap config DOMAIN : backend = rid
      ```
c. Set a range that is big enough to include all RIDs that will be assigned in the future. For example:

```
idmap config DOMAIN : range = 2000000-2999999
```

Samba ignores users and groups whose RIDs in this domain are not within the range.

**IMPORTANT**

The range must not overlap with any other domain configuration on this server. For further details, see Section 3.4.1, “Planning Samba ID ranges”.

d. Set a shell and home directory path that will be assigned to all mapped users. For example:

```
template shell = /bin/bash
template homedir = /home/%U
```

2. Verify the `/etc/samba/smb.conf` file:

```
# testparm
```

3. Reload the Samba configuration:

```
# smbcontrol all reload-config
```

Additional resources

- Section 3.4.2, “The * default domain”
- For details about variable substitution, see the VARIABLE SUBSTITUTIONS section in the `smb.conf(5)` man page.
- For details, how Samba calculates the local ID from a RID, see the `idmap_rid(8)` man page.

### 3.4.6. Using the autorid ID mapping back end

This section describes how to configure a Samba domain member to use the autorid ID mapping back end.

The autorid back end works similar to the rid ID mapping back end, but can automatically assign IDs for different domains. This enables you to use the autorid back end in the following situations:

- Only for the * default domain
- For the * default domain and additional domains, without the need to create ID mapping configurations for each of the additional domains
- Only for specific domains

**NOTE**

If you use autorid for the default domain, adding additional ID mapping configuration for domains is optional.
Benefits of using the autorid back end

- All domain users and groups whose calculated UID and GID is within the configured range are automatically available on the domain member.
- You do not need to manually assign IDs, home directories, and login shells.
- No duplicate IDs, even if multiple objects in a multi-domain environment have the same RID.

Drawbacks

- User and group IDs are not the same across Samba domain members.
- All domain users get the same login shell and home directory assigned. However, you can use variables.
- You cannot exclude individual users or groups from being available on the domain member. Only users and groups whose calculated UID or GID is outside of the configured range are excluded.

Prerequisites

- You installed Samba.
- The Samba configuration, except ID mapping, exists in the /etc/samba/smb.conf file.

Procedure

1. Edit the [global] section in the /etc/samba/smb.conf file:
   a. Enable the autorid ID mapping back end for the * default domain:

   ```
   idmap config * : backend = autorid
   ```

   b. Set a range that is big enough to assign IDs for all existing and future objects. For example:

   ```
   idmap config * : range = 10000-999999
   ```

   Samba ignores users and groups whose calculated IDs in this domain are not within the range.

   **WARNING**

   After you set the range and Samba starts using it, you can only increase the upper limit of the range. Any other change to the range can result in new ID assignments, and thus in losing file ownerships.

   c. Optionally, set a range size. For example:
idmap config * : rangesize = 200000

Samba assigns this number of continuous IDs for each domain’s object until all IDs from the range set in the `idmap config * : range` parameter are taken.

d. Set a shell and home directory path that will be assigned to all mapped users. For example:

```
template shell = /bin/bash
template homedir = /home/%U
```

e. Optionally, add additional ID mapping configuration for domains. If no configuration for an individual domain is available, Samba calculates the ID using the `autorid` back end settings in the previously configured * default domain.

**IMPORTANT**

If you configure additional back ends for individual domains, the ranges for all ID mapping configuration must not overlap. For further details, see Section 3.4.1, “Planning Samba ID ranges”.

2. Verify the `/etc/samba/smb.conf` file:

```
# testparm
```

3. Reload the Samba configuration:

```
# smbcontrol all reload-config
```

Additional resources

- For details about how the back end calculated IDs, see the **THE MAPPING FORMULAS** section in the `idmap_autorid(8)` man page.

- For details about using the `idmap config rangesize` parameter, see the `rangesize` parameter description in the `idmap_autorid(8)` man page.

- For details about variable substitution, see the **VARIABLE SUBSTITUTIONS** section in the `smb.conf(5)` man page.

### 3.5. SETTING UP SAMBA AS AN AD DOMAIN MEMBER SERVER

If you are running an AD or NT4 domain, use Samba to add your Red Hat Enterprise Linux server as a member to the domain to gain the following:

- Access domain resources on other domain members
- Authenticate domain users to local services, such as `sshd`
- Share directories and printers hosted on the server to act as a file and print server

#### 3.5.1. Joining a RHEL system to an AD domain
This section describes how to join a Red Hat Enterprise Linux system to an AD domain by using **realm** to configure Samba Winbind.

**Procedure**

1. If your AD requires the deprecated RC4 encryption type for Kerberos authentication, enable support for these ciphers in RHEL:
   
   ```
   # update-crypto-policies --set DEFAULT:AD-SUPPORT
   ```

2. Install the following packages:
   
   ```
   # yum install realmd oddjob-mkhomedir oddjob samba-winbind-clients \ samba-winbind samba-common-tools samba-winbind-krb5-locator
   ```

3. To share directories or printers on the domain member, install the **samba** package:
   
   ```
   # yum install samba
   ```

4. Backup the existing `/etc/samba/smb.conf` Samba configuration file:
   
   ```
   # mv /etc/samba/smb.conf /etc/samba/smb.conf.bak
   ```

5. Join the domain. For example, to join a domain named `ad.example.com`:
   
   ```
   # realm join --membership-software=samba --client-software=winbind ad.example.com
   ```

   Using the previous command, the **realm** utility automatically:
   
   - Creates a `/etc/samba/smb.conf` file for a membership in the `ad.example.com` domain
   - Adds the `winbind` module for user and group lookups to the `/etc/nsswitch.conf` file
   - Updates the Pluggable Authentication Module (PAM) configuration files in the `/etc/pam.d/` directory
   - Starts the `winbind` service and enables the service to start when the system boots

6. Optionally, set an alternative ID mapping back end or customized ID mapping settings in the `/etc/samba/smb.conf` file. For details, see Section 3.4, "Understanding and configuring Samba ID mapping".

7. Verify that the `winbind` service is running:
   
   ```
   # systemctl status winbind
   ...
   Active: active (running) since Tue 2018-11-06 19:10:40 CET; 15s ago
   ```

   **IMPORTANT**

   To enable Samba to query domain user and group information, the `winbind` service must be running before you start `smb`. 

8. If you installed the **samba** package to share directories and printers, enable and start the **smb** service:

```bash
# systemctl enable --now smb
```

9. Optionally, if you are authenticating local logins to Active Directory, enable the **winbind_krb5_localauth** plug-in. See Section 3.5.2, “Using the local authorization plug-in for MIT Kerberos”.

Verification steps

1. Display an AD user’s details, such as the AD administrator account in the AD domain:

```bash
# getent passwd "AD\administrator"
AD\administrator:*:10000:10000::/home/administrator@AD:/bin/bash
```

2. Query the members of the domain users group in the AD domain:

```bash
# getent group "AD\Domain Users"
AD\domain users:x:10000:user1,user2
```

3. Optionally, verify that you can use domain users and groups when you set permissions on files and directories. For example, to set the owner of the */srv/samba/example.txt* file to **AD\administrator** and the group to **AD\Domain Users**:

```bash
# chown "AD\administrator":"AD\Domain Users" /srv/samba/example.txt
```

4. Verify that Kerberos authentication works as expected:
   a. On the AD domain member, obtain a ticket for the **administrator@AD.EXAMPLE.COM** principal:

```bash
# kinit administrator@AD.EXAMPLE.COM
```

   b. Display the cached Kerberos ticket:

```bash
# klist
Ticket cache: KCM:0
Default principal: administrator@AD.EXAMPLE.COM

Valid starting     Expires            Service principal
01.11.2018 10:00:00  01.11.2018 20:00:00
krbtgt/AD.EXAMPLE.COM@AD.EXAMPLE.COM
renew until 08.11.2018 05:00:00
```

5. Display the available domains:

```bash
# wbinfo --all-domains
BUILTIN
SAMBA-SERVER
AD
```

Additional resources
• If you do not want to use the deprecated RC4 ciphers, you can enable the AES encryption type in AD. See Section 3.6.2, "Enabling the AES encryption type in Active Directory using a GPO". Note that this can have an impact on other services in your AD.

• For further details about the realm utility, see the realm(8) man page.

3.5.2. Using the local authorization plug-in for MIT Kerberos

The winbind service provides Active Directory users to the domain member. In certain situations, administrators want to enable domain users to authenticate to local services, such as an SSH server, which are running on the domain member. When using Kerberos to authenticate the domain users, enable the winbind_krb5_localauth plug-in to correctly map Kerberos principals to Active Directory accounts through the winbind service.

For example, if the sAMAccountName attribute of an Active Directory user is set to EXAMPLE and the user tries to log with the user name lowercase, Kerberos returns the user name in upper case. As a consequence, the entries do not match an authentication fails.

Using the winbind_krb5_localauth plug-in, the account names are mapped correctly. Note that this only applies to GSSAPI authentication and not for getting the initial ticket granting ticket (TGT).

Prerequisites

• Samba is configured as a member of an Active Directory.

• Red Hat Enterprise Linux authenticates log in attempts against Active Directory.

• The winbind service is running.

Procedure

Edit the /etc/krb5.conf file and add the following section:

```
[plugins]
localauth = {
    module = winbind:/usr/lib64/samba/krb5/winbind_krb5_localauth.so
    enable_only = winbind
}
```

Additional resources

• See the winbind_krb5_localauth(8) man page.

3.6. SETTING UP SAMBA ON AN IDM DOMAIN MEMBER

This section describes how to set up Samba on a host that is joined to a Red Hat Identity Management (IdM) domain. Users from IdM and also, if available, from trusted Active Directory (AD) domains, can access shares and printer services provided by Samba.
IMPORTANT

Using Samba on an IdM domain member is an unsupported Technology Preview feature and contains certain limitations. For example, due to IdM trust controllers not supporting the Global Catalog service, AD-enrolled Windows hosts cannot find IdM users and groups in Windows. Additionally, IdM Trust Controllers do not support resolving IdM groups using the Distributed Computing Environment / Remote Procedure Calls (DCE/RPC) protocols. As a consequence, AD users can only access the Samba shares and printers from IdM clients.

Customers deploying Samba on IdM domain members are encouraged to provide feedback to Red Hat.

Prerequisites

- The host is joined as a client to the IdM domain.
- Both the IdM servers and the client must run on RHEL 8.1 or later.

3.6.1. Preparing the IdM domain for installing Samba on domain members

Before you can establish a trust with AD and if you want to set up Samba on an IdM client, you must prepare the IdM domain using the `ipa-adtrust-install` utility on an IdM server. However, even if both situations apply, you must run `ipa-adtrust-install` only once on an IdM master.

Prerequisites

- IdM is installed.

Procedure

1. Install the required packages:
   
   [root@ipaserver ~]# yum install ipa-server ipa-server-trust-ad samba-client

2. Authenticate as the IdM administrative user:
   
   [root@ipaserver ~]# kinit admin

3. Run the `ipa-adtrust-install` utility:
   
   [root@ipaserver ~]# ipa-adtrust-install

   The DNS service records are created automatically if IdM was installed with an integrated DNS server.

   If IdM was installed without an integrated DNS server, `ipa-adtrust-install` prints a list of service records that must be manually added to DNS before you can continue.

4. The script prompts you that the `/etc/samba/smb.conf` already exists and will be rewritten:

   WARNING: The smb.conf already exists. Running ipa-adtrust-install will break your existing Samba configuration.
Do you wish to continue? [no]: yes

5. The script prompts you to configure the **slapi-nis** plug-in, a compatibility plug-in that allows older Linux clients to work with trusted users:

Do you want to enable support for trusted domains in Schema Compatibility plugin? This will allow clients older than SSSD 1.9 and non-Linux clients to work with trusted users.

Enable trusted domains support in slapi-nis? [no]: yes

6. When prompted, enter the NetBIOS name for the IdM domain or press Enter to accept the name suggested:

Trust is configured but no NetBIOS domain name found, setting it now. Enter the NetBIOS name for the IPA domain.
Only up to 15 uppercase ASCII letters, digits and dashes are allowed. Example: EXAMPLE.

NetBIOS domain name [IDM]:

7. You are prompted to run the SID generation task to create a SID for any existing users:

Do you want to run the ipa-sidgen task? [no]: yes

When the directory is first installed, at least one user (the IdM administrator) exists and as this is a resource-intensive task, if you have a high number of users, you can run this at another time.

8. (Optional) By default, the Dynamic RPC port range is defined as **49152-65535** for Windows Server 2008 and later. If you need to define a different Dynamic RPC port range for your environment, configure Samba to use different ports and open those ports in your firewall settings. The following example sets the port range to **55000-65000**.

   ```
   [root@ipaserver ~]# net conf setparm global 'rpc server dynamic port range' 55000-65000
   [root@ipaserver ~]# firewall-cmd --add-port=55000-65000/tcp
   [root@ipaserver ~]# firewall-cmd --runtime-to-permanent
   ```

9. Restart the **ipa** service:

   ```
   [root@ipaserver ~]# ipactl restart
   ```

10. Use the **smbclient** utility to verify that Samba responds to Kerberos authentication from the IdM side:

    ```
    [root@ipaserver ~]# smbclient -L server.idm.example.com -k
    lp_load_ex: changing to config backend registry
    Sharename       Type      Comment
    ---------       ----      -------
    IPC$            IPC       IPC Service (Samba 4.12.3)
    ...
    ```

3.6.2. Enabling the AES encryption type in Active Directory using a GPO
This section describes how to enable the AES encryption type in Active Directory (AD) using a group policy object (GPO). Certain features on RHEL 8, such as running a Samba server on an IdM client, require this encryption type.

Note that RHEL 8 does not support the weak DES and RC4 encryption types.

### Prerequisites

- You are logged into AD as a user who can edit group policies.
- The **Group Policy Management Console** is installed on the computer.

### Procedure

1. Open the **Group Policy Management Console**.
2. Right-click **Default Domain Policy**, and select **Edit**. The **Group Policy Management Editor** opens.
4. Double-click the **Network security: Configure encryption types allowed for Kerberos** policy.
5. Select **AES256_HMAC_SHA1** and, optionally, **Future encryption types**.
6. Click **OK**.
7. Close the **Group Policy Management Editor**.
8. Repeat the steps for the **Default Domain Controller Policy**.
9. Wait until the Windows domain controllers (DC) applied the group policy automatically. Alternatively, to apply the GPO manually on a DC, enter the following command using an account that has administrator permissions:

   ```
   C:\> gpupdate /force /target:computer
   ```

### 3.6.3. Installing and configuring a Samba server on an IdM client

This section describes how to install and configure Samba on a client enrolled in an IdM domain.

### Prerequisites

- Both the IdM servers and the client must run on RHEL 8.1 or later.
- The IdM domain is prepared as described in Section 3.6.1, “Preparing the IdM domain for installing Samba on domain members”.
- If IdM has a trust configured with AD, enable the AES encryption type for Kerberos. For example, use a group policy object (GPO) to enable the AES encryption type. For details, see Section 3.6.2, “Enabling the AES encryption type in Active Directory using a GPO”.

### Procedure
1. Install the **ipa-client-samba** package:

   ```bash
   [root@idm_client]# yum install ipa-client-samba
   ```

2. Use the **ipa-client-samba** utility to prepare the client and create an initial Samba configuration:

   ```bash
   [root@idm_client]# ipa-client-samba
   Searching for IPA server...  
   IPA server: DNS discovery  
   Chosen IPA master: idm_server.idm.example.com  
   SMB principal to be created: cifs/idm_client.idm.example.com@IDM.EXAMPLE.COM  
   NetBIOS name to be used: IDM_CLIENT  
   Discovered domains to use:  
   Domain name: idm.example.com  
   NetBIOS name: IDM  
   SID: S-1-5-21-525930803-952335037-206501584  
   ID range: 212000000 - 212199999  
   Domain name: ad.example.com  
   NetBIOS name: AD  
   SID: None  
   ID range: 1918400000 - 1918599999  
   
   Continue to configure the system with these values? [no]: yes  
   Samba domain member is configured. Please check configuration at /etc/samba/smb.conf  
   and start smb and winbind services
   ```

3. By default, **ipa-client-samba** automatically adds the [homes] section to the 
   /etc/samba/smb.conf file that dynamically shares a user’s home directory when the user 
   connects. If users do not have home directories on this server, or if you do not want to share 
   them, remove the following lines from /etc/samba/smb.conf:

   ```
   [homes]  
   read only = no
   ```

4. Share directories and printers. For details, see:

   - Section 3.7, “Setting up a Samba file share that uses POSIX ACLs”
   - Section 3.9, “Setting up a share that uses Windows ACLs”
   - Section 3.15, “Setting up Samba as a print server”

5. Open the ports required for a Samba client in the local firewall:

   ```bash
   [root@idm_client]# firewall-cmd --permanent --add-service=samba-client  
   [root@idm_client]# firewall-cmd --reload
   ```

6. Enable and start the smb and winbind services:

   ```bash
   [root@idm_client]# systemctl enable --now smb winbind
   ```

**Verification steps**
Run the following verification steps on a different IdM domain member that has the `samba-client` package installed:

1. Authenticate and obtain a Kerberos ticket-granting ticket:

   ```bash
   $ kinit example_user
   ```

2. List the shares on the Samba server using Kerberos authentication:

   ```bash
   $ smbclient -L idm_client.idm.example.com -k
   lp_load_ex: changing to config backend registry
   
   Sharename   Type   Comment
   --------    ----   ------
   example     Disk    
   IPC$         IPC   IPC Service (Samba 4.12.3)
   ...          
   ```

Additional resources

- For details about which steps `ipa-client-samba` performs during the configuration, see the `ipa-client-samba(1)` man page.

### 3.6.4. Manually adding an ID mapping configuration if IdM trusts a new domain

Samba requires an ID mapping configuration for each domain from which users access resources. On an existing Samba server running on an IdM client, you must manually add an ID mapping configuration after the administrator added a new trust to an Active Directory (AD) domain.

**Prerequisites**

- You configured Samba on an IdM client. Afterward, a new trust was added to IdM.

- The DES and RC4 encryption types for Kerberos must be disabled in the trusted AD domain. For security reasons, RHEL 8 does not support these weak encryption types.

**Procedure**

1. Authenticate using the host’s keytab:

   ```bash
   [root@idm_client]# kinit -k
   ```

2. Use the `ipa idrange-find` command to display both the base ID and the ID range size of the new domain. For example, the following command displays the values for the `ad.example.com` domain:

   ```bash
   [root@idm_client]# ipa idrange-find --name="AD.EXAMPLE.COM_id_range" --raw
   ---------------
   1 range matched
   ---------------
   cn: AD.EXAMPLE.COM_id_range
   ipabaseid: 1918400000
   ipaidrangesize: 200000
   ipabaserid: 0
   ```
You need the values from the ipabaseid and ipadrangesize attributes in the next steps.

3. To calculate the highest usable ID, use the following formula:

\[
\text{maximum_range} = \text{ipabaseid} + \text{ipadrangesize} - 1
\]

With the values from the previous step, the highest usable ID for the ad.example.com domain is 1918599999 (1918400000 + 200000 - 1).

4. Edit the `/etc/samba/smb.conf` file, and add the ID mapping configuration for the domain to the `[global]` section:

```
idmap config AD : range = 1918400000 - 1918599999
idmap config AD : backend = sss
```

Specify the value from ipabaseid attribute as the lowest and the computed value from the previous step as the highest value of the range.

5. Restart the smb and winbind services:

```
[root@idm_client]# systemctl restart smb winbind
```

Verification steps

1. Authenticate as a user from the new domain and obtain a Kerberos ticket-granting ticket:

```
$ kinit example_user
```

2. List the shares on the Samba server using Kerberos authentication:

```
$ smbclient -L idm_client.idm.example.com -k
lp_load_ex: changing to config backend registry

<table>
<thead>
<tr>
<th>Sharename</th>
<th>Type</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>example</td>
<td>Disk</td>
<td></td>
</tr>
<tr>
<td>IPC$</td>
<td>IPC</td>
<td>IPC Service (Samba 4.12.3)</td>
</tr>
</tbody>
</table>
```

3.6.5. Additional resources

- For details about joining RHEL 8 to an IdM domain, see the Installing an Identity Management client section in the Installing Identity Management guide.

3.7. SETTING UP A SAMBA FILE SHARE THAT USES POSIX ACLS
As a Linux service, Samba supports shares with POSIX ACLs. They enable you to manage permissions locally on the Samba server using utilities, such as `chmod`. If the share is stored on a file system that supports extended attributes, you can define ACLs with multiple users and groups.

**NOTE**

If you need to use fine-granular Windows ACLs instead, see Section 3.9, “Setting up a share that uses Windows ACLs”.

Parts of this section were adopted from the Setting up a Share Using POSIX ACLs documentation published in the Samba Wiki. License: CC BY 4.0. Authors and contributors: See the history tab on the Wiki page.

### 3.7.1. Adding a share that uses POSIX ACLs

This section describes how to create a share named `example` that provides the content of the `/srv/samba/example/` directory, and uses POSIX ACLs.

**Prerequisites**

Samba has been set up in one of the following modes:

- Standalone server
- Domain member

**Procedure**

1. Create the folder if it does not exist. For example:

   ```
   # mkdir -p /srv/samba/example/
   ```

2. If you run SELinux in **enforcing** mode, set the `samba_share_t` context on the directory:

   ```
   # semanage fcontext -a -t samba_share_t "/srv/samba/example(/.*)?"
   # restorecon -Rv /srv/samba/example/
   ```

3. Set file system ACLs on the directory. For details, see:

   - Section 3.7.2, “Setting standard Linux ACLs on a Samba share that uses POSIX ACLs”
   - Section 3.7.3, “Setting extended ACLs on a Samba share that uses POSIX ACLs”.

4. Add the example share to the `/etc/samba/smb.conf` file. For example, to add the share write-enabled:

   ```
   [example]
   path = /srv/samba/example/
   read only = no
   ```

   **NOTE**

   Regardless of the file system ACLs; if you do not set `read only = no`, Samba shares the directory in read-only mode.
5. Verify the `/etc/samba/smb.conf` file:

   ```
   # testparm
   ```

6. Open the required ports and reload the firewall configuration using the `firewall-cmd` utility:

   ```
   # firewall-cmd --permanent --add-service=samba
   # firewall-cmd --reload
   ```

7. Restart the `smb` service:

   ```
   # systemctl restart smb
   ```

### 3.7.2. Setting standard Linux ACLs on a Samba share that uses POSIX ACLs

The standard ACLs on Linux support setting permissions for one owner, one group, and for all other undefined users. You can use the `chown`, `chgrp`, and `chmod` utility to update the ACLs. If you require precise control, then you use the more complex POSIX ACLs, see Section 3.7.3, "Setting extended ACLs on a Samba share that uses POSIX ACLs." Setting extended ACLs on a Samba share that uses POSIX ACLs in the Deploying different types of servers documentation.

The following procedure sets the owner of the `/srv/samba/example/` directory to the `root` user, grants read and write permissions to the `Domain Users` group, and denies access to all other users.

**Prerequisites**

- The Samba share on which you want to set the ACLs exists.

**Procedure**

```
# chown root:"Domain Users" /srv/samba/example/
# chmod 2770 /srv/samba/example/
```

**NOTE**

Enabling the set-group-ID (SGID) bit on a directory automatically sets the default group for all new files and subdirectories to that of the directory group, instead of the usual behavior of setting it to the primary group of the user who created the new directory entry.

**Additional resources**

- For further details about permissions, see the `chown(1)` and `chmod(1)` man pages.

### 3.7.3. Setting extended ACLs on a Samba share that uses POSIX ACLs

If the file system the shared directory is stored on supports extended ACLs, you can use them to set complex permissions. Extended ACLs can contain permissions for multiple users and groups.

Extended POSIX ACLs enable you to configure complex ACLs with multiple users and groups. However, you can only set the following permissions:
No access
• Read access
• Write access
• Full control

If you require the fine-granular Windows permissions, such as Create folder / append data, configure the share to use Windows ACLs. See Section 3.9, “Setting up a share that uses Windows ACLs”.

The following procedure shows how to enable ACLs on a share. Additionally, it contains an example about setting extended ACLs.

Prerequisites
• The Samba share on which you want to set the ACLs exists.

Procedure

1. Enable the following parameter in the share’s section in the /etc/samba/smb.conf file to enable ACL inheritance of extended ACLs:
   inherit acls = yes

   For details, see the parameter description in the smb.conf(5) man page.

2. Restart the smb service:
   # systemctl restart smb

3. Set the ACLs on the directory. For example:

   Example 3.2. Setting Extended ACLs

   The following procedure sets read, write, and execute permissions for the Domain Admins group, read, and execute permissions for the Domain Users group, and deny access to everyone else on the /srv/samba/example/ directory:

   1. Disable auto-granting permissions to the primary group of user accounts:

      # setfacl -m group::--- /srv/samba/example/
      # setfacl -m default:group::--- /srv/samba/example/

      The primary group of the directory is additionally mapped to the dynamic CREATOR GROUP principal. When you use extended POSIX ACLs on a Samba share, this principal is automatically added and you cannot remove it.

   2. Set the permissions on the directory:

      a. Grant read, write, and execute permissions to the Domain Admins group:

         # setfacl -m group:"DOMAIN\Domain Admins":rwx /srv/samba/example/

      b. Grant read and execute permissions to the Domain Users group:
c. Set permissions for the other ACL entry to deny access to users that do not match the other ACL entries:

```
# setfacl -m -R -m other::--- /srv/samba/example/
```

These settings apply only to this directory. In Windows, these ACLs are mapped to the This folder only mode.

3. To enable the permissions set in the previous step to be inherited by new file system objects created in this directory:

```
# setfacl -m default:group:"DOMAIN\Domain Admins"::rwx /srv/samba/example/
# setfacl -m default:group:"DOMAIN\Domain Users"::r-x /srv/samba/example/
# setfacl -m default:other::--- /srv/samba/example/
```

With these settings, the This folder only mode for the principals is now set to This folder, subfolders, and files.

Samba maps the permissions set in the procedure to the following Windows ACLs:

<table>
<thead>
<tr>
<th>Principal</th>
<th>Access</th>
<th>Applies to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain\Domain Admins</td>
<td>Full control</td>
<td>This folder, subfolders, and files</td>
</tr>
<tr>
<td>Domain\Domain Users</td>
<td>Read &amp; execute</td>
<td>This folder, subfolders, and files</td>
</tr>
<tr>
<td><strong>Everyone</strong>[a]</td>
<td>None</td>
<td>This folder, subfolders, and files</td>
</tr>
<tr>
<td>owner (Unix User\owner)[b]</td>
<td>Full control</td>
<td>This folder only</td>
</tr>
<tr>
<td>primary_group (Unix User\primary_group)[c]</td>
<td>None</td>
<td>This folder only</td>
</tr>
<tr>
<td>CREATOR OWNER [d][e]</td>
<td>Full control</td>
<td>Subfolders and files only</td>
</tr>
<tr>
<td>CREATOR GROUP [e][f]</td>
<td>None</td>
<td>Subfolders and files only</td>
</tr>
</tbody>
</table>

[a] Samba maps the permissions for this principal from the other ACL entry.
[b] Samba maps the owner of the directory to this entry.
[c] Samba maps the primary group of the directory to this entry.
[d] On new file system objects, the creator inherits automatically the permissions of this principal.
[e] Configuring or removing these principals from the ACLs not supported on shares that use POSIX ACLs.
[f] On new file system objects, the creator’s primary group inherits automatically the permissions of this principal.
3.8. SETTING PERMISSIONS ON A SHARE THAT USES POSIX ACLS

Optionally, to limit or grant access to a Samba share, you can set certain parameters in the share’s section in the /etc/samba/smb.conf file.

**NOTE**

Share-based permissions manage if a user, group, or host is able to access a share. These settings do not affect file system ACLs.

Use share-based settings to restrict access to shares, for example, to deny access from specific hosts.

**Prerequisites**

- A share with POSIX ACLs has been set up.

### 3.8.1. Configuring user and group-based share access

User and group-based access control enables you to grant or deny access to a share for certain users and groups.

**Prerequisites**

- The Samba share on which you want to set user or group-based access exists.

**Procedure**

1. For example, to enable all members of the **Domain Users** group to access a share while access is denied for the **user** account, add the following parameters to the share’s configuration:

   ```
   valid users = +DOMAIN:"Domain Users"
   invalid users = DOMAIN:user
   ```

   The **invalid users** parameter has a higher priority than the **valid users** parameter. For example, if the **user** account is a member of the **Domain Users** group, access is denied to this account when you use the previous example.

2. Reload the Samba configuration:

   ```
   # smbcontrol all reload-config
   ```

**Additional resources**

- For further details, see the parameter descriptions in the **smb.conf(5)** man page.

### 3.8.2. Configuring host-based share access

Host-based access control enables you to grant or deny access to a share based on client’s host names, IP addresses, or IP range.
The following procedure explains how to enable the 127.0.0.1 IP address, the 192.0.2.0/24 IP range, and the client1.example.com host to access a share, and additionally deny access for the client2.example.com host:

**Prerequisites**
- The Samba share on which you want to set host-based access exists.

**Procedure**
1. Add the following parameters to the configuration of the share in the /etc/samba/smb.conf file:

   ```
   hosts allow = 127.0.0.1 192.0.2.0/24 client1.example.com
   hosts deny = client2.example.com
   ```

   The hosts deny parameter has a higher priority than hosts allow. For example, if client1.example.com resolves to an IP address that is listed in the hosts allow parameter, access for this host is denied.

2. Reload the Samba configuration:

   ```
   # smbcontrol all reload-config
   ```

**Additional resources**
- For further details, see the parameter descriptions in the smb.conf(5) man page.

### 3.9. SETTING UP A SHARE THAT USES WINDOWS ACLS

Samba supports setting Windows ACLs on shares and file system object. This enables you to:
- Use the fine-granular Windows ACLs
- Manage share permissions and file system ACLs using Windows

Alternatively, you can configure a share to use POSIX ACLs. For details, see Section 3.7, “Setting up a Samba file share that uses POSIX ACLs”. Parts of this section were adopted from the Setting up a Share Using Windows ACLs documentation published in the Samba Wiki. License: CC BY 4.0. Authors and contributors: See the history tab on the Wiki page.

#### 3.9.1. Granting the SeDiskOperatorPrivilege privilege

Only users and groups having the SeDiskOperatorPrivilege privilege granted can configure permissions on shares that use Windows ACLs.

**Procedure**
1. For example, to grant the SeDiskOperatorPrivilege privilege to the DOMAIN\Domain Admins group:

   ```
   # net rpc rights grant "DOMAIN\Domain Admins" SeDiskOperatorPrivilege -U "DOMAIN\administrator"
   ```
Enter DOMAIN\administrator's password:
Successfully granted rights.

NOTE
In a domain environment, grant SeDiskOperatorPrivilege to a domain group. This enables you to centrally manage the privilege by updating a user’s group membership.

2. To list all users and groups having SeDiskOperatorPrivilege granted:

```
# net rpc rights list privileges SeDiskOperatorPrivilege -U "DOMAIN\administrator"
Enter administrator's password:
SeDiskOperatorPrivilege:
BUILTIN\Administrators
DOMAIN\Domain Admins
```

3.9.2. Enabling Windows ACL support

To configure shares that support Windows ACLs, you must enable this feature in Samba.

Prerequisites

- A user share is configured on the Samba server.

Procedure

1. To enable it globally for all shares, add the following settings to the [global] section of the /etc/samba/smb.conf file:

```
vfs objects = acl_xattr
map acl inherit = yes
store dos attributes = yes
```

Alternatively, you can enable Windows ACL support for individual shares, by adding the same parameters to a share’s section instead.

2. Restart the smb service:

```
# systemctl restart smb
```

3.9.3. Adding a share that uses Windows ACLs

This section describes how to create a share named example, that shares the content of the /srv/samba/example/ directory, and uses Windows ACLs.

Procedure

1. Create the folder if it does not exists. For example:

```
# mkdir -p /srv/samba/example/
```
2. If you run SELinux in enforcing mode, set the `samba_share_t` context on the directory:

```
# semanage fcontext -a -t samba_share_t "/srv/samba/example(/.*)?"
# restorecon -Rv /srv/samba/example/
```

3. Add the example share to the `/etc/samba/smb.conf` file. For example, to add the share write-enabled:

```
[example]
path = /srv/samba/example/
read only = no
```

**NOTE**

Regardless of the file system ACLs; if you do not set `read only = no`, Samba shares the directory in read-only mode.

4. If you have not enabled Windows ACL support in the `[global]` section for all shares, add the following parameters to the `[example]` section to enable this feature for this share:

```
vfs objects = acl_xattr
map acl inherit = yes
store dos attributes = yes
```

5. Verify the `/etc/samba/smb.conf` file:

```
# testparm
```

6. Open the required ports and reload the firewall configuration using the `firewall-cmd` utility:

```
# firewall-cmd --permanent --add-service=samba
# firewall-cmd --reload
```

7. Restart the `smb` service:

```
# systemctl restart smb
```

### 3.9.4. Managing share permissions and file system ACLs of a share that uses Windows ACLs

To manage share permissions and file system ACLs on a Samba share that uses Windows ACLs, use a Windows application, such as **Computer Management**. For details, see the Windows documentation. Alternatively, use the `smbcacls` utility to manage ACLs.

**NOTE**

To modify the file system permissions from Windows, you must use an account that has the `SeDiskOperatorPrivilege` privilege granted.

**Additional resources**

- Section 3.10, “Managing ACLs on an SMB share using smbcascls”
3.10. MANAGING ACLS ON AN SMB SHARE USING SMBCACLS

The `smbcacls` utility can list, set, and delete ACLs of files and directories stored on an SMB share. You can use `smbcacls` to manage file system ACLs:

- On a local or remote Samba server that uses advanced Windows ACLs or POSIX ACLs
- On Red Hat Enterprise Linux to remotely manage ACLs on a share hosted on Windows

3.10.1. Access control entries

Each ACL entry of a file system object contains Access Control Entries (ACE) in the following format:

```
security_principal:access_right/inheritance_information/permissions
```

**Example 3.3. Access control entries**

If the `AD\Domain Users` group has **Modify** permissions that apply to **This folder, subfolders, and files** on Windows, the ACL contains the following ACE:

```
AD\Domain Users:ALLOWED/OI|CI/CHANGE
```

An ACE contains the following parts:

**Security principal**

The security principal is the user, group, or SID the permissions in the ACL are applied to.

**Access right**

Defines if access to an object is granted or denied. The value can be **ALLOWED** or **DENIED**.

**Inheritance information**

The following values exist:

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
<th>Maps to</th>
</tr>
</thead>
<tbody>
<tr>
<td>OI</td>
<td>Object Inherit</td>
<td>This folder and files</td>
</tr>
<tr>
<td>CI</td>
<td>Container Inherit</td>
<td>This folder and subfolders</td>
</tr>
<tr>
<td>IO</td>
<td>Inherit Only</td>
<td>The ACE does not apply to the current file or directory</td>
</tr>
<tr>
<td>ID</td>
<td>Inherited</td>
<td>The ACE was inherited from the parent directory</td>
</tr>
</tbody>
</table>

Additionally, the values can be combined as follows:

<table>
<thead>
<tr>
<th>Table 3.2. Inheritance settings combinations</th>
</tr>
</thead>
</table>
Value combinations | Maps to the Windows Applies to setting
--- | ---
OI|CI | This folder, subfolders, and files
OI|CI|IO | Subfolders and files only
CI|IO | Subfolders only
OI|IO | Files only

Permissions
This value can be either a hex value that represents one or more Windows permissions or an smbcacls alias:

- A hex value that represents one or more Windows permissions. The following table displays the advanced Windows permissions and their corresponding value in hex format:

### Table 3.3. Windows permissions and their corresponding smbcacls value in hex format

<table>
<thead>
<tr>
<th>Windows permissions</th>
<th>Hex values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full control</td>
<td>0x001F01FF</td>
</tr>
<tr>
<td>Traverse folder / execute file</td>
<td>0x00100020</td>
</tr>
<tr>
<td>List folder / read data</td>
<td>0x00100001</td>
</tr>
<tr>
<td>Read attributes</td>
<td>0x00100080</td>
</tr>
<tr>
<td>Read extended attributes</td>
<td>0x00100008</td>
</tr>
<tr>
<td>Create files / write data</td>
<td>0x00100002</td>
</tr>
<tr>
<td>Create folders / append data</td>
<td>0x00100004</td>
</tr>
<tr>
<td>Write attributes</td>
<td>0x00100010</td>
</tr>
<tr>
<td>Write extended attributes</td>
<td>0x00100010</td>
</tr>
<tr>
<td>Delete subfolders and files</td>
<td>0x00100040</td>
</tr>
<tr>
<td>Delete</td>
<td>0x00110000</td>
</tr>
<tr>
<td>Read permissions</td>
<td>0x00120000</td>
</tr>
<tr>
<td>Change permissions</td>
<td>0x00140000</td>
</tr>
</tbody>
</table>
Multiple permissions can be combined as a single hex value using the bit-wise OR operation. For details, see Section 3.10.3, “ACE mask calculation”.

- An smbcacils alias. The following table displays the available aliases:

<table>
<thead>
<tr>
<th>smbcacils alias</th>
<th>Maps to Windows permission</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>Read</td>
</tr>
<tr>
<td>READ</td>
<td>Read &amp; execute</td>
</tr>
<tr>
<td>W</td>
<td>Special:</td>
</tr>
<tr>
<td></td>
<td>- Create files / write data</td>
</tr>
<tr>
<td></td>
<td>- Create folders / append data</td>
</tr>
<tr>
<td></td>
<td>- Write attributes</td>
</tr>
<tr>
<td></td>
<td>- Write extended attributes</td>
</tr>
<tr>
<td></td>
<td>- Read permissions</td>
</tr>
<tr>
<td>D</td>
<td>Delete</td>
</tr>
<tr>
<td>P</td>
<td>Change permissions</td>
</tr>
<tr>
<td>O</td>
<td>Take ownership</td>
</tr>
<tr>
<td>X</td>
<td>Traverse / execute</td>
</tr>
<tr>
<td>CHANGE</td>
<td>Modify</td>
</tr>
<tr>
<td>FULL</td>
<td>Full control</td>
</tr>
</tbody>
</table>

**NOTE**

You can combine single-letter aliases when you set permissions. For example, you can set RD to apply the Windows permission Read and Delete. However, you can neither combine multiple non-single-letter aliases nor combine aliases and hex values.
3.10.2. Displaying ACLs using `smbcacls`

To display ACLs on an SMB share, use the `smbcacls` utility. If you run `smbcacls` without any operation parameter, such as `--add`, the utility displays the ACLs of a file system object.

Procedure

For example, to list the ACLs of the root directory of the `//server/example` share:

```
# smbcacls //server/example / -U "DOMAIN\administrator"
```

Enter `DOMAIN\administrator`'s password:

```
REVISION:1
CONTROL:SR|PD|DI|DP
OWNER:AD\Administrators
GROUP:AD\Domain Users
ACL:AD\Administrator:ALLOWED/OI|CI/FULL
ACL:AD\Domain Users:ALLOWED/OI|CI/CHANGE
ACL:AD\Domain Guests:ALLOWED/OI|CI/0x00100021
```

The output of the command displays:

- **REVISION**: The internal Windows NT ACL revision of the security descriptor
- **CONTROL**: Security descriptor control
- **OWNER**: Name or SID of the security descriptor’s owner
- **GROUP**: Name or SID of the security descriptor’s group
- **ACL** entries. For details, see Section 3.10.1, “Access control entries”.

3.10.3. ACE mask calculation

In most situations, when you add or update an ACE, you use the `smbcacls` aliases listed in Table 3.4, “Existing smbcacls aliases and their corresponding Windows permission”. However, if you want to set advanced Windows permissions as listed in Table 3.3, “Windows permissions and their corresponding smbcacls value in hex format”, you must use the bit-wise OR operation to calculate the correct value. You can use the following shell command to calculate the value:

```
# echo $(printf '0x%X' $(( hex_value_1 | hex_value_2 | ... )))
```

**Example 3.4. Calculating an ACE Mask**

You want to set the following permissions:

- Traverse folder / execute file (0x00100020)
- List folder / read data (0x00100001)
- Read attributes (0x001000080)

To calculate the hex value for the previous permissions, enter:

```
# echo $(printf '0x%X' $(( 0x00100020 | 0x00100001 | 0x001000080 )))
```

0x1000A1
Use the returned value when you set or update an ACE.

3.10.4. Adding, updating, and removing an ACL using `smbcacls`

Depending on the parameter you pass to the `smbcacls` utility, you can add, update, and remove ACLs from a file or directory.

**Adding an ACL**

To add an ACL to the root of the `//server/example` share that grants `CHANGE` permissions for This folder, subfolders, and files to the AD\Domain Users group:

```
# smbcacls //server/example / -U "DOMAIN\administrator --add ACL:"AD\Domain Users":ALLOWED/OI|CI/CHANGE
```

**Updating an ACL**

Updating an ACL is similar to adding a new ACL. You update an ACL by overriding the ACL using the `--modify` parameter with an existing security principal. If `smbcacls` finds the security principal in the ACL list, the utility updates the permissions. Otherwise the command fails with an error:

```
ACL for SID principal_name not found
```

For example, to update the permissions of the AD\Domain Users group and set them to `READ` for This folder, subfolders, and files:

```
# smbcacls //server/example / -U "DOMAIN\administrator --modify ACL:"AD\Domain Users":ALLOWED/OI|CI/READ
```

**Deleting an ACL**

To delete an ACL, pass the `--delete` parameter with the exact ACL to the `smbcacls` utility. For example:

```
# smbcacls //server/example / -U "DOMAIN\administrator --delete ACL:"AD\Domain Users":ALLOWED/OI|CI/READ
```

3.11. ENABLING USERS TO SHARE DIRECTORIES ON A SAMBA SERVER

On a Samba server, you can configure that users can share directories without root permissions.

3.11.1. Enabling the user shares feature

Before users can share directories, the administrator must enable user shares in Samba.

For example, to enable only members of the local example group to create user shares.

**Procedure**

1. Create the local example group, if it does not exist:

```
# groupadd example
```
2. Prepare the directory for Samba to store the user share definitions and set its permissions properly. For example:
   a. Create the directory:
      
      ```
      # mkdir -p /var/lib/samba/usershares/
      ```
   b. Set write permissions for the `example` group:
      
      ```
      # chgrp example /var/lib/samba/usershares/
      # chmod 1770 /var/lib/samba/usershares/
      ```
   c. Set the sticky bit to prevent users to rename or delete files stored by other users in this directory.

3. Edit the `/etc/samba/smb.conf` file and add the following to the `[global]` section:
   a. Set the path to the directory you configured to store the user share definitions. For example:
      
      ```
      usershare path = /var/lib/samba/usershares/
      ```
   b. Set how many user shares Samba allows to be created on this server. For example:
      
      ```
      usershare max shares = 100
      ```
      
      If you use the default of 0 for the `usershare max shares` parameter, user shares are disabled.
   c. Optionally, set a list of absolute directory paths. For example, to configure that Samba only allows to share subdirectories of the `/data` and `/srv` directory to be shared, set:
      
      ```
      usershare prefix allow list = /data /srv
      ```
      
      For a list of further user share-related parameters you can set, see the `USERSHARES` section in the `smb.conf(5)` man page.

4. Verify the `/etc/samba/smb.conf` file:
   
   ```
   # testparm
   ```

5. Reload the Samba configuration:
   
   ```
   # smbcontrol all reload-config
   ```
   
   Users are now able to create user shares.

3.11.2. Adding a user share

After you enabled the user share feature in Samba, users can share directories on the Samba server without `root` permissions by running the `net usershare add` command.

Synopsis of the `net usershare add` command:
**net usershare add** share_name path [[ comment ]][[ ACLs ]][ guest_ok=y|n ]

**IMPORTANT**

If you set ACLs when you create a user share, you must specify the comment parameter prior to the ACLs. To set an empty comment, use an empty string in double quotes.

Note that users can only enable guest access on a user share, if the administrator set **usershare allow guests = yes** in the **[global]** section in the `/etc/samba/smb.conf` file.

**Example 3.5. Adding a user share**

A user wants to share the `/srv/samba/` directory on a Samba server. The share should be named `example`, have no comment set, and should be accessible by guest users. Additionally, the share permissions should be set to full access for the `AD\Domain Users` group and read permissions for other users. To add this share, run as the user:

```
$ net usershare add example /srv/samba/ "" "AD\Domain Users":F,Everyone:R
guest_ok=yes
```

**3.11.3. Updating settings of a user share**

To update settings of a user share, override the share by using the **net usershare add** command with the same share name and the new settings. See **Section 3.11.2, “Adding a user share”**.

**3.11.4. Displaying information about existing user shares**

Users can enter the **net usershare info** command on a Samba server to display user shares and their settings.

**Prerequisites**

- A user share is configured on the Samba server.

**Procedure**

1. To display all user shares created by any user:

   ```
   $ net usershare info -l
   [share_1]
   path=/srv/samba/
   comment=
   usershare_acl=Everyone:R,host_name\user:F,
   guest_ok=y
   ...
   ```

   To list only shares created by the user who runs the command, omit the `-l` parameter.

2. To display only the information about specific shares, pass the share name or wild cards to the command. For example, to display the information about shares whose name starts with `share_`:

   ```
   $ net usershare info -l share_*
   ```
3.11.5. Listing user shares

If you want to list only the available user shares without their settings on a Samba server, use the `net usershare list` command.

Prerequisites
- A user share is configured on the Samba server.

Procedure
1. To list the shares created by any user:

   ```
   $ net usershare list -l
   share_1
   share_2
   ...
   ```

   To list only shares created by the user who runs the command, omit the `-l` parameter.

2. To list only specific shares, pass the share name or wild cards to the command. For example, to list only shares whose name starts with `share_`:

   ```
   $ net usershare list -l share_*
   ```

3.11.6. Deleting a user share

To delete a user share, use the command `net usershare delete` command as the user who created the share or as the `root` user.

Prerequisites
- A user share is configured on the Samba server.

Procedure

```
$ net usershare delete share_name
```  

3.12. CONFIGURING A SHARE TO ALLOW ACCESS WITHOUT AUTHENTICATION

In certain situations, you want to share a directory to which users can connect without authentication. To configure this, enable guest access on a share.

WARNING
Shares that do not require authentication can be a security risk.
3.12.1. Enabling guest access to a share

If guest access is enabled on a share, Samba maps guest connections to the operating system account set in the `guest account` parameter. Guest users can access files on this share if at least one of the following conditions is satisfied:

- The account is listed in file system ACLs
- The POSIX permissions for other users allow it

**Example 3.6. Guest share permissions**

If you configured Samba to map the guest account to `nobody`, which is the default, the ACLs in the following example:

- Allow guest users to read `file1.txt`
- Allow guest users to read and modify `file2.txt`
- Prevent guest users to read or modify `file3.txt`

```bash
-rw-r--r--. 1 root       root      1024 1. Sep 10:00 file1.txt
-rw-r-----. 1 nobody     root      1024 1. Sep 10:00 file2.txt
-rw-r-----. 1 root       root      1024 1. Sep 10:00 file3.txt
```

**Procedure**

1. Edit the `/etc/samba/smb.conf` file:
   
   a. If this is the first guest share you set up on this server:
      
      i. Set `map to guest = Bad User` in the `[global]` section:

      ```bash
      [global]
      ...
      map to guest = Bad User
      
      With this setting, Samba rejects login attempts that use an incorrect password unless the user name does not exist. If the specified user name does not exist and guest access is enabled on a share, Samba treats the connection as a guest log in.
      
      ii. By default, Samba maps the guest account to the `nobody` account on Red Hat Enterprise Linux. Alternatively, you can set a different account. For example:

      ```bash
      [global]
      ...
      guest account = user_name
      
      The account set in this parameter must exist locally on the Samba server. For security reasons, Red Hat recommends using an account that does not have a valid shell assigned.
      
      b. Add the `guest ok = yes` setting to the `[example]` share section:
2. Verify the `/etc/samba/smb.conf` file:

```plaintext
# testparm
```

3. Reload the Samba configuration:

```plaintext
# smbcontrol all reload-config
```

### 3.13. CONFIGURING SAMBA FOR MACOS CLIENTS

The **fruit** virtual file system (VFS) Samba module provides enhanced compatibility with Apple server message block (SMB) clients.

#### 3.13.1. Optimizing the Samba configuration for providing file shares for macOS clients

This section describes how to configure the **fruit** module for all Samba shares hosted on the server to optimize Samba file shares for macOS clients.

**NOTE**

Red Hat recommends enabling the **fruit** module globally. Clients using macOS negotiate the server server message block version 2 (SMB2) Apple (AAPL) protocol extensions when the client establishes the first connection to the server. If the client first connects to a share without AAPL extensions enabled, the client does not use the extensions for any share of the server.

**Prerequisites**

- Samba is configured as a file server.

**Procedure**

1. Edit the `/etc/samba/smb.conf` file, and enable the **fruit** and **streams_xattr** VFS modules in the `[global]` section:

```plaintext
vfs objects = fruit streams_xattr
```

**IMPORTANT**

You must enable the **fruit** module before enabling **streams_xattr**. The **fruit** module uses alternate data streams (ADS). For this reason, you must also enable the **streams_xattr** module.

2. Optionally, to provide macOS Time Machine support on a share, add the following setting to the share configuration in the `/etc/samba/smb.conf` file:
3. Verify the `/etc/samba/smb.conf` file:

```
# testparm
```

4. Reload the Samba configuration:

```
# smbcontrol all reload-config
```

**Additional resources**

- For further details about the `fruit` VFS module, see the `vfs_fruit(8)` man page.
- For details about configuring file shares, see:
  - Section 3.7, “Setting up a Samba file share that uses POSIX ACLs”
  - Section 3.9, “Setting up a share that uses Windows ACLs”.

### 3.14. USING THE SMBCLIENT UTILITY TO ACCESS AN SMB SHARE

The `smbclient` utility enables you to access file shares on an SMB server, similarly to a command-line FTP client. You can use it, for example, to upload and download files to and from a share.

**Prerequisites**

- The `samba-client` package is installed.

#### 3.14.1. How the smbclient interactive mode works

For example, to authenticate to the `example` share hosted on `server` using the `DOMAIN\user` account:

```
# smbclient -U "DOMAIN\user" //server/example
```

Enter `domain\user`'s password:

```
smb: \>
```

After `smbclient` connected successfully to the share, the utility enters the interactive mode and shows the following prompt:

```
smb: \>
```

To display all available commands in the interactive shell, enter:

```
smb: \> help
```

To display the help for a specific command, enter:

```
smb: \> help command_name
```
Additional resources

- For further details and descriptions of the commands available in the interactive shell, see the `smbclient(1)` man page.

### 3.14.2. Using smbclient in interactive mode

If you use `smbclient` without the `-c` parameter, the utility enters the interactive mode. The following procedure shows how to connect to an SMB share and download a file from a subdirectory.

**Procedure**

1. Connect to the share:
   ```
   # smbclient -U "DOMAIN\user_name" //server_name/share_name
   ```
2. Change into the `/example/` directory:
   ```
   smb: > d /example/
   ```
3. List the files in the directory:
   ```
   smb: \example\> ls
   .                  D       0  Thu Nov 1 10:00:00 2018
   ..                  D       0  Thu Nov 1 10:00:00 2018
   example.txt        N  1048576  Thu Nov 1 10:00:00 2018
   9950208 blocks of size 1024. 8247144 blocks available
   ```
4. Download the `example.txt` file:
   ```
   smb: \example\> get example.txt
   getting file \directory\subdirectory\example.txt of size 1048576 as example.txt (511975,0 KiloBytes/sec) (average 170666,7 KiloBytes/sec)
   ```
5. Disconnect from the share:
   ```
   smb: \example\> exit
   ```

### 3.14.3. Using smbclient in scripting mode

If you pass the `-c` parameter to `smbclient`, you can automatically execute the commands on the remote SMB share. This enables you to use `smbclient` in scripts.

The following procedure shows how to connect to an SMB share and download a file from a subdirectory.

**Procedure**

- Use the following command to connect to the share, change into the `example` directory, download the `example.txt` file:
# smbclient -U DOMAIN\user_name //server_name/share_name -c "cd /example/ ; get example.txt ; exit"

3.15. SETTING UP SAMBA AS A PRINT SERVER

If you set up Samba as a print server, clients in your network can use Samba to print. Additionally, Windows clients can, if configured, download the driver from the Samba server.

Parts of this section were adopted from the Setting up Samba as a Print Server documentation published in the Samba Wiki. License: CC BY 4.0. Authors and contributors: See the history tab on the Wiki page.

Prerequisites

Samba has been set up in one of the following modes:

- Standalone server
- Domain member

3.15.1. The Samba spoolssd service

The Samba spoolssd is a service that is integrated into the smbd service. Enable spoolssd in the Samba configuration to significantly increase the performance on print servers with a high number of jobs or printers.

Without spoolssd, Samba forks the smbd process and initializes the printcap cache for each print job. In case of a large number of printers, the smbd service can become unresponsive for multiple seconds while the cache is initialized. The spoolssd service enables you to start pre-forked smbd processes that are processing print jobs without any delays. The main spoolssd smbd process uses a low amount of memory, and forks and terminates child processes.

The following procedure explains how to enable the spoolssd service.

Procedure

1. Edit the [global] section in the /etc/samba/smb.conf file:

   a. Add the following parameters:

   ```
   rpc_server:spoolss = external
   rpc_daemon:spoolssd = fork
   ```

   b. Optionally, you can set the following parameters:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>spoolssd:prefork_min_children</td>
<td>5</td>
<td>Minimum number of child processes</td>
</tr>
<tr>
<td>spoolssd:prefork_max_children</td>
<td>25</td>
<td>Maximum number of child processes</td>
</tr>
<tr>
<td>Parameter</td>
<td>Default</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td><code>spoolssd:prefork_spawn_rate</code></td>
<td>5</td>
<td>Samba forks the number of new child processes set in this parameter, up to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the value set in <code>spoolssd:prefork_max_children</code>, if a new connection is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>established</td>
</tr>
<tr>
<td><code>spoolssd:prefork_max_allowed_clients</code></td>
<td>100</td>
<td>Number of clients, a child process serves</td>
</tr>
<tr>
<td><code>spoolssd:prefork_child_min_life</code></td>
<td>60</td>
<td>Minimum lifetime of a child process in seconds. 60 seconds is the minimum.</td>
</tr>
</tbody>
</table>

2. Verify the `/etc/samba/smb.conf` file:

   ```
   # testparm
   ```

3. Restart the `smb` service:

   ```
   # systemctl restart smb
   ```

   After you restarted the service, Samba automatically starts `smbd` child processes:

   ```
   # ps axf
   ...
   30903 smbd
   30912  `_ smbd
   30913     `_ smbd
   30914     `_ smbd
   30915     `_ smbd
   ...
   ```

### 3.15.2. Enabling print server support in Samba

This section explains how to enable the print server support in Samba.

**Procedure**

1. On the Samba server, set up CUPS and add the printer to the CUPS back end. For details about configuring printers in CUPS; see the documentation provided in the CUPS web console ([https://print_server_host_name:631/help](https://print_server_host_name:631/help)) on the print server.

   **NOTE**

   Samba can only forward the print jobs to CUPS if CUPS is installed locally on the Samba print server.

2. Edit the `/etc/samba/smb.conf` file:
a. If you want to enable the spoolssd service, add the following parameters to the [global] section:

```plaintext
rpc_server:spoolss = external
rpc_daemon:spoolssd = fork
```

b. To configure the printing back end, add the [printers] section:

```plaintext
[printers]
  comment = All Printers
  path = /var/tmp/
  printable = yes
  create mask = 0600
```

**IMPORTANT**

The [printers] share name is hard-coded and cannot be changed.

3. Verify the `/etc/samba/smb.conf` file:

```plaintext
# testparm
```

4. Open the required ports and reload the firewall configuration using the `firewall-cmd` utility:

```plaintext
# firewall-cmd --permanent --add-service=samba
# firewall-cmd --reload
```

5. Restart the `smb` service:

```plaintext
# systemctl restart smb
```

After restarting the service, Samba automatically shares all printers that are configured in the CUPS back end. If you want to manually share only specific printers, see Section 3.15.3, “Manually sharing specific printers”.

### 3.15.3. Manually sharing specific printers

If you configured Samba as a print server, by default, Samba shares all printers that are configured in the CUPS back end. The following procedure explains how to share only specific printers.

**Prerequisites**

- Samba is set up as a print server

**Procedure**

1. Edit the `/etc/samba/smb.conf` file:

   a. In the [global] section, disable automatic printer sharing by setting:

```plaintext
load printers = no
```
b. Add a section for each printer you want to share. For example, to share the printer named \texttt{example} in the CUPS back end as \texttt{Example-Printer} in Samba, add the following section:

\begin{verbatim}
[Example-Printer]
path = /var/tmp/
printable = yes
printer name = example
\end{verbatim}

You do not need individual spool directories for each printer. You can set the same spool directory in the \texttt{path} parameter for the printer as you set in the \texttt{[printers]} section.

2. Verify the /etc/samba/smb.conf file:

\begin{verbatim}
# testparm
\end{verbatim}

3. Reload the Samba configuration:

\begin{verbatim}
# smbcontrol all reload-config
\end{verbatim}

\section*{3.16. Setting up automatic printer driver downloads for Windows clients on Samba print servers}

If you are running a Samba print server for Windows clients, you can upload drivers and preconfigure printers. If a user connects to a printer, Windows automatically downloads and installs the driver locally on the client. The user does not require local administrator permissions for the installation. Additionally, Windows applies preconfigured driver settings, such as the number of trays.

Parts of this section were adopted from the \textit{Setting up Automatic Printer Driver Downloads for Windows Clients} documentation published in the Samba Wiki. License: \textit{CC BY 4.0}. Authors and contributors: See the \texttt{history} tab on the Wiki page.

\subsection*{Prerequisites}

- Samba is set up as a print server

\subsection*{3.16.1. Basic information about printer drivers}

This section provides general information about printer drivers.

\textbf{Supported driver model version}

Samba only supports the printer driver model version 3 which is supported in Windows 2000 and later, and Windows Server 2000 and later. Samba does not support the driver model version 4, introduced in Windows 8 and Windows Server 2012. However, these and later Windows versions also support version 3 drivers.

\textbf{Package-aware drivers}

Samba does not support package-aware drivers.

\textbf{Preparing a printer driver for being uploaded}

Before you can upload a driver to a Samba print server:

- Unpack the driver if it is provided in a compressed format.
● Some drivers require to start a setup application that installs the driver locally on a Windows host. In certain situations, the installer extracts the individual files into the operating system’s temporary folder during the setup runs. To use the driver files for uploading:

a. Start the installer.

b. Copy the files from the temporary folder to a new location.

c. Cancel the installation.

Ask your printer manufacturer for drivers that support uploading to a print server.

Providing 32-bit and 64-bit drivers for a printer to a client
To provide the driver for a printer for both 32-bit and 64-bit Windows clients, you must upload a driver with exactly the same name for both architectures. For example, if you are uploading the 32-bit driver named Example PostScript and the 64-bit driver named Example PostScript (v1.0), the names do not match. Consequently, you can only assign one of the drivers to a printer and the driver will not be available for both architectures.

3.16.2. Enabling users to upload and preconfigure drivers
To be able to upload and preconfigure printer drivers, a user or a group needs to have the SePrintOperatorPrivilege privilege granted. A user must be added into the printadmin group. Red Hat Enterprise Linux automatically creates this group when you install the samba package. The printadmin group gets assigned the lowest available dynamic system GiD that is lower than 1000.

Procedure
1. For example, to grant the SePrintOperatorPrivilege privilege to the printadmin group:

```
# net rpc rights grant "printadmin" SePrintOperatorPrivilege -U "DOMAIN\administrator"
Enter DOMAIN\administrator's password:
Successfully granted rights.
```

   **NOTE**
   
   In a domain environment, grant SePrintOperatorPrivilege to a domain group. This enables you to centrally manage the privilege by updating a user’s group membership.

2. To list all users and groups having SePrintOperatorPrivilege granted:

```
# net rpc rights list privileges SePrintOperatorPrivilege -U "DOMAIN\administrator"
Enter administrator's password:
SePrintOperatorPrivilege:
   BUILTIN\Administrators
   DOMAIN\printadmin
```

3.16.3. Setting up the print$ share
Windows operating systems download printer drivers from a share named print$ from a print server. This share name is hard-coded in Windows and cannot be changed.
The following procedure explains how to share the `/var/lib/samba/drivers/` directory as `print$`, and enable members of the local `printadmin` group to upload printer drivers.

**Procedure**

1. Add the `[print$]` section to the `/etc/samba/smb.conf` file:

   ```
   [print$]
   path = /var/lib/samba/drivers/
   read only = no
   write list = @printadmin
   force group = @printadmin
   create mask = 0664
   directory mask = 2775
   ```

   Using these settings:
   - Only members of the `printadmin` group can upload printer drivers to the share.
   - The group of new created files and directories will be set to `printadmin`.
   - The permissions of new files will be set to `664`.
   - The permissions of new directories will be set to `2775`.

2. To upload only 64-bit drivers for all printers, include this setting in the `[global]` section in the `/etc/samba/smb.conf` file:

   ```
   spoolss: architecture = Windows x64
   ```

   Without this setting, Windows only displays drivers for which you have uploaded at least the 32-bit version.

3. Verify the `/etc/samba/smb.conf` file:

   ```
   # testparm
   ```

4. Reload the Samba configuration

   ```
   # smbcontrol all reload-config
   ```

5. Create the `printadmin` group if it does not exists:

   ```
   # groupadd printadmin
   ```

6. Grant the `SePrintOperatorPrivilege` privilege to the `printadmin` group.

   ```
   # net rpc rights grant "printadmin" SePrintOperatorPrivilege -U "DOMAIN\administrator"
   Enter DOMAIN\administrator's password:
   Successfully granted rights.
   ```

7. If you run SELinux in `enforcing` mode, set the `samba_share_t` context on the directory:
8. Set the permissions on the `/var/lib/samba/drivers/` directory:

   - If you use POSIX ACLs, set:
     ```
     # chgrp -R "printadmin" /var/lib/samba/drivers/
     # chmod -R 2775 /var/lib/samba/drivers/
     ```

   - If you use Windows ACLs, set:

     | Principal          | Access                      | Apply to                                      |
     |--------------------|-----------------------------|-----------------------------------------------|
     | CREATOR OWNER      | Full control                | Subfolders and files only                     |
     | Authenticated Users| Read & execute, List folder contents, Read | This folder, subfolders, and files           |
     | printadmin         | Full control                | This folder, subfolders, and files           |

For details about setting ACLs on Windows, see the Windows documentation.

Additional resources

   - Section 3.16.2, "Enabling users to upload and preconfigure drivers".

3.16.4. Creating a GPO to enable clients to trust the Samba print server

For security reasons, recent Windows operating systems prevent clients from downloading non-package-aware printer drivers from an untrusted server. If your print server is a member in an AD, you can create a Group Policy Object (GPO) in your domain to trust the Samba server.

Prerequisites

   - The Samba print server is a member of an AD domain.

   - The Windows computer you are using to create the GPO must have the Windows Remote Server Administration Tools (RSAT) installed. For details, see the Windows documentation.

Procedure

   1. Log into a Windows computer using an account that is allowed to edit group policies, such as the AD domain Administrator user.

   2. Open the Group Policy Management Console.

   3. Right-click to your AD domain and select Create a GPO in this domain, and Link it here.
4. Enter a name for the GPO, such as **Legacy Printer Driver Policy** and click **OK**. The new GPO will be displayed under the domain entry.

5. Right-click to the newly-created GPO and select **Edit** to open the **Group Policy Management Editor**.

6. Navigate to **Computer Configuration → Policies → Administrative Templates → Printers**.

7. On the right side of the window, double-click **Point and Print Restriction** to edit the policy:
   a. Enable the policy and set the following options:
      i. Select **Users can only point and print to these servers** and enter the fully-qualified domain name (FQDN) of the Samba print server to the field next to this option.
      ii. In both check boxes under **Security Prompts**, select **Do not show warning or elevation prompt**.
b. Click OK.

8. Double-click **Package Point and Print - Approved servers** to edit the policy:
   a. Enable the policy and click the **Show** button.
   b. Enter the FQDN of the Samba print server.
c. Close both the **Show Contents** and the policy’s properties window by clicking **OK**.

9. Close the **Group Policy Management Editor**.

10. Close the **Group Policy Management Console**.

After the Windows domain members applied the group policy, printer drivers are automatically downloaded from the Samba server when a user connects to a printer.

**Additional resources**

- For further details about using group policies, see the Windows documentation.

### 3.16.5. Uploading drivers and preconfiguring printers

Use the **Print Management** application on a Windows client to upload drivers and preconfigure printers hosted on the Samba print server. For further details, see the Windows documentation.

### 3.17. TUNING THE PERFORMANCE OF A SAMBA SERVER

This chapter describes what settings can improve the performance of Samba in certain situations, and which settings can have a negative performance impact.

Parts of this section were adopted from the **Performance Tuning** documentation published in the Samba Wiki. License: **CC BY 4.0**. Authors and contributors: See the **history** tab on the Wiki page.

**Prerequisites**

- Samba is set up as a file or print server

#### 3.17.1. Setting the SMB protocol version

Each new SMB version adds features and improves the performance of the protocol. The recent Windows and Windows Server operating systems always supports the latest protocol version. If Samba also uses the latest protocol version, Windows clients connecting to Samba benefit from the performance improvements. In Samba, the default value of the server max protocol is set to the latest supported stable SMB protocol version.
NOTE

To always have the latest stable SMB protocol version enabled, do not set the server max protocol parameter. If you set the parameter manually, you will need to modify the setting with each new version of the SMB protocol, to have the latest protocol version enabled.

The following procedure explains how to use the default value in the server max protocol parameter.

Procedure

1. Remove the server max protocol parameter from the [global] section in the /etc/samba/smb.conf file.

2. Reload the Samba configuration

   # smbcontrol all reload-config

3.17.2. Tuning shares with directories that contain a large number of files

Linux supports case-sensitive file names. For this reason, Samba needs to scan directories for uppercase and lowercase file names when searching or accessing a file. You can configure a share to create new files only in lowercase or uppercase, which improves the performance.

Prerequisites

- Samba is configured as a file server

Procedure

1. Rename all files on the share to lowercase.

   NOTE

   Using the settings in this procedure, files with names other than in lowercase will no longer be displayed.

2. Set the following parameters in the share’s section:

   - case sensitive = true
   - default case = lower
   - preserve case = no
   - short preserve case = no

   For details about the parameters, see their descriptions in the smb.conf(5) man page.

3. Verify the /etc/samba/smb.conf file:

   # testparm

4. Reload the Samba configuration:

   # smbcontrol all reload-config
After you applied these settings, the names of all newly created files on this share use lowercase. Because of these settings, Samba no longer needs to scan the directory for uppercase and lowercase, which improves the performance.

3.17.3. Settings that can have a negative performance impact

By default, the kernel in Red Hat Enterprise Linux is tuned for high network performance. For example, the kernel uses an auto-tuning mechanism for buffer sizes. Setting the `socket options` parameter in the `/etc/samba/smb.conf` file overrides these kernel settings. As a result, setting this parameter decreases the Samba network performance in most cases.

To use the optimized settings from the Kernel, remove the `socket options` parameter from the `[global]` section in the `/etc/samba/smb.conf`.

3.18. CONFIGURING SAMBA TO BE COMPATIBLE WITH CLIENTS THAT REQUIRE AN SMB VERSION LOWER THAN THE DEFAULT

Samba uses a reasonable and secure default value for the minimum server message block (SMB) version it supports. However, if you have clients that require an older SMB version, you can configure Samba to support it.

3.18.1. Setting the minimum SMB protocol version supported by a Samba server

In Samba, the `server min protocol` parameter in the `/etc/samba/smb.conf` file defines the minimum server message block (SMB) protocol version the Samba server supports. This section describes how to change the minimum SMB protocol version.

**NOTE**

By default, Samba on RHEL 8.2 and later supports only SMB2 and newer protocol versions. Red Hat recommends to not use the deprecated SMB1 protocol. However, if your environment requires SMB1, you can manually set the `server min protocol` parameter to `NT1` to re-enable SMB1.

Prerequisites

- Samba is installed and configured.

Procedure

1. Edit the `/etc/samba/smb.conf` file, add the `server min protocol` parameter, and set the parameter to the minimum SMB protocol version the server should support. For example, to set the minimum SMB protocol version to `SMB3`, add:

   ```
   server min protocol = SMB3
   ```

2. Restart the `smb` service:

   ```
   # systemctl restart smb
   ```

Additional resources
For a list of protocol versions you can set in server min protocol parameter, see the description of the server max protocol parameter in the smb.conf(5) man page.

3.19. FREQUENTLY USED SAMBA COMMAND-LINE UTILITIES

This chapter describes frequently used commands when working with a Samba server.

3.19.1. Using the net ads join and net rpc join commands

Using the join subcommand of the net utility, you can join Samba to an AD or NT4 domain. To join the domain, you must create the /etc/samba/smb.conf file manually, and optionally update additional configurations, such as PAM.

IMPORTANT

Red Hat recommends using the realm utility to join a domain. The realm utility automatically updates all involved configuration files.

Procedure

1. Manually create the /etc/samba/smb.conf file with the following settings:

   - For an AD domain member:
     ```
     [global]
     workgroup = domain_name
     security = ads
     passdb backend = tdbsam
     realm = AD_REALM
     ```

   - For an NT4 domain member:
     ```
     [global]
     workgroup = domain_name
     security = user
     passdb backend = tdbsam
     ```

2. Add an ID mapping configuration for the * default domain and for the domain you want to join to the [global] section in the /etc/samba/smb.conf file.

3. Verify the /etc/samba/smb.conf file:

   ```
   # testparm
   ```

4. Join the domain as the domain administrator:

   - To join an AD domain:
     ```
     # net ads join -U "DOMAIN\administrator"
     ```

   - To join an NT4 domain:
     ```
     # net rpc join -U "DOMAIN\administrator"
     ```
5. Append the `winbind` source to the `passwd` and `group` database entry in the `/etc/nsswitch.conf` file:

```
passwd:     files winbind
group:      files winbind
```

6. Enable and start the `winbind` service:

```
# systemctl enable --now winbind
```

7. Optionally, configure PAM using the `authselect` utility.
   For details, see the `authselect(8)` man page.

8. Optionally for AD environments, configure the Kerberos client.
   For details, see the documentation of your Kerberos client.

Additional resources

- Section 3.5.1, “Joining a RHEL system to an AD domain”.
- Section 3.4, “Understanding and configuring Samba ID mapping”.

### 3.19.2. Using the `net rpc rights` command

In Windows, you can assign privileges to accounts and groups to perform special operations, such as setting ACLs on a share or upload printer drivers. On a Samba server, you can use the `net rpc rights` command to manage privileges.

**Listing privileges you can set**

To list all available privileges and their owners, use the `net rpc rights list` command. For example:

```
# net rpc rights list -U "DOMAIN\administrator"
```

Enter `DOMAIN\administrator`'s password:
- `SeMachineAccountPrivilege` Add machines to domain
- `SeTakeOwnershipPrivilege` Take ownership of files or other objects
  - `SeBackupPrivilege` Back up files and directories
  - `SeRestorePrivilege` Restore files and directories
- `SeRemoteShutdownPrivilege` Force shutdown from a remote system
- `SePrintOperatorPrivilege` Manage printers
  - `SeAddUsersPrivilege` Add users and groups to the domain
  - `SeDiskOperatorPrivilege` Manage disk shares
  - `SeSecurityPrivilege` System security

**Granting privileges**

To grant a privilege to an account or group, use the `net rpc rights grant` command. For example, grant the `SePrintOperatorPrivilege` privilege to the `DOMAIN\printadmin` group:

```
# net rpc rights grant "DOMAIN\printadmin" SePrintOperatorPrivilege -U "DOMAIN\administrator"
```

Enter `DOMAIN\administrator`'s password:
Successfully granted rights.

**Revoking privileges**
To revoke a privilege from an account or group, use the `net rpc rights revoke` command.

For example, to revoke the `SePrintOperatorPrivilege` privilege from the `DOMAIN\printadmin` group:

```
# net rpc rights remoke "DOMAIN\printadmin" SePrintOperatorPrivilege -U "DOMAIN\administrator"
Enter DOMAIN\administrator's password: Successfully revoked rights.
```

3.19.3. Using the net rpc share command

The `net rpc share` command provides the capability to list, add, and remove shares on a local or remote Samba or Windows server.

Listing shares

To list the shares on an SMB server, use the `net rpc share list` command. Optionally, pass the `-S server_name` parameter to the command to list the shares of a remote server. For example:

```
# net rpc share list -U "DOMAIN\administrator" -S server_name
Enter DOMAIN\administrator's password:
IPC$
share_1
share_2
...
```

**NOTE**

Shares hosted on a Samba server that have `browseable = no` set in their section in the `/etc/samba/smb.conf` file are not displayed in the output.

Adding a share

The `net rpc share add` command enables you to add a share to an SMB server.

For example, to add a share named `example` on a remote Windows server that shares the `C:\example\` directory:

```
# net rpc share add example="C:\example" -U "DOMAIN\administrator" -S server_name
```

**NOTE**

You must omit the trailing backslash in the path when specifying a Windows directory name.

To use the command to add a share to a Samba server:

- The user specified in the `-U` parameter must have the `SeDiskOperatorPrivilege` privilege granted on the destination server.

- You must write a script that adds a share section to the `/etc/samba/smb.conf` file and reloads Samba. The script must be set in the `add share command` parameter in the `[global]` section in `/etc/samba/smb.conf`. For further details, see the `add share command` description in the `smb.conf(5)` man page.
Removing a share
The `net rpc share delete` command enables you to remove a share from an SMB server.

For example, to remove the share named example from a remote Windows server:

```
# net rpc share delete example -U "DOMAINDomain\administrator" -S server_name
```

To use the command to remove a share from a Samba server:

- The user specified in the `-U` parameter must have the `SeDiskOperatorPrivilege` privilege granted.
- You must write a script that removes the share’s section from the `/etc/samba/smb.conf` file and reloads Samba. The script must be set in the `delete share command` parameter in the `[global]` section in `/etc/samba/smb.conf`. For further details, see the `delete share command` description in the `smb.conf(5)` man page.

3.19.4. Using the net user command

The `net user` command enables you to perform the following actions on an AD DC or NT4 PDC:

- List all user accounts
- Add users
- Remove Users

**NOTE**
Specifying a connection method, such as `ads` for AD domains or `rpc` for NT4 domains, is only required when you list domain user accounts. Other user-related subcommands can auto-detect the connection method.

Pass the `-U user_name` parameter to the command to specify a user that is allowed to perform the requested action.

**Listing domain user accounts**
To list all users in an AD domain:

```
# net ads user -U "DOMAINDomain\administrator"
```

To list all users in an NT4 domain:

```
# net rpc user -U "DOMAINDomain\administrator"
```

**Adding a user account to the domain**
On a Samba domain member, you can use the `net user add` command to add a user account to the domain.

For example, add the `user` account to the domain:

1. Add the account:
2. Optionally, use the remote procedure call (RPC) shell to enable the account on the AD DC or NT4 PDC. For example:

```bash
# net rpc shell -U "DOMAIN\administrator" -S DC_or_PDC_name
Talking to domain DOMAIN (S-1-5-21-1424831554-512457234-5642315751)
net rpc> user edit disabled user: no
Set user's disabled flag from [yes] to [no]
net rpc> exit
```

Deleting a user account from the domain

On a Samba domain member, you can use the `net user delete` command to remove a user account from the domain.

For example, to remove the user account from the domain:

```bash
# net user delete user -U "DOMAIN\administrator"
User user deleted
```

3.19.5. Using the `rpcclient` utility

The `rpcclient` utility enables you to manually execute client-side Microsoft Remote Procedure Call (MS-RPC) functions on a local or remote SMB server. However, most of the features are integrated into separate utilities provided by Samba. Use `rpcclient` only for testing MS-PRC functions.

Prerequisites

- The `samba-client` package is installed.

Examples

For example, you can use the `rpcclient` utility to:

- Manage the printer Spool Subsystem (SPOOLSS).

  Example 3.7. Assigning a Driver to a Printer

  ```bash
  # rpcclient server_name -U "DOMAIN\administrator" -c 'setdriver "printer_name" "driver_name"'
  Enter DOMAIN\administrators password:
  Successfully set printer_name to driver driver_name.
  ```

- Retrieve information about an SMB server.

  Example 3.8. Listing all File Shares and Shared Printers

  ```bash
  # rpcclient server_name -U "DOMAIN\administrator" -c 'netshareenum'
  Enter DOMAIN\administrators password:
  netname: Example_Share
  remark:
  ```
path: C:srv\samba\example_share\npassword: netname: Example_Printer
remark: path: C:\var\spool\samba\npassword:

- Perform actions using the Security Account Manager Remote (SAMR) protocol.

**Example 3.9. Listing Users on an SMB Server**

```bash
# rpcclient server_name -U "DOMAIN\administrator" -c 'enumdomusers'
Enter DOMAIN\administrators password:
user:[user1] rid:[0x3e8]
user:[user2] rid:[0x3e9]
```

If you run the command against a standalone server or a domain member, it lists the users in the local database. Running the command against an AD DC or NT4 PDC lists the domain users.

**Additional resources**

For a complete list of supported subcommands, see the **COMMANDS** section in the `rpcclient(1)` man page.

### 3.19.6. Using the samba-regedit application

Certain settings, such as printer configurations, are stored in the registry on the Samba server. You can use the ncurses-based `samba-regedit` application to edit the registry of a Samba server.

![Registry Edit](registry.png)

**Prerequisites**

- The **samba-client** package is installed.
Procedure

To start the application, enter:

```
# samba-regedit
```

Use the following keys:

- Cursor up and cursor down: Navigate through the registry tree and the values.
- **Enter**: Opens a key or edits a value.
- **Tab**: Switches between the **Key** and **Value** pane.
- **Ctrl+C**: Closes the application.

### 3.19.7. Using the smbcontrol utility

The `smbcontrol` utility enables you to send command messages to the `smbd`, `nmbd`, `winbindd`, or all of these services. These control messages instruct the service, for example, to reload its configuration.

The procedure in this section shows how to reload the configuration of the `smbd`, `nmbd`, `winbindd` services by sending the `reload-config` message type to the `all` destination.

**Prerequisites**

- The `samba-common-tools` package is installed.

**Procedure**

```
# smbcontrol all reload-config
```

**Additional resources**

For further details and a list of available command message types, see the `smbcontrol(1)` man page.

### 3.19.8. Using the smbpasswd utility

The `smbpasswd` utility manages user accounts and passwords in the local Samba database.

**Prerequisites**

- The `samba-common-tools` package is installed.

**Procedure**

1. If you run the command as a user, `smbpasswd` changes the Samba password of the user who runs the command. For example:

```
[user@server ~]$ smbpasswd
New SMB password: password
Retype new SMB password: password
```

2. If you run `smbpasswd` as the `root` user, you can use the utility, for example, to:
• Create a new user:

  [root@server ~]# smbpasswd -a user_name
  New SMB password: password  
  Retype new SMB password: [command]password
  Added user user_name.

  **NOTE**
  Before you can add a user to the Samba database, you must create the account in the local operating system. See the Adding a new user from the command line section in the Configuring basic system settings guide.

• Enable a Samba user:

  [root@server ~]# smbpasswd -e user_name
  Enabled user user_name.

• Disable a Samba user:

  [root@server ~]# smbpasswd -x user_name
  Disabled user user_name

• Delete a user:

  [root@server ~]# smbpasswd -x user_name
  Deleted user user_name.

**Additional resources**

For further details, see the `smbpasswd(8)` man page.

### 3.19.9. Using the smbstatus utility

The `smbstatus` utility reports on:

• Connections per PID of each `smbd` daemon to the Samba server. This report includes the user name, primary group, SMB protocol version, encryption, and signing information.

• Connections per Samba share. This report includes the PID of the `smbd` daemon, the IP of the connecting machine, the time stamp when the connection was established, encryption, and signing information.

• A list of locked files. The report entries include further details, such as opportunistic lock (oplock) types

**Prerequisites**

• The `samba` package is installed.

• The `smbd` service is running.

**Procedure**
### smbstatus

Samba version 4.12.3

<table>
<thead>
<tr>
<th>PID</th>
<th>Username</th>
<th>Group</th>
<th>Machine</th>
<th>Protocol Version</th>
<th>Encryption Signing</th>
</tr>
</thead>
<tbody>
<tr>
<td>963</td>
<td>DOMAIN\administrator</td>
<td>DOMAIN\domain users</td>
<td>client-pc  (ipv4:192.0.2.1:57786)</td>
<td>SMB3_02</td>
<td>AES-128-CMAC</td>
</tr>
</tbody>
</table>

Service pid Machine Connected at Encryption Signing:

| example | 969 | 192.0.2.1 | Thu Nov 1 10:00:00 2018 CEST | AES-128-CMAC |

Locked files:

<table>
<thead>
<tr>
<th>Pid</th>
<th>Uid</th>
<th>DenyMode</th>
<th>Access</th>
<th>R/W</th>
<th>Oplock</th>
<th>SharePath</th>
<th>Name</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>969</td>
<td>10000</td>
<td>DENY_WRITE</td>
<td>0x120089</td>
<td>RDONLY</td>
<td>LEASE(RWH)</td>
<td>/srv/samba/example</td>
<td>file.txt</td>
<td>Thu Nov 1 10:00:00 2018</td>
</tr>
</tbody>
</table>

**Additional resources**

For further details, see the `smbstatus(1)` man page.

### 3.19.10. Using the smbtar utility

The `smbtar` utility backs up the content of an SMB share or a subdirectory of it and stores the content in a `tar` archive. Alternatively, you can write the content to a tape device.

**Prerequisites**

- The `samba-client` package is installed.

**Procedure**

- Use the following command to back up the content of the `demo` directory on the `//server/example/` share and store the content in the `/root/example.tar` archive:

  ```bash
  # smbtar -s server -x example -u user_name -p password -t /root/example.tar
  ```

**Additional resources**

For further details, see the `smbtar(1)` man page.

### 3.19.11. Using the wbinfo utility

The `wbinfo` utility queries and returns information created and used by the `winbindd` service.

**Prerequisites**

- The `samba-winbind-clients` package is installed.

**Procedure**

You can use `wbinfo`, for example, to:
• List domain users:

```
# wbinfo -u
AD\administrator
AD\guest
... 
```

• List domain groups:

```
# wbinfo -g
AD\domain computers
AD\domain admins
AD\domain users
... 
```

• Display the SID of a user:

```
# wbinfo --name-to-sid="AD\administrator"
S-1-5-21-1762709870-351891212-3141221786-500 SID_USER (1)
```

• Display information about domains and trusts:

```
# wbinfo --trusted-domains --verbose

<table>
<thead>
<tr>
<th>Domain Name</th>
<th>DNS Domain</th>
<th>Trust Type</th>
<th>Transitive</th>
<th>In</th>
<th>Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILTIN</td>
<td>None</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>server</td>
<td>None</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DOMAIN1</td>
<td>domain1.example.com</td>
<td>None</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>DOMAIN2</td>
<td>domain2.example.com</td>
<td>External</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
```

Additional resources

For further details, see the `wbinfo(1)` man page.

### 3.20. RELATED INFORMATION

• The Red Hat Samba packages include manual pages for all Samba commands and configuration files the package installs. For example, to display the man page of the `/etc/samba/smb.conf` file that explains all configuration parameters you can set in this file:

```
# man smb.conf
```

• The `/usr/share/docs/samba-version/` directory contains general documentation, example scripts, and LDAP schema files, provided by the Samba project.

• `Red Hat Cluster Storage Administration Guide`: Provides information about setting up Samba and the Clustered Trivial Database (CDTB) to share directories stored on an GlusterFS volume.

• For details about mounting an SMB share on Red Hat Enterprise Linux, see `Mounting an SMB Share on Red Hat Enterprise Linux`. 

```
CHAPTER 4. EXPORTING NFS SHARES

As a system administrator, you can use the NFS server to share a directory on your system over network.

4.1. INTRODUCTION TO NFS

This section explains the basic concepts of the NFS service.

A Network File System (NFS) allows remote hosts to mount file systems over a network and interact with those file systems as though they are mounted locally. This enables you to consolidate resources onto centralized servers on the network.

The NFS server refers to the `/etc/exports` configuration file to determine whether the client is allowed to access any exported file systems. Once verified, all file and directory operations are available to the user.

4.2. SUPPORTED NFS VERSIONS

This section lists versions of NFS supported in Red Hat Enterprise Linux and their features.

Currently, Red Hat Enterprise Linux 8 supports the following major versions of NFS:

- NFS version 3 (NFSv3) supports safe asynchronous writes and is more robust at error handling than the previous NFSv2; it also supports 64-bit file sizes and offsets, allowing clients to access more than 2 GB of file data.

- NFS version 4 (NFSv4) works through firewalls and on the Internet, no longer requires an `rpcbind` service, supports Access Control Lists (ACLs), and utilizes stateful operations.

NFS version 2 (NFSv2) is no longer supported by Red Hat.

Default NFS version
The default NFS version in Red Hat Enterprise Linux 8 is 4.2. NFS clients attempt to mount using NFSv4.2 by default, and fall back to NFSv4.1 when the server does not support NFSv4.2. The mount later falls back to NFSv4.0 and then to NFSv3.

Features of minor NFS versions
Following are the features of NFSv4.2 in Red Hat Enterprise Linux 8:

**Server-side copy**
Enables the NFS client to efficiently copy data without wasting network resources using the `copy_file_range()` system call.

**Sparse files**
Enables files to have one or more holes, which are unallocated or uninitialized data blocks consisting only of zeroes. The `lseek()` operation in NFSv4.2 supports `seek_hole()` and `seek_data()`, which enables applications to map out the location of holes in the sparse file.

**Space reservation**
Permits storage servers to reserve free space, which prohibits servers to run out of space. NFSv4.2 supports the `allocate()` operation to reserve space, the `deallocate()` operation to unreserve space, and the `fallocate()` operation to preallocate or deallocate space in a file.

**Labeled NFS**
Enforces data access rights and enables SELinux labels between a client and a server for individual files on an NFS file system.
Layout enhancements

Provides the layoutstats() operation, which enables some Parallel NFS (pNFS) servers to collect better performance statistics.

Following are the features of NFSv4.1:

- Enhances performance and security of network, and also includes client-side support for pNFS.
- No longer requires a separate TCP connection for callbacks, which allows an NFS server to grant delegations even when it cannot contact the client: for example, when NAT or a firewall interferes.
- Provides exactly once semantics (except for reboot operations), preventing a previous issue whereby certain operations sometimes returned an inaccurate result if a reply was lost and the operation was sent twice.

4.3. THE TCP AND UDP PROTOCOLS IN NFSV3 AND NFSV4

NFSv4 requires the Transmission Control Protocol (TCP) running over an IP network.

NFSv3 could also use the User Datagram Protocol (UDP) in earlier Red Hat Enterprise Linux versions. In Red Hat Enterprise Linux 8, NFS over UDP is no longer supported. By default, UDP is disabled in the NFS server.

4.4. SERVICES REQUIRED BY NFS

This section lists system services that are required for running an NFS server or mounting NFS shares. Red Hat Enterprise Linux starts these services automatically.

Red Hat Enterprise Linux uses a combination of kernel-level support and service processes to provide NFS file sharing. All NFS versions rely on Remote Procedure Calls (RPC) between clients and servers. To share or mount NFS file systems, the following services work together depending on which version of NFS is implemented:

- **nfsd**
  
  The NFS server kernel module that services requests for shared NFS file systems.

- **rpcbind**
  
  Accepts port reservations from local RPC services. These ports are then made available (or advertised) so the corresponding remote RPC services can access them. The rpcbind service responds to requests for RPC services and sets up connections to the requested RPC service. This is not used with NFSv4.

- **rpc.mountd**
  
  This process is used by an NFS server to process MOUNT requests from NFSv3 clients. It checks that the requested NFS share is currently exported by the NFS server, and that the client is allowed to access it. If the mount request is allowed, the nfs-mountd service replies with a Success status and provides the File-Handle for this NFS share back to the NFS client.

- **rpc.nfsd**
  
  This process enables explicit NFS versions and protocols the server advertises to be defined. It works with the Linux kernel to meet the dynamic demands of NFS clients, such as providing server threads each time an NFS client connects. This process corresponds to the nfs-server service.

- **lockd**
  
  This is a kernel thread that runs on both clients and servers. It implements the Network Lock
This is a kernel thread that runs on both clients and servers. It implements the Network Lock Manager (NLM) protocol, which enables NFSv3 clients to lock files on the server. It is started automatically whenever the NFS server is run and whenever an NFS file system is mounted.

**rpc.statd**

This process implements the Network Status Monitor (NSM) RPC protocol, which notifies NFS clients when an NFS server is restarted without being gracefully brought down. The `rpc.statd` service is started automatically by the `nfs-server` service, and does not require user configuration. This is not used with NFSv4.

**rpc.rquotad**

This process provides user quota information for remote users. The `rpc.rquotad` service is started automatically by the `nfs-server` service and does not require user configuration.

**rpc.idmapd**

This process provides NFSv4 client and server upcalls, which map between on-the-wire NFSv4 names (strings in the form of `user@domain`) and local UIDs and GIDs. For `idmapd` to function with NFSv4, the `/etc/idmapd.conf` file must be configured. At a minimum, the `Domain` parameter should be specified, which defines the NFSv4 mapping domain. If the NFSv4 mapping domain is the same as the DNS domain name, this parameter can be skipped. The client and server must agree on the NFSv4 mapping domain for ID mapping to function properly.

Only the NFSv4 server uses `rpc.idmapd`, which is started by the `nfs-idmapd` service. The NFSv4 client uses the keyring-based `nfsidmap` utility, which is called by the kernel on-demand to perform ID mapping. If there is a problem with `nfsidmap`, the client falls back to using `rpc.idmapd`.

**The RPC services with NFSv4**

The mounting and locking protocols have been incorporated into the NFSv4 protocol. The server also listens on the well-known TCP port 2049. As such, NFSv4 does not need to interact with `rpcbind`, `lockd`, and `rpc.statd` services. The `nfs-mountd` service is still required on the NFS server to set up the exports, but is not involved in any over-the-wire operations.

**Additional resources**

- To configure an NFSv4-only server, which does not require `rpcbind`, see Section 4.14, “Configuring an NFSv4-only server”.

**4.5. NFS HOST NAME FORMATS**

This section describes different formats that you can use to specify a host when mounting or exporting an NFS share.

You can specify the host in the following formats:

**Single machine**

Either of the following:

- A fully-qualified domain name (that can be resolved by the server)
- Host name (that can be resolved by the server)
- An IP address.

**IP networks**

Either of the following formats is valid:
a.b.c.d/z, where a.b.c.d is the network and z is the number of bits in the netmask; for example 192.168.0.0/24.

a.b.c.d/netmask, where a.b.c.d is the network and netmask is the netmask; for example, 192.168.100.8/255.255.255.0.

Netgroups
The @group-name format, where group-name is the NIS netgroup name.

4.6. NFS SERVER CONFIGURATION
This section describes the syntax and options of two ways to configure exports on an NFS server:

- Manually editing the /etc/exports configuration file
- Using the exportfs utility on the command line

4.6.1. The /etc/exports configuration file
The /etc/exports file controls which file systems are exported to remote hosts and specifies options. It follows the following syntax rules:

- Blank lines are ignored.
- To add a comment, start a line with the hash mark (#).
- You can wrap long lines with a backslash (\).
- Each exported file system should be on its own individual line.
- Any lists of authorized hosts placed after an exported file system must be separated by space characters.
- Options for each of the hosts must be placed in parentheses directly after the host identifier, without any spaces separating the host and the first parenthesis.

Export entry
Each entry for an exported file system has the following structure:

```
export host(options)
```

It is also possible to specify multiple hosts, along with specific options for each host. To do so, list them on the same line as a space-delimited list, with each host name followed by its respective options (in parentheses), as in:

```
export host1(options1) host2(options2) host3(options3)
```

In this structure:

- `export` The directory being exported
- `host` The host or network to which the export is being shared
The options to be used for host

**Example 4.1. A simple /etc/exports file**

In its simplest form, the /etc/exports file only specifies the exported directory and the hosts permitted to access it:

```
/exported/directory bob.example.com
```

Here, *bob.example.com* can mount /exported/directory/ from the NFS server. Because no options are specified in this example, NFS uses default options.

**IMPORTANT**

The format of the /etc/exports file is very precise, particularly in regards to use of the space character. Remember to always separate exported file systems from hosts and hosts from one another with a space character. However, there should be no other space characters in the file except on comment lines.

For example, the following two lines do not mean the same thing:

```
/home bob.example.com(rw)
/home bob.example.com (rw)
```

The first line allows only users from *bob.example.com* read and write access to the /home directory. The second line allows users from *bob.example.com* to mount the directory as read-only (the default), while the rest of the world can mount it read/write.

**Default options**

The default options for an export entry are:

- **ro**
  
The exported file system is read-only. Remote hosts cannot change the data shared on the file system. To allow hosts to make changes to the file system (that is, read and write), specify the rw option.

- **sync**
  
The NFS server will not reply to requests before changes made by previous requests are written to disk. To enable asynchronous writes instead, specify the option async.

- **wdelay**
  
The NFS server will delay writing to the disk if it suspects another write request is imminent. This can improve performance as it reduces the number of times the disk must be accessed by separate write commands, thereby reducing write overhead. To disable this, specify the no_wdelay option, which is available only if the default sync option is also specified.

- **root_squash**
  
  This prevents root users connected remotely (as opposed to locally) from having root privileges; instead, the NFS server assigns them the user ID nobody. This effectively "squashes" the power of the remote root user to the lowest local user, preventing possible unauthorized writes on the remote server. To disable root squashing, specify the no_root_squash option.
To squash every remote user (including root), use the `all_squash` option. To specify the user and group IDs that the NFS server should assign to remote users from a particular host, use the `anonuid` and `anongid` options, respectively, as in:

```
export host(anonuid=uid,anongid=gid)
```

Here, `uid` and `gid` are user ID number and group ID number, respectively. The `anonuid` and `anongid` options enable you to create a special user and group account for remote NFS users to share.

By default, access control lists (ACLs) are supported by NFS under Red Hat Enterprise Linux. To disable this feature, specify the `no_acl` option when exporting the file system.

### Default and overridden options

Each default for every exported file system must be explicitly overridden. For example, if the `rw` option is not specified, then the exported file system is shared as read-only. The following is a sample line from `/etc/exports` which overrides two default options:

```
/another/exported/directory 192.168.0.3(rw,async)
```

In this example, `192.168.0.3` can mount `/another/exported/directory/` read and write, and all writes to disk are asynchronous.

#### 4.6.2. The `exportfs` utility

The `exportfs` utility enables the root user to selectively export or unexport directories without restarting the NFS service. When given the proper options, the `exportfs` utility writes the exported file systems to `/var/lib/nfs/xtab`. Because the `nfs-mountd` service refers to the `xtab` file when deciding access privileges to a file system, changes to the list of exported file systems take effect immediately.

### Common `exportfs` options

The following is a list of commonly-used options available for `exportfs`:

- `-r`
  - Causes all directories listed in `/etc/exports` to be exported by constructing a new export list in `/etc/lib/nfs/xtab`. This option effectively refreshes the export list with any changes made to `/etc/exports`.

- `-a`
  - Causes all directories to be exported or unexported, depending on what other options are passed to `exportfs`. If no other options are specified, `exportfs` exports all file systems specified in `/etc/exports`.

- `-o file-systems`
  - Specifies directories to be exported that are not listed in `/etc/exports`. Replace `file-systems` with additional file systems to be exported. These file systems must be formatted in the same way they are specified in `/etc/exports`. This option is often used to test an exported file system before adding it permanently to the list of exported file systems.

- `-i`
  - Ignores `/etc/exports`; only options given from the command line are used to define exported file systems.

- `-u`
  - Unexports all shared directories. The command `exportfs -ua` suspends NFS file sharing while keeping all NFS services up. To re-enable NFS sharing, use `exportfs -r`.

- `-v`
Verbose operation, where the file systems being exported or unexported are displayed in greater detail when the `exportfs` command is executed.

If no options are passed to the `exportfs` utility, it displays a list of currently exported file systems.

**Additional resources**

- For information on different methods for specifying host names, see Section 4.5, “NFS host name formats”.
- For a complete list of export options, see the `exports(5)` man page.
- For more information about the `exportfs` utility, see the `exportfs(8)` man page.

### 4.7. NFS AND RPCBIND

This section explains the purpose of the `rpcbind` service, which is required by NFSv3.

The `rpcbind` service maps Remote Procedure Call (RPC) services to the ports on which they listen. RPC processes notify `rpcbind` when they start, registering the ports they are listening on and the RPC program numbers they expect to serve. The client system then contacts `rpcbind` on the server with a particular RPC program number. The `rpcbind` service redirects the client to the proper port number so it can communicate with the requested service.

Because RPC-based services rely on `rpcbind` to make all connections with incoming client requests, `rpcbind` must be available before any of these services start.

Access control rules for `rpcbind` affect all RPC-based services. Alternatively, it is possible to specify access control rules for each of the NFS RPC daemons.

**Additional resources**

- For the precise syntax of access control rules, see the `rpc.mountd(8)` and `rpc.statd(8)` man pages.

### 4.8. INSTALLING NFS

This procedure installs all packages necessary to mount or export NFS shares.

**Procedure**

- Install the `nfs-utils` package:

```
# yum install nfs-utils
```

### 4.9. STARTING THE NFS SERVER

This procedure describes how to start the NFS server, which is required to export NFS shares.

**Prerequisites**

- For servers that support NFSv2 or NFSv3 connections, the `rpcbind` service must be running. To verify that `rpcbind` is active, use the following command:
$ systemctl status rpcbind

If the service is stopped, start and enable it:

$ systemctl enable --now rpcbind

Procedure

- To start the NFS server and enable it to start automatically at boot, use the following command:

  # systemctl enable --now nfs-server

Additional resources

- To configure an NFSv4-only server, which does not require rpcbind, see Section 4.14, “Configuring an NFSv4-only server”.

### 4.10. TROUBLESHOOTING NFS AND RPCBIND

Because the rpcbind service provides coordination between RPC services and the port numbers used to communicate with them, it is useful to view the status of current RPC services using rpcbind when troubleshooting. The rpcinfo utility shows each RPC-based service with port numbers, an RPC program number, a version number, and an IP protocol type (TCP or UDP).

Procedure

1. To make sure the proper NFS RPC-based services are enabled for rpcbind, use the following command:

   # rpcinfo -p

Example 4.2. rpcinfo -p command output

The following is sample output from this command:

```
program vers proto    port   service
100000    4   tcp   111 portmapper
100000    3   tcp   111 portmapper
100000    2   tcp   111 portmapper
100000    4   udp   111 portmapper
100000    3   udp   111 portmapper
100000    2   udp   111 portmapper
100005    1   udp   20048 mountd
100005    1   tcp   20048 mountd
100005    2   udp   20048 mountd
100005    2   tcp   20048 mountd
100005    3   udp   20048 mountd
100005    3   tcp   20048 mountd
100024    1   udp   37769 status
100024    1   tcp   49349 status
100003    3   tcp   2049 nfs
100003    4   tcp   2049 nfs
100227    3   tcp   2049 nfs_acl
```
If one of the NFS services does not start up correctly, `rpcbind` will be unable to map RPC requests from clients for that service to the correct port.

2. In many cases, if NFS is not present in `rpcinfo` output, restarting NFS causes the service to correctly register with `rpcbind` and begin working:

```
# systemctl restart nfs-server
```

Additional resources

- For more information and a list of `rpcinfo` options, see the `rpcinfo(8)` man page.
- To configure an NFSv4-only server, which does not require `rpcbind`, see Section 4.14, “Configuring an NFSv4-only server”.

### 4.11. CONFIGURING THE NFS SERVER TO RUN BEHIND A FIREWALL

NFS requires the `rpcbind` service, which dynamically assigns ports for RPC services and can cause issues for configuring firewall rules. This procedure describes how to configure the NFS server to work behind a firewall.

**Procedure**

1. To allow clients to access NFS shares behind a firewall, set which ports the RPC services run on in the `[mountd]` section of the `/etc/nfs.conf` file:

   ```
   [mountd]
   port=port-number
   ```

   This adds the `-p port-number` option to the `rpc.mount` command line: `rpc.mount -p port-number`.

2. To allow clients to access NFS shares behind a firewall, configure the firewall by running the following commands on the NFS server:

   ```
   firewall-cmd --permanent --add-service mountd
   firewall-cmd --permanent --add-service rpc-bind
   firewall-cmd --permanent --add-service nfs
   firewall-cmd --permanent --add-port=<mountd-port>/tcp
   firewall-cmd --permanent --add-port=<mountd-port>/udp
   firewall-cmd --reload
   ```

   In the commands, replace `<mountd-port>` with the intended port or a port range. When specifying a port range, use the `--add-port=<mountd-port>-<mountd-port>/udp` syntax.
3. To allow NFSv4.0 callbacks to pass through firewalls, set
   `/proc/sys/fs/nfs/nfs_callback_tcpport` and allow the server to connect to that port on the
   client.
   This step is not needed for NFSv4.1 or higher, and the other ports for `mountd`, `statd`, and `lockd`
   are not required in a pure NFSv4 environment.

4. To specify the ports to be used by the RPC service `nlockmgr`, set the port number for the
   `nlm_tcpport` and `nlm_udpport` options in the `/etc/modprobe.d/lockd.conf` file.

5. Restart the NFS server:

   ```
   # systemctl restart nfs-server
   ```

   If NFS fails to start, check `/var/log/messages`. Commonly, NFS fails to start if you specify a port
   number that is already in use.

6. Confirm the changes have taken effect:

   ```
   # rpcinfo -p
   ```

Additional resources

- To configure an NFSv4-only server, which does not require `rpcbind`, see `Section 4.14`,
  “Configuring an NFSv4-only server”.

### 4.12. EXPORTING RPC QUOTA THROUGH A FIREWALL

If you export a file system that uses disk quotas, you can use the quota Remote Procedure Call (RPC)
 service to provide disk quota data to NFS clients.

**Procedure**

1. Enable and start the `rpc-rquotad` service:

   ```
   # systemctl enable --now rpc-rquotad
   ```

   **NOTE**

   The `rpc-rquotad` service is, if enabled, started automatically after starting the
   `nfs-server` service.

2. To make the quota RPC service accessible behind a firewall, the TCP (or UDP, if UDP is
   enabled) port 875 need to be open. The default port number is defined in the `/etc/services`
   file.
   You can override the default port number by appending `-p port-number` to the
   `RPCRQUOTADOPTS` variable in the `/etc/sysconfig/rpc-rquotad` file.

3. By default, remote hosts can only read quotas. If you want to allow clients to set quotas, append
   the `-S` option to the `RPCRQUOTADOPTS` variable in the `/etc/sysconfig/rpc-rquotad` file.

4. Restart `rpc-rquotad` for the changes in the `/etc/sysconfig/rpc-rquotad` file to take effect:

   ```
   # systemctl restart rpc-rquotad
   ```
4.13. ENABLING NFS OVER RDMA (NFSORDMA)

The remote direct memory access (RDMA) service works automatically in Red Hat Enterprise Linux 8 if there is RDMA-capable hardware present.

Procedure

1. Install the rdma-core package:
   ```bash
   # yum install rdma-core
   ```

2. To enable automatic loading of NFSoRDMA server modules, add the `SVCRDMA_LOAD=yes` option on a new line in the `/etc/rdma/rdma.conf` configuration file. The `rdma=20049` option in the `[nfsd]` section of the `/etc/nfs.conf` file specifies the port number on which the NFSoRDMA service listens for clients. The RFC 5667 standard specifies that servers must listen on port 20049 when providing NFSv4 services over RDMA.

   The `/etc/rdma/rdma.conf` file contains a line that sets the `XPRTRDMA_LOAD=yes` option by default, which requests the `rdma` service to load the NFSoRDMA client module.

3. Restart the nfs-server service:
   ```bash
   # systemctl restart nfs-server
   ```

Additional resources


4.14. CONFIGURING AN NFSV4-ONLY SERVER

As an NFS server administrator, you can configure the NFS server to support only NFSv4, which minimizes the number of open ports and running services on the system.

4.14.1. Benefits and drawbacks of an NFSv4-only server

This section explains the benefits and drawbacks of configuring the NFS server to only support NFSv4.

By default, the NFS server supports NFSv3 and NFSv4 connections in Red Hat Enterprise Linux 8. However, you can also configure NFS to support only NFS version 4.0 and later. This minimizes the number of open ports and running services on the system, because NFSv4 does not require the `rpcbind` service to listen on the network.

When your NFS server is configured as NFSv4-only, clients attempting to mount shares using NFSv3 fail with an error like the following:

- Requested NFS version or transport protocol is not supported.

Optionally, you can also disable listening for the `RPCBIND`, `MOUNT`, and `NSM` protocol calls, which are not necessary in the NFSv4-only case.

The effects of disabling these additional options are:

- Clients that attempt to mount shares from your server using NFSv3 become unresponsive.
The NFS server itself is unable to mount NFSv3 file systems.

4.14.2. NFS and rpcbind

This section explains the purpose of the rpcbind service, which is required by NFSv3.

The rpcbind service maps Remote Procedure Call (RPC) services to the ports on which they listen. RPC processes notify rpcbind when they start, registering the ports they are listening on and the RPC program numbers they expect to serve. The client system then contacts rpcbind on the server with a particular RPC program number. The rpcbind service redirects the client to the proper port number so it can communicate with the requested service.

Because RPC-based services rely on rpcbind to make all connections with incoming client requests, rpcbind must be available before any of these services start.

Access control rules for rpcbind affect all RPC-based services. Alternatively, it is possible to specify access control rules for each of the NFS RPC daemons.

Additional resources

- For the precise syntax of access control rules, see the rpc.mountd(8) and rpc.statd(8) man pages.

4.14.3. Configuring the NFS server to support only NFSv4

This procedure describes how to configure your NFS server to support only NFS version 4.0 and later.

Procedure

1. Disable NFSv3 by adding the following lines to the [nfsd] section of the /etc/nfs.conf configuration file:

   ![Code]

2. Optionally, disable listening for the RPCBIND, MOUNT, and NSM protocol calls, which are not necessary in the NFSv4-only case. Disable related services:

   ![Code]

3. Restart the NFS server:

   ![Code]

The changes take effect as soon as you start or restart the NFS server.

4.14.4. Verifying the NFSv4-only configuration

This procedure describes how to verify that your NFS server is configured in the NFSv4-only mode by using the netstat utility.

Procedure
Use the `netstat` utility to list services listening on the TCP and UDP protocols:

```
# netstat --listening --tcp --udp
```

**Example 4.3. Output on an NFSv4-only server**

The following is an example `netstat` output on an NFSv4-only server; listening for **RPCBIND**, **MOUNT**, and **NSM** is also disabled. Here, **nfs** is the only listening NFS service:

```
# netstat --listening --tcp --udp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address State
tcp        0      0 0.0.0.0:ssh             0.0.0.0:*       LISTEN
tcp        0      0 0.0.0.0:nfs             0.0.0.0:*       LISTEN
tcp6       0      0 [::]:ssh                [:]:*           LISTEN
tcp6       0      0 [::]:nfs                [:]:*           LISTEN
udp        0      0 localhost.locald:bootpc 0.0.0.0:*       LISTEN
```

**Example 4.4. Output before configuring an NFSv4-only server**

In comparison, the `netstat` output before configuring an NFSv4-only server includes the **sunrpc** and **mountd** services:

```
# netstat --listening --tcp --udp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address State
tcp        0      0 0.0.0.0:ssh             0.0.0.0:*       LISTEN
tcp        0      0 0.0.0.0:40189           0.0.0.0:*       LISTEN
tcp        0      0 0.0.0.0:46813           0.0.0.0:*       LISTEN
tcp        0      0 0.0.0.0:nfs             0.0.0.0:*       LISTEN
tcp        0      0 0.0.0.0:sunrpc          0.0.0.0:*       LISTEN
tcp        0      0 0.0.0.0:mountd          0.0.0.0:*       LISTEN
tcp6       0      0 [::]:ssh                [::]:*           LISTEN
tcp6       0      0 [::]:51227               [::]:*           LISTEN
tcp6       0      0 [::]:nfs                [::]:*           LISTEN
tcp6       0      0 [::]:sunrpc             [::]:*           LISTEN
tcp6       0      0 [::]:mountd             [::]:*           LISTEN
tcp6       0      0 [::]:45043               [::]:*           LISTEN
udp        0      0 localhost:1018         0.0.0.0:*       LISTEN
udp        0      0 localhost.locald:bootpc 0.0.0.0:*       LISTEN
udp        0      0 0.0.0.0:mountd          0.0.0.0:*       LISTEN
udp        0      0 0.0.0.0:46672           0.0.0.0:*       LISTEN
udp        0      0 0.0.0.0:sunrpc          0.0.0.0:*       LISTEN
udp        0      0 0.0.0.0:33494           0.0.0.0:*       LISTEN
udp6       0      0 [::]:33734              [::]:*           LISTEN
udp6       0      0 [::]:mountd             [::]:*           LISTEN
udp6       0      0 [::]:sunrpc             [::]:*           LISTEN
udp6       0      0 [::]:40243              [::]:*           LISTEN
```
4.15. RELATED INFORMATION

- The Linux NFS wiki: https://linux-nfs.org
CHAPTER 5. SECURING NFS

To minimize NFS security risks and protect data on the server, consider the following sections when exporting NFS file systems on a server or mounting them on a client.

5.1. NFS SECURITY WITH AUTH_SYS AND EXPORT CONTROLS

NFS provides the following traditional options in order to control access to exported files:

- The server restricts which hosts are allowed to mount which file systems either by IP address or by host name.

- The server enforces file system permissions for users on NFS clients in the same way it does for local users. Traditionally, NFS does this using the AUTH_SYS call message (also called AUTH_UNIX), which relies on the client to state the UID and GIDs of the user. Be aware that this means that a malicious or misconfigured client might easily get this wrong and allow a user access to files that it should not.

To limit the potential risks, administrators often limit the access to read-only or squash user permissions to a common user and group ID. Unfortunately, these solutions prevent the NFS share from being used in the way it was originally intended.

Additionally, if an attacker gains control of the DNS server used by the system exporting the NFS file system, they can point the system associated with a particular hostname or fully qualified domain name to an unauthorized machine. At this point, the unauthorized machine is the system permitted to mount the NFS share, because no username or password information is exchanged to provide additional security for the NFS mount.

Wildcards should be used sparingly when exporting directories through NFS, as it is possible for the scope of the wildcard to encompass more systems than intended.

Additional resources

- To secure NFS and rpcbind, use, for example, nftables and firewalld. For details about configuring these frameworks, see the nft(8) and firewalld-cmd(1) man pages.

5.2. NFS SECURITY WITH AUTH_GSS

All versions of NFS support RPCSEC_GSS and the Kerberos mechanism.

Unlike AUTH_SYS, with the RPCSEC_GSS Kerberos mechanism, the server does not depend on the client to correctly represent which user is accessing the file. Instead, cryptography is used to authenticate users to the server, which prevents a malicious client from impersonating a user without having that user’s Kerberos credentials. Using the RPCSEC_GSS Kerberos mechanism is the most straightforward way to secure mounts because after configuring Kerberos, no additional setup is needed.

5.3. CONFIGURING AN NFS SERVER AND CLIENT TO USE KERBEROS

Kerberos is a network authentication system that allows clients and servers to authenticate to each other by using symmetric encryption and a trusted third party, the KDC. Red Hat recommends using Identity Management (IdM) for setting up Kerberos.

Prerequisites
The Kerberos Key Distribution Centre (KDC) is installed and configured.

Procedure

1. Create the `nfs/hostname.domain@REALM` principal on the NFS server side.
   - Create the `host/hostname.domain@REALM` principal on both the server and the client side.
   - Add the corresponding keys to keytabs for the client and server.

2. On the server side, use the `sec=` option to enable the wanted security flavors. To enable all security flavors as well as non-cryptographic mounts:

   /export *(sec=sys:krb5:krb5i:krb5p)

   Valid security flavors to use with the `sec=` option are:
   - `sys`: no cryptographic protection, the default
   - `krb5`: authentication only
   - `krb5i`: integrity protection
   - `krb5p`: privacy protection

3. On the client side, add `sec=krb5` (or `sec=krb5i`, or `sec=krb5p`, depending on the setup) to the mount options:

   # mount -o sec=krb5 server:/export /mnt

Additional resources

- If you need to write files as root on the Kerberos-secured NFS share and keep root ownership on these files, see https://access.redhat.com/articles/4040141. Note that this configuration is not recommended.

- For more information on NFS configuration, see the `exports(5)` and `nfs(5)` man pages.

5.4. NFSv4 SECURITY OPTIONS

NFSv4 includes ACL support based on the Microsoft Windows NT model, not the POSIX model, because of the Microsoft Windows NT model’s features and wide deployment.

Another important security feature of NFSv4 is the removal of the use of the `MOUNT` protocol for mounting file systems. The `MOUNT` protocol presented a security risk because of the way the protocol processed file handles.

5.5. FILE PERMISSIONS ON MOUNTED NFS EXPORTS

Once the NFS file system is mounted as either read or read and write by a remote host, the only protection each shared file has is its permissions. If two users that share the same user ID value mount the same NFS file system on different client systems, they can modify each others’ files. Additionally,
anyone logged in as root on the client system can use the `su -` command to access any files with the NFS share.

By default, access control lists (ACLs) are supported by NFS under Red Hat Enterprise Linux. Red Hat recommends to keep this feature enabled.

By default, NFS uses *root squashing* when exporting a file system. This sets the user ID of anyone accessing the NFS share as the root user on their local machine to *nobody*. Root squashing is controlled by the default option `root_squash`; for more information about this option, see Section 4.6, “NFS server configuration”.

When exporting an NFS share as read-only, consider using the `all_squash` option. This option makes every user accessing the exported file system take the user ID of the *nobody* user.
CHAPTER 6. ENABLING PNFS SCSI LAYOUTS IN NFS

You can configure the NFS server and client to use the pNFS SCSI layout for accessing data. pNFS SCSI is beneficial in use cases that involve longer-duration single-client access to a file.

Prerequisites

- Both the client and the server must be able to send SCSI commands to the same block device. That is, the block device must be on a shared SCSI bus.
- The block device must contain an XFS file system.
- The SCSI device must support SCSI Persistent Reservations as described in the SCSI-3 Primary Commands specification.

6.1. THE PNFS TECHNOLOGY

The pNFS architecture improves the scalability of NFS. When a server implements pNFS, the client is able to access data through multiple servers concurrently. This can lead to performance improvements.

pNFS supports the following storage protocols or layouts on RHEL:

- Files
- Flexfiles
- SCSI

6.2. PNFS SCSI LAYOUTS

The SCSI layout builds on the work of pNFS block layouts. The layout is defined across SCSI devices. It contains a sequential series of fixed-size blocks as logical units (LUs) that must be capable of supporting SCSI persistent reservations. The LU devices are identified by their SCSI device identification.

pNFS SCSI performs well in use cases that involve longer-duration single-client access to a file. An example might be a mail server or a virtual machine housing a cluster.

Operations between the client and the server

When an NFS client reads from a file or writes to it, the client performs a LAYOUTGET operation. The server responds with the location of the file on the SCSI device. The client might need to perform an additional operation of GETDEVICEINFO to determine which SCSI device to use. If these operations work correctly, the client can issue I/O requests directly to the SCSI device instead of sending READ and WRITE operations to the server.

Errors or contention between clients might cause the server to recall layouts or not issue them to the clients. In those cases, the clients fall back to issuing READ and WRITE operations to the server instead of sending I/O requests directly to the SCSI device.

To monitor the operations, see Section 6.7, “Monitoring pNFS SCSI layouts functionality”.

Device reservations

pNFS SCSI handles fencing through the assignment of reservations. Before the server issues layouts to clients, it reserves the SCSI device to ensure that only registered clients may access the device. If a client can issue commands to that SCSI device but is not registered with the device, many operations
from the client on that device fail. For example, the `blkid` command on the client fails to show the UUID of the XFS file system if the server has not given a layout for that device to the client.

The server does not remove its own persistent reservation. This protects the data within the file system on the device across restarts of clients and servers. In order to repurpose the SCSI device, you might need to manually remove the persistent reservation on the NFS server.

6.3. CHECKING FOR A SCSI DEVICE COMPATIBLE WITH PNFS

This procedure checks if a SCSI device supports the pNFS SCSI layout.

**Prerequisites**

- Install the `sg3_utils` package:

```
# yum install sg3_utils
```

**Procedure**

- On both the server and client, check for the proper SCSI device support:

```
# sg_persist --in --report-capabilities --verbose path-to-scsi-device
```

Ensure that the `Persist Through Power Loss Active (PTPL_A)` bit is set.

**Example 6.1. A SCSI device that supports pNFS SCSI**

The following is an example of `sg_persist` output for a SCSI device that supports pNFS SCSI. The `PTPL_A` bit reports 1.

```
iquiry cdb: 12 00 00 00 24 00
  Persistent Reservation In cmd: 5e 02 00 00 00 00 00 20 00 00
LIO-ORG block11  4.0
Peripheral device type: disk
Report capabilities response:
  Compatible Reservation Handling(CRH): 1
  Specify Initiator Ports Capable(SIP_C): 1
  All Target Ports Capable(ATP_C): 1
  Persist Through Power Loss Capable(PTPL_C): 1
  Type Mask Valid(TMV): 1
  Allow Commands: 1
  Persist Through Power Loss Active(PTPL_A): 1
Support indicated in Type mask:
  Write Exclusive, all registrants: 1
  Exclusive Access, registrants only: 1
  Write Exclusive, registrants only: 1
  Exclusive Access: 1
  Write Exclusive: 1
  Exclusive Access, all registrants: 1
```

**Additional resources**
6.4. SETTING UP PNFS SCSI ON THE SERVER

This procedure configures an NFS server to export a pNFS SCSI layout.

Procedure

1. On the server, mount the XFS file system created on the SCSI device.

2. Configure the NFS server to export NFS version 4.1 or higher. Set the following option in the `[nfsd]` section of the `/etc/nfs.conf` file:

   ```
   [nfsd]
   vers4.1=y
   ```

3. Configure the NFS server to export the XFS file system over NFS with the `pnfs` option:

   Example 6.2. An entry in `/etc/exports` to export pNFS SCSI

   The following entry in the `/etc/exports` configuration file exports the file system mounted at `/exported/directory/` to the `allowed.example.com` client as a pNFS SCSI layout:

   ```
   /exported/directory allowed.example.com(pnfs)
   ```

Additional resources

- For more information on configuring an NFS server, see Chapter 4, Exporting NFS shares.

6.5. SETTING UP PNFS SCSI ON THE CLIENT

This procedure configures an NFS client to mount a pNFS SCSI layout.

Prerequisites

- The NFS server is configured to export an XFS file system over pNFS SCSI. See Section 6.4, “Setting up pNFS SCSI on the server”.

Procedure

1. On the client, mount the exported XFS file system using NFS version 4.1 or higher:

   ```
   # mount -t nfs -o nfsvers=4.1 host:remote/export /local/directory
   ```

   Do not mount the XFS file system directly without NFS.

Additional resources

- For more information on mounting NFS shares, see Mounting NFS shares.
6.6. RELEASING THE PNFS SCSI RESERVATION ON THE SERVER

This procedure releases the persistent reservation that an NFS server holds on a SCSI device. This enables you to repurpose the SCSI device when you no longer need to export pNFS SCSI.

You must remove the reservation from the server. It cannot be removed from a different IT Nexus.

Prerequisites

- Install the `sg3_utils` package:

  ```sh
  # yum install sg3_utils
  ```

Procedure

1. Query an existing reservation on the server:

   ```sh
   # sg_persist --read-reservation path-to-scsi-device
   ```

   **Example 6.3. Querying a reservation on /dev/sda**

   ```sh
   # sg_persist --read-reservation /dev/sda
   LIO-ORG  block_1  4.0
   Peripheral device type: disk
   PR generation=0x8, Reservation follows:
   Key=0x1000000000000000
   scope: LU_SCOPE, type: Exclusive Access, registrants only
   ```

2. Remove the existing registration on the server:

   ```sh
   # sg_persist --out "
   --release 
   --param-rk=reservation-key 
   --prout-type=6 
   path-to-scsi-device"
   ```

   **Example 6.4. Removing a reservation on /dev/sda**

   ```sh
   # sg_persist --out "
   --release 
   --param-rk=0x1000000000000000 
   --prout-type=6 
   /dev/sda"
   LIO-ORG  block_1  4.0
   Peripheral device type: disk
   ```

Additional resources
The `sgPersist(8)` man page

6.7. MONITORING PNFS SCSI LAYOUTS FUNCTIONALITY

You can monitor if the pNFS client and server exchange proper pNFS SCSI operations or if they fall back on regular NFS operations.

Prerequisites

- A pNFS SCSI client and server are configured.

6.7.1. Checking pNFS SCSI operations from the server using `nfsstat`

This procedure uses the `nfsstat` utility to monitor pNFS SCSI operations from the server.

Procedure

1. Monitor the operations serviced from the server:

```
# watch --differences "nfsstat --server | egrep --after-context=1 read\|write\|layout"
```

Every 2.0s: `nfsstat --server | egrep --after-context=1 read\|write\|layout`

```
putrootfh    read         readdir      readlink     remove  rename
2         0% 0         0% 1         0% 0         0% 0         0% 0         0%
--
setcltidconf verify   write        rellockowner bc_ctl bind_conn
0         0% 0         0% 0         0% 0         0% 0         0% 0         0%
--
getdevlist   layoutcommit layoutget    layoutreturn secinfononam sequence
0         0% 29        1% 49        1% 5         0% 0         0% 2435     86%
```

2. The client and server use pNFS SCSI operations when:

- The `layoutget`, `layoutreturn`, and `layoutcommit` counters increment. This means that the server is serving layouts.
- The server read and write counters do not increment. This means that the clients are performing I/O requests directly to the SCSI devices.

6.7.2. Checking pNFS SCSI operations from the client using `mountstats`

This procedure uses the `/proc/self/mountstats` file to monitor pNFS SCSI operations from the client.

Procedure

1. List the per-mount operation counters:

```
# cat /proc/self/mountstats \ 
  | awk /scsi_lun_0/,/^$/ \ 
  | egrep device\|READ\|WRITE\|LAYOUT

device 192.168.122.73:/exports/scsi_lun_0 mounted on /mnt/rhel7/scsi_lun_0 with fstype
```
nfs4 statvers=1.1
nfsv4:
bm0=0xfdffbff,bm1=0x40f9be3e,bm2=0x803,acl=0x3,sessions,pnfs=LAYOUT_SCSI
   READ: 0 0 0 0 0 0 0 0
   WRITE: 0 0 0 0 0 0 0 0
   READLINK: 0 0 0 0 0 0 0 0
   READDIR: 0 0 0 0 0 0 0 0
   LAYOUTGET: 49 49 0 11172 9604 2 19448 19454
   LAYOUTCOMMIT: 28 28 0 7776 4808 0 24719 24722
   LAYOUTRETURN: 0 0 0 0 0 0 0 0
   LAYOUTSTATS: 0 0 0 0 0 0 0 0

2. In the results:
   - The LAYOUT statistics indicate requests where the client and server use pNFS SCSI operations.
   - The READ and WRITE statistics indicate requests where the client and server fall back to NFS operations.
CHAPTER 7. CONFIGURING THE SQUID CACHING PROXY SERVER

Squid is a proxy server that caches content to reduce bandwidth and load web pages more quickly. This chapter describes how to set up Squid as a proxy for the HTTP, HTTPS, and FTP protocol, as well as authentication and restricting access.

7.1. SETTING UP SQUID AS A CACHING PROXY WITHOUT AUTHENTICATION

This section describes a basic configuration of Squid as a caching proxy without authentication. The procedure limits access to the proxy based on IP ranges.

Prerequisites

- The procedure assumes that the `/etc/squid/squid.conf` file is as provided by the `squid` package. If you edited this file before, remove the file and reinstall the package.

Procedure

1. Install the `squid` package:

   ```
   # yum install squid
   ```

2. Edit the `/etc/squid/squid.conf` file:

   a. Adapt the `localnet` access control lists (ACL) to match the IP ranges that should be allowed to use the proxy:

   ```
   acl localnet src 192.0.2.0/24
   acl localnet 2001:db8:1::/64
   ```

   By default, the `/etc/squid/squid.conf` file contains the `http_access allow localnet` rule that allows using the proxy from all IP ranges specified in `localnet` ACLs. Note that you must specify all `localnet` ACLs before the `http_access allow localnet` rule.

   IMPORTANT

   Remove all existing `acl localnet` entries that do not match your environment.

   b. The following ACL exists in the default configuration and defines 443 as a port that uses the HTTPS protocol:

   ```
   acl SSL_ports port 443
   ```

   If users should be able to use the HTTPS protocol also on other ports, add an ACL for each of these port:

   ```
   acl SSL_ports port port_number
   ```

   c. Update the list of `acl Safe_ports` rules to configure to which ports Squid can establish a connection. For example, to configure that clients using the proxy can only access
resources on port 21 (FTP), 80 (HTTP), and 443 (HTTPS), keep only the following \texttt{acl Safe\_ports} statements in the configuration:

\begin{verbatim}
  acl Safe_ports port 21
  acl Safe_ports port 80
  acl Safe_ports port 443
\end{verbatim}

By default, the configuration contains the \texttt{http\_access deny !Safe\_ports} rule that defines access denial to ports that are not defined in \texttt{Safe\_ports} ACLs.

d. Configure the cache type, the path to the cache directory, the cache size, and further cache type-specific settings in the \texttt{cache\_dir} parameter:

\begin{verbatim}
  cache\_dir ufs /var/spool/squid 10000 16 256
\end{verbatim}

With these settings:

- Squid uses the \texttt{ufs} cache type.
- Squid stores its cache in the \texttt{/var/spool/squid/} directory.
- The cache grows up to \texttt{10000 MB}.
- Squid creates \texttt{16} level-1 sub-directories in the \texttt{/var/spool/squid/} directory.
- Squid creates \texttt{256} sub-directories in each level-1 directory.
  If you do not set a \texttt{cache\_dir} directive, Squid stores the cache in memory.

3. If you set a different cache directory than \texttt{/var/spool/squid/} in the \texttt{cache\_dir} parameter:

   a. Create the cache directory:

   \begin{verbatim}
   # mkdir -p path\_to\_cache\_directory
   \end{verbatim}

   b. Configure the permissions for the cache directory:

   \begin{verbatim}
   # chown squid:squid path\_to\_cache\_directory
   \end{verbatim}

   c. If you run SELinux in \texttt{enforcing} mode, set the \texttt{squid\_cache\_t} context for the cache directory:

   \begin{verbatim}
   # semanage fcontext -a -t squid_cache_t "path\_to\_cache\_directory/(.\*)?"
   # restorecon -Rv path\_to\_cache\_directory
   \end{verbatim}

   If the \texttt{semanage} utility is not available on your system, install the \texttt{policycoreutils-python-utils} package.

4. Open the \texttt{3128} port in the firewall:

\begin{verbatim}
# firewall-cmd --permanent --add-port=3128/tcp
# firewall-cmd --reload
\end{verbatim}

5. Enable and start the \texttt{squid} service:

\begin{verbatim}
# systemctl enable --now squid
\end{verbatim}
Verification steps
To verify that the proxy works correctly, download a web page using the curl utility:

```
# curl -O -L "https://www.redhat.com/index.html" -x "proxy.example.com:3128"
```

If curl does not display any error and the index.html file was downloaded to the current directory, the proxy works.

7.2. SETTING UP SQUID AS A CACHING PROXY WITH LDAP AUTHENTICATION

This section describes a basic configuration of Squid as a caching proxy that uses LDAP to authenticate users. The procedure configures that only authenticated users can use the proxy.

Prerequisites

- The procedure assumes that the /etc/squid/squid.conf file is as provided by the squid package. If you edited this file before, remove the file and reinstall the package.

- An service user, such as uid=proxy_user,cn=users,cn=accounts,dc=example,dc=com exists in the LDAP directory. Squid uses this account only to search for the authenticating user. If the authenticating user exists, Squid binds as this user to the directory to verify the authentication.

Procedure

1. Install the squid package:

```
# yum install squid
```

2. Edit the /etc/squid/squid.conf file:

   a. To configure the basic_ldap_auth helper utility, add the following configuration entry to the top of /etc/squid/squid.conf:

   ```
   auth_param basic program /usr/lib64/squid/basic_ldap_auth -b "cn=users,dc=example,dc=com" -D "uid=proxy_user,cn=users,dc=example,dc=com" -W /etc/squid/ldap_password -f "(&(objectClass=person)(uid=%s))" -ZZ -H ldap://ldap_server.example.com:389
   ```

   The following describes the parameters passed to the basic_ldap_auth helper utility in the example above:

   - **-B base_DN** sets the LDAP search base.

   - **-D proxy_service_user_DN** sets the distinguished name (DN) of the account Squid uses to search for the authenticating user in the directory.

   - **-W path_to_password_file** sets the path to the file that contains the password of the proxy service user. Using a password file prevents that the password is visible in the operating system’s process list.
- **LDAP_filter** specifies the LDAP search filter. Squid replaces the `%s` variable with the user name provided by the authenticating user. The `(&(objectClass=person)(uid=%s))` filter in the example defines that the user name must match the value set in the `uid` attribute and that the directory entry contains the `person` object class.

- `-ZZ` enforces a TLS-encrypted connection over the LDAP protocol using the `STARTTLS` command. Omit the `-ZZ` in the following situations:
  - The LDAP server does not support encrypted connections.
  - The port specified in the URL uses the LDAPS protocol.

- The `-H LDAP_URL` parameter specifies the protocol, the host name or IP address, and the port of the LDAP server in URL format.

b. Add the following ACL and rule to configure that Squid allows only authenticated users to use the proxy:

```
acl ldap-auth proxy_auth REQUIRED
http_access allow ldap-auth
```

**IMPORTANT**

Specify these settings before the `http_access deny` rule.

c. Remove the following rule to disable bypassing the proxy authentication from IP ranges specified in `localnet` ACLs:

```
http_access allow localnet
```

d. The following ACL exists in the default configuration and defines `443` as a port that uses the HTTPS protocol:

```
 acl SSL_ports port 443
```

If users should be able to use the HTTPS protocol also on other ports, add an ACL for each of these port:

```
 acl SSL_ports port port_number
```

e. Update the list of `acl Safe_ports` rules to configure to which ports Squid can establish a connection. For example, to configure that clients using the proxy can only access resources on port 21 (FTP), 80 (HTTP), and 443 (HTTPS), keep only the following `acl Safe_ports` statements in the configuration:

```
 acl Safe_ports port 21
 acl Safe_ports port 80
 acl Safe_ports port 443
```

By default, the configuration contains the `http_access deny !Safe_ports` rule that defines access denial to ports that are not defined in `Safe_ports` ACLs.
f. Configure the cache type, the path to the cache directory, the cache size, and further cache type-specific settings in the `cache_dir` parameter:

```
  cache_dir ufs /var/spool/squid 10000 16 256
```

With these settings:

- Squid uses the `ufs` cache type.
- Squid stores its cache in the `/var/spool/squid/` directory.
- The cache grows up to 10000 MB.
- Squid creates 16 level-1 sub-directories in the `/var/spool/squid/` directory.
- Squid creates 256 sub-directories in each level-1 directory.

If you do not set a `cache_dir` directive, Squid stores the cache in memory.

3. If you set a different cache directory than `/var/spool/squid/` in the `cache_dir` parameter:

   a. Create the cache directory:

      ```
      # mkdir -p path_to_cache_directory
      ```

   b. Configure the permissions for the cache directory:

      ```
      # chown squid:squid path_to_cache_directory
      ```

   c. If you run SELinux in enforcing mode, set the `squid_cache_t` context for the cache directory:

      ```
      # semanage fcontext -a -t squid_cache_t "path_to_cache_directory(/.*)?"
      # restorecon -Rv path_to_cache_directory
      ```

      If the `semanage` utility is not available on your system, install the `policycoreutils-python-utils` package.

4. Store the password of the LDAP service user in the `/etc/squid/ldap_password` file, and set appropriate permissions for the file:

   ```
   # echo "password" > /etc/squid/ldap_password
   # chown root:squid /etc/squid/ldap_password
   # chmod 640 /etc/squid/ldap_password
   ```

5. Open the 3128 port in the firewall:

   ```
   # firewall-cmd --permanent --add-port=3128/tcp
   # firewall-cmd --reload
   ```

6. Enable and start the `squid` service:

   ```
   # systemctl enable --now squid
   ```

Verification steps
To verify that the proxy works correctly, download a web page using the `curl` utility:

```
# curl -O -L "https://www.redhat.com/index.html" -x "user_name:password@proxy.example.com:3128"
```

If curl does not display any error and the `index.html` file was downloaded to the current directory, the proxy works.

**Troubleshooting steps**

To verify that the helper utility works correctly:

1. Manually start the helper utility with the same settings you used in the `auth_param` parameter:

   ```
   # /usr/lib64/squid/basic_ldap_auth -b "cn=users,cn=accounts,dc=example,dc=com" -D "uid=proxy_user,cn=users,cn=accounts,dc=example,dc=com" -W /etc/squid/ldap_password -f "(&(objectClass=person)(uid=%s))" -ZZ -H ldap://ldap_server.example.com:389
   ```

2. Enter a valid user name and password, and press Enter:

   ```
   user_name password
   ```

   If the helper utility returns `OK`, authentication succeeded.

### 7.3. SETTING UP SQUID AS A CACHING PROXY WITH KERBEROS AUTHENTICATION

This section describes a basic configuration of Squid as a caching proxy that authenticates users to an Active Directory (AD) using Kerberos. The procedure configures that only authenticated users can use the proxy.

**Prerequisites**

- The procedure assumes that the `/etc/squid/squid.conf` file is as provided by the `squid` package. If you edited this file before, remove the file and reinstall the package.

- The server on which you want to install Squid is a member of the AD domain. For details, see Setting up Samba as a Domain Member in the Red Hat Enterprise Linux 8 Deploying different types of servers documentation.

**Procedure**

1. Install the following packages:

   ```
   yum install squid krb5-workstation
   ```

2. Authenticate as the AD domain administrator:

   ```
   # kinit administrator@AD.EXAMPLE.COM
   ```

3. Create a keytab for Squid and store it in the `/etc/squid/HTTP.keytab` file:
# export KRB5_KTNAME=FILE:/etc/squid/HTTP.keytab
# net ads keytab CREATE -U administrator

4. Add the HTTP service principal to the keytab:

   # net ads keytab ADD HTTP -U administrator

5. Set the owner of the keytab file to the squid user:

   # chown squid /etc/squid/HTTP.keytab

6. Optionally, verify that the keytab file contains the HTTP service principal for the fully-qualified domain name (FQDN) of the proxy server:

   # klist -k /etc/squid/HTTP.keytab
   Keytab name: FILE:/etc/squid/HTTP.keytab
   KVNO Principal
   ---- ---------------------------------------------------
   ...
   2 HTTP/proxy.ad.example.com@AD.EXAMPLE.COM
   ...

7. Edit the /etc/squid/squid.conf file:

   a. To configure the `negotiate_kerberos_auth` helper utility, add the following configuration entry to the top of /etc/squid/squid.conf:

      ```
      auth_param negotiate program /usr/lib64/squid/negotiate_kerberos_auth -k
      /etc/squid/HTTP.keytab -s HTTP/proxy.ad.example.com@AD.EXAMPLE.COM
      ```

      The following describes the parameters passed to the `negotiate_kerberos_auth` helper utility in the example above:

      - `-k file` sets the path to the key tab file. Note that the squid user must have read permissions on this file.
      - `-s HTTP/host_name@kerberos_realm` sets the Kerberos principal that Squid uses. Optionally, you can enable logging by passing one or both of the following parameters to the helper utility:
        - `-i` logs informational messages, such as the authenticating user.
        - `-d` enables debug logging. Squid logs the debugging information from the helper utility to the `/var/log/squid/cache.log` file.

   b. Add the following ACL and rule to configure that Squid allows only authenticated users to use the proxy:

      ```
      acl kerb-auth proxy_auth REQUIRED
      http_access allow kerb-auth
      ```
IMPORTANT

Specify these settings before the `http_access deny all` rule.

c. Remove the following rule to disable bypassing the proxy authentication from IP ranges specified in `localnet` ACLs:

```plaintext
http_access allow localnet
```

d. The following ACL exists in the default configuration and defines 443 as a port that uses the HTTPS protocol:

```plaintext
acl SSL_ports port 443
```

If users should be able to use the HTTPS protocol also on other ports, add an ACL for each of these port:

```plaintext
acl SSL_ports port port_number
```

e. Update the list of `acl Safe_ports` rules to configure to which ports Squid can establish a connection. For example, to configure that clients using the proxy can only access resources on port 21 (FTP), 80 (HTTP), and 443 (HTTPS), keep only the following `acl Safe_ports` statements in the configuration:

```plaintext
acl Safe_ports port 21
acl Safe_ports port 80
acl Safe_ports port 443
```

By default, the configuration contains the `http_access deny !Safe_ports` rule that defines access denial to ports that are not defined in `Safe_ports` ACLs.

f. Configure the cache type, the path to the cache directory, the cache size, and further cache type-specific settings in the `cache_dir` parameter:

```plaintext
cache_dir ufs /var/spool/squid 10000 16 256
```

With these settings:

- Squid uses the `ufs` cache type.
- Squid stores its cache in the `/var/spool/squid/` directory.
- The cache grows up to 10000 MB.
- Squid creates 16 level-1 sub-directories in the `/var/spool/squid/` directory.
- Squid creates 256 sub-directories in each level-1 directory.

If you do not set a `cache_dir` directive, Squid stores the cache in memory.

8. If you set a different cache directory than `/var/spool/squid/` in the `cache_dir` parameter:

   a. Create the cache directory:

   ```plaintext
   # mkdir -p path_to_cache_directory
   ```
b. Configure the permissions for the cache directory:

```
# chown squid:squid path_to_cache_directory
```

c. If you run SELinux in enforcing mode, set the squid_cache_t context for the cache directory:

```
# semanage fcontext -a -t squid_cache_t "path_to_cache_directory(\.*?)"
# restorecon -Rv path_to_cache_directory
```

If the semanage utility is not available on your system, install the policycoreutils-python-utils package.

9. Open the 3128 port in the firewall:

```
# firewall-cmd --permanent --add-port=3128/tcp
# firewall-cmd --reload
```

10. Enable and start the squid service:

```
# systemctl enable --now squid
```

Verification steps

To verify that the proxy works correctly, download a web page using the curl utility:

```
# curl -O -L "https://www.redhat.com/index.html" --proxy-negotiate -u : -x "proxy.ad.example.com:3128"
```

If curl does not display any error and the index.html file exists in the current directory, the proxy works.

Troubleshooting steps

To manually test Kerberos authentication:

1. Obtain a Kerberos ticket for the AD account:

```
# kinit user@AD.EXAMPLE.COM
```

2. Optionally, display the ticket:

```
# klist
```

3. Use the negotiate_kerberos_auth_test utility to test the authentication:

```
#/usr/lib64/squid/negotiate_kerberos_auth_test proxy.ad.example.com
```

If the helper utility returns a token, the authentication succeeded:

```
Token: YIIFtAYGKwYBBQUcoIFqDC...
```

7.4. CONFIGURING A DOMAIN BLACKLIST IN SQUID
Frequently, administrators want to block access to specific domains. This section describes how to configure a domain blacklist in Squid.

**Prerequisites**

- Squid is configured, and users can use the proxy.

**Procedure**

1. Edit the `/etc/squid/squid.conf` file and add the following settings:
   
   ```
   acl domain_blacklist dstdomain "/etc/squid/domain_blacklist.txt"
   http_access deny all domain_blacklist
   ```

   **IMPORTANT**
   
   Add these entries before the first `http_access allow` statement that allows access to users or clients.

2. Create the `/etc/squid/domain_blacklist.txt` file and add the domains you want to block. For example, to block access to `example.com` including subdomains and to block `example.net`, add:
   
   ```
   .example.com
   example.net
   ```

   **IMPORTANT**
   
   If you referred to the `/etc/squid/domain_blacklist.txt` file in the squid configuration, this file must not be empty. If the file is empty, Squid fails to start.

3. Restart the `squid` service:
   
   ```
   # systemctl restart squid
   ```

**7.5. CONFIGURING THE SQUID SERVICE TO LISTEN ON A SPECIFIC PORT OR IP ADDRESS**

By default, the Squid proxy service listens on the **3128** port on all network interfaces. This section describes how to change the port and configuring Squid to listen on a specific IP address.

**Prerequisites**

- The `squid` package is installed.

**Procedure**

1. Edit the `/etc/squid/squid.conf` file:
   
   ```
   http_port 8080
   ```

   **IMPORTANT**
   
   To set the port on which the Squid service listens, set the port number in the `http_port` parameter. For example, to set the port to **8080**, set:
To configure on which IP address the Squid service listens, set the IP address and port number in the `http_port` parameter. For example, to configure that Squid listens only on the `192.0.2.1` IP address on port `3128`, set:

```
http_port 192.0.2.1:3128
```

Add multiple `http_port` parameters to the configuration file to configure that Squid listens on multiple ports and IP addresses:

```
http_port 192.0.2.1:3128
http_port 192.0.2.1:8080
```

2. If you configured that Squid uses a different port as the default (`3128`):
   a. Open the port in the firewall:
      ```
      # firewall-cmd --permanent --add-port=port_number/tcp
      # firewall-cmd --reload
      ```
   b. If you run SELinux in enforcing mode, assign the port to the `squid_port_t` port type definition:
      ```
      # semanage port -a -t squid_port_t -p tcp port_number
      ```
      If the `semanage` utility is not available on your system, install the `policycoreutils-python-utils` package.

3. Restart the `squid` service:
   ```
   # systemctl restart squid
   ```

### 7.6. ADDITIONAL RESOURCES

- See the `usr/share/doc/squid-<version>/squid.conf.documented` file for a list of all configuration parameters you can set in the `/etc/squid/squid.conf` file together with a detailed description.
8.1. INTRODUCTION TO DATABASE SERVERS

A database server is a hardware device which has a certain amount of main memory, and a database (DB) application installed. This DB application provides services as a means of writing the cached data from the main memory, which is usually small and expensive, to DB files (database). These services are provided to multiple clients on a network. There can be as many DB servers as a machine’s main memory and storage allows.

Red Hat Enterprise Linux 8 provides the following database applications:

- MariaDB 10.3
- MySQL 8.0
- PostgreSQL 10
- PostgreSQL 9.6
- PostgreSQL 12 - available since RHEL 8.1.1

8.2. USING MARIADB

8.2.1. Getting started with MariaDB

The MariaDB server is an open source fast and robust database server that is based on MySQL technology.

MariaDB is a relational database which converts data into structured information and provides an SQL interface for accessing data. It includes multiple storage engines and plug-ins, as well as geographic information system (GIS) and JavaScript Object Notation (JSON) features.

This section describes how to install the MariaDB server in Installing MariaDB or how to migrate from the Red Hat Enterprise Linux 7 default version, MariaDB 5.5, to the Red Hat Enterprise Linux 8 default version, MariaDB 10.3, in Migrating to MariaDB 10.3, and also how to back up MariaDB data. Performing data backup is one of the prerequisites for MariaDB migration.

8.2.2. Installing MariaDB

To install MariaDB, follow this procedure:

1. Ensure that all necessary packages for MariaDB server are available on the system by installing the mariadb module using a specific stream:

   # yum module install mariadb:10.3/server

2. Start the mariadb service:

   # systemctl start mariadb.service

3. Enable the mariadb service to start at boot:
NOTE

Note that the MariaDB and MySQL database servers cannot be installed in parallel in Red Hat Enterprise Linux 8.0 due to conflicting RPM packages. Parallel installation of components is possible in Red Hat Software Collections for Red Hat Enterprise Linux 6 and Red Hat Enterprise Linux 7. In Red Hat Enterprise Linux 8, different versions of database servers can be used in containers.

8.2.2.1. Improving MariaDB installation security

To improve security when installing MariaDB, run the following command.

```
# mysql_secure_installation
```

The command launches a fully interactive script, which prompts for each step in the process.

---

8.2.3. Configuring MariaDB

8.2.3.1. Configuring the MariaDB server for networking

To configure the MariaDB server for networking, use the [mysqld] section of the /etc/my.cnf.d/mariadb-server.cnf file, where you can set the following configuration directives:

- **bind-address**
  Bind-address is the address on which the server will listen.
  Possible options are: a host name, an IPv4 address, or an IPv6 address.

- **skip-networking**
  Possible values are:
  - 0 - to listen for all clients
  - 1 - to listen for local clients only

- **port**
  The port on which MariaDB listens for TCP/IP connections.

8.2.4. Backing up MariaDB data

There are two main ways to back up data from a MariaDB database:

- Logical backup
Logical backup consists of the SQL statements necessary to restore the data. This type of backup exports information and records in plain text files.

The main advantage of logical backup over physical backup is portability and flexibility. The data can be restored on other hardware configurations, MariaDB versions or Database Management System (DBMS), which is not possible with physical backups.

Note that logical backup can be performed if the mariadb.service is running. Logical backup does not include log and configuration files.

Physical backup consists of copies of files and directories that store the content.

Physical backup has the following advantages compared to logical backup:

- Output is more compact.
- Backup is smaller in size.
- Backup and restore are faster.
- Backup includes log and configuration files.

Note that physical backup must be performed when the mariadb.service is not running or all tables in the database are locked to prevent changes during the backup.

You can use one of the following MariaDB backup approaches to back up data from a MariaDB database:

- Logical backup with mysqldump
- Physical online backup using the Mariabackup tool
- File system backup
- Replication as a backup solution

8.2.4.1. Performing logical backup with mysqldump

The mysqldump client is a backup utility, which can be used to dump a database or a collection of databases for the purpose of a backup or transfer to another database server. The output of mysqldump typically consists of SQL statements to re-create the server table structure, populate it with data, or both. Alternatively, mysqldump can also generate files in other formats, including CSV or other delimited text formats, and XML.

To perform the mysqldump backup, you can use one of the following options:

- Back up a selected database
- Back up a subset of tables from one database
- Back up multiple databases
- Back up all databases

8.2.4.1.1. Backing up an entire database with mysqldump
Procedure

- To back up an entire database, run:
  
  ```
  # mysqldump [options] db_name > backup-file.sql
  ```

8.2.4.1.2. Using mysqldump to back up a set of tables from one database

Procedure

- To back up a subset of tables from one database, add a list of the chosen tables at the end of the `mysqldump` command:
  
  ```
  # mysqldump [options] db_name [tbl_name ...]
  ```

8.2.4.1.3. Using mysqldump to load the dump file back into a server

Procedure

- To load the dump file back into a server, use either of these:
  
  ```
  # mysql db_name < backup-file.sql
  
  # mysql -e "source /path-to-backup/backup-file.sql" db_name
  ```

8.2.4.1.4. Using mysqldump to copy data between two databases

Procedure

- To populate databases by copying data from one MariaDB server to another, run:
  
  ```
  # mysqldump --opt db_name | mysql --host=remote_host -C db_name
  ```

8.2.4.1.5. Dumping multiple databases with mysqldump

Procedure

- To dump multiple databases at once, run:
  
  ```
  # mysqldump [options] --databases db_name1 [db_name2 ...] > my_databases.sql
  ```

8.2.4.1.6. Dumping all databases with mysqldump

Procedure

- To dump all databases, run:
  
  ```
  # mysqldump [options] --all-databases > all_databases.sql
  ```
8.2.4.1.7. Reviewing mysqldump options

Procedure

- To see a list of the options that mysqldump supports, run:

  $ mysqldump --help

8.2.4.1.8. Additional resources

For more information on logical backup with mysqldump, see the MariaDB Documentation.

8.2.4.2. Performing physical online backup using the Mariabackup tool

Mariabackup is a tool based on the Percona XtraBackup technology, which enables performing physical online backups of InnoDB, Aria, and MyISAM tables.

Mariabackup, provided by the mariadb-backup package from the AppStream repository, supports full backup capability for MariaDB server, which includes encrypted and compressed data.

Prerequisites

- The mariadb-backup package is installed on the system:

  # yum install mariadb-backup

- Mariabackup needs to be provided with credentials for the user by which the backup will be run. You can either provide the credentials on the command line, as shown in the procedure, or by a configuration file before applying the procedure. To set the credentials using the configuration file, first create the file (for example, /etc/my.cnf.d/mariabackup.cnf), and then add the following lines into the [xtrabackup] or [mysqld] section of the new file:

  [xtrabackup]
  user=myuser
  password=mypassword

IMPORTANT

Mariabackup does not read options in the [mariadb] section of configuration files. If a non-default data directory is specified on a MariaDB server, you must specify this directory in the [xtrabackup] or [mysqld] sections of configuration files, so that Mariabackup is able to find the data directory.

To specify such a data directory, include the following line in the [xtrabackup] or [mysqld] sections of MariaDB configuration files:

  datadir=/var/mycustomdatadir

NOTE

Users of Mariabackup must have the RELOAD, LOCK TABLES, and REPLICATION CLIENT privileges to be able to work with the backup.
To create a backup of a database using **Mariabackup**, use the following procedure:

**Procedure**

- Run the following command:

  ```
  $ mariabackup --backup --target-dir <backup_directory> --user <backup_user> --password <backup_passwd>
  ```

  The **target-dir** option defines the directory where the backup files are stored. If you want to perform a full backup, the target directory must be empty or not exist.

  The **user** and **password** options allow you to configure the user name and the password. Do not use these options if you already configured the user name and the password in the configuration file as described in prerequisites.

**Additional resources**

For more information on performing backups with **Mariabackup**, see [Full Backup and Restore with Mariabackup](#).

### 8.2.4.3. Restoring data using the Mariabackup tool

When the backup is complete, you can restore the data from the backup by using the **mariabackup** command with one of the following options:

- **--copy-back**
- **--move-back**

The **--copy-back** option allows you to keep the original backup files. The **--move-back** option moves the backup files to the data directory, and removes the original backup files.

**Prerequisites**

- Make sure that the **mariadb** service is not running:

  ```
  # systemctl stop mariadb.service
  ```

- Make sure that the data directory is empty.

#### 8.2.4.3.1. Restoring data with Mariabackup while keeping the backup files

To restore the data while keeping the original backup files, use the following procedure.

**Procedure**

1. Run the **mariabackup** command with the **--copy-back** option:

   ```
   $ mariabackup --copy-back --target-dir=/var/mariadb/backup/
   ```

2. Fix the file permissions.
   When restoring a database, **Mariabackup** preserves the file and directory privileges of the backup. However, **Mariabackup** writes the files to disk as the user and group restoring the
database. Consequently, after restoring a backup, you may need to adjust the owner of the data directory to match the user and group for the MariaDB Server, typically mysql for both.

For example, to recursively change ownership of the files to the mysql user and group:

```
# chown -R mysql:mysql /var/lib/mysql/
```

3. Start the mariadb service:

```
# systemctl start mariadb.service
```

8.2.4.3.2. Restoring data with Mariabackup while removing the backup files

To restore the data, and not keep the original backup files, use the following procedure.

Procedure

1. Run the mariabackup command with the --move-back option:

   ```
   $ mariabackup --move-back --target-dir=/var/mariadb/backup/
   ```

2. Fix the file permissions.

   When restoring a database, Mariabackup preserves the file and directory privileges of the backup. However, Mariabackup writes the files to disk as the user and group restoring the database. Consequently, after restoring a backup, you may need to adjust the owner of the data directory to match the user and group for the MariaDB Server, typically mysql for both.

   For example, to recursively change ownership of the files to the mysql user and group:

   ```
   # chown -R mysql:mysql /var/lib/mysql/
   ```

3. Start the mariadb service:

   ```
   # systemctl start mariadb.service
   ```

8.2.4.3.3. Additional resources

For more information see Full Backup and Restore with Mariabackup.

8.2.4.4. Performing file system backup

To create a file system backup of MariaDB data files, switch to the root user, and copy the content of the MariaDB data directory to your backup location.

To back up also your current configuration or the log files, use the optional steps of the following procedure.

Procedure

1. Stop the mariadb service:

   ```
   # systemctl stop mariadb.service
   ```
2. Copy the data files to the required location:
   
   # cp -r /var/lib/mysql /backup-location
   
3. Optionally, copy the configuration files to the required location:
   
   # cp -r /etc/my.cnf /etc/my.cnf.d /backup-location/configuration
   
4. Optionally, copy the log files to the required location:
   
   # cp /var/log/mariadb/* /backup-location/logs
   
5. Start the mariadb service:
   
   # systemctl start mariadb.service

### 8.2.4.5. Introduction to replication as a backup solution

Replication is an alternative backup solution for master servers. If a master server replicates to a slave server, backups can be run on the slave without any impact on the master. Master can still run while you shut down the slave, and back the data up from him.

**WARNING**

Replication itself is not a sufficient backup solution. Replication protects master servers against hardware failures, but it does not ensure protection against data loss. It is recommended that you use any other backup solution on the replication slave together with this method.

**Additional resources**

For more information on replication as a backup solution, see [MariaDB Documentation](https://mariadb.com/).

### 8.2.5. Migrating to MariaDB 10.3

Red Hat Enterprise Linux 7 contains MariaDB 5.5 as the default implementation of a server from the MySQL databases family. Later versions of the MariaDB database server are available as Software Collections for Red Hat Enterprise Linux 6 and Red Hat Enterprise Linux 7. Red Hat Enterprise Linux 8 provides MariaDB 10.3 and MySQL 8.0.

#### 8.2.5.1. Notable differences between the RHEL 7 and RHEL 8 versions of MariaDB

The most important changes between MariaDB 5.5 and MariaDB 10.3 are as follows:

- MariaDB Galera Cluster, a synchronous multi-master cluster, is a standard part of MariaDB since 10.1.

- The ARCHIVE storage engine is no longer enabled by default, and the plug-in needs to be specifically enabled.
The BLACKHOLE storage engine is no longer enabled by default, and the plug-in needs to be specifically enabled.

InnoDB is used as the default storage engine instead of XtraDB, which was used in MariaDB 10.1 and earlier versions. For more details, see Why does MariaDB 10.2 use InnoDB instead of XtraDB?

The new mariadb-connector-c packages provide a common client library for MySQL and MariaDB. This library is usable with any version of the MySQL and MariaDB database servers. As a result, the user is able to connect one build of an application to any of the MySQL and MariaDB servers distributed with Red Hat Enterprise Linux 8.

To migrate from MariaDB 5.5 to MariaDB 10.3, you need to perform multiple configuration changes as described in Section 8.2.5.2, “Configuration changes”.

8.2.5.2. Configuration changes

The recommended migration path from MariaDB 5.5 to MariaDB 10.3 is to upgrade to MariaDB 10.0 first, and then upgrade by one version successively.

The main advantage of upgrading one by one version is better adaptation of the database, including both data and configuration to the changes. The upgrade ends on the same major version as is available in RHEL 8 (MariaDB 10.3), which significantly reduces configuration changes or other issues.

For more information about configuration changes when migrating from MariaDB 5.5 to MariaDB 10.0, see Migrating to MariaDB 10.0 in Red Hat Software Collections documentation.

The migration to following successive versions of MariaDB and the required configuration changes is described in these documents:

- Migrating to MariaDB 10.1 in Red Hat Software Collections documentation.
- Migrating to MariaDB 10.2 in Red Hat Software Collections documentation.
- Migrating to MariaDB 10.3 in Red Hat Software Collections documentation.

**NOTE**

Migration directly from MariaDB 5.5 to MariaDB 10.3 is also possible, but you must perform all configuration changes that are required by differences described in the migration documents above.

8.2.5.3. In-place upgrade using the mysql_upgrade tool

To migrate the database files to Red Hat Enterprise Linux 8, users of MariaDB on Red Hat Enterprise Linux 7 need to perform the in-place upgrade using the mysql_upgrade tool. The mysql_upgrade tool is provided by the mariadb-server-utils subpackage, which is installed as a dependency of the mariadb-server package.

To perform an in-place upgrade, you need to copy binary data files to the /var/lib/mysql/ data directory on the Red Hat Enterprise Linux 8 system and use the mysql_upgrade tool.

You can use this method for migrating data from:

- The Red Hat Enterprise Linux 7 version of MariaDB 5.5
The Red Hat Software Collections versions of:

- MariaDB 5.5 (no longer supported)
- MariaDB 10.0 (no longer supported)
- MariaDB 10.1 (no longer supported)
- MariaDB 10.2

Note that it is recommended to upgrade to MariaDB 10.2 by one version successively. See the respective Migration chapters in the Release Notes for Red Hat Software Collections.

**NOTE**

If you are upgrading from the Red Hat Enterprise Linux 7 version of MariaDB, the source data is stored in the `/var/lib/mysql/` directory. In case of Red Hat Software Collections versions of MariaDB, the source data directory is `/var/opt/rh/<collection_name>/lib/mysql/` (with the exception of the mariadb55, which uses the `/opt/rh/mariadb55/root/var/lib/mysql/` data directory).

**IMPORTANT**

Before performing the upgrade, back up all your data stored in the MariaDB databases.

To perform the in-place upgrade, change to the root user, and use the following procedure:

1. Ensure that the mariadb-server package is installed on the Red Hat Enterprise Linux 8 system:
   ```
   # yum install mariadb-server
   ```

2. Ensure that the mariadb daemon is not running on either of the source and target systems at the time of copying data:
   ```
   # systemctl stop mariadb.service
   ```

3. Copy the data from the source location to the `/var/lib/mysql/` directory on the Red Hat Enterprise Linux 8 target system.

4. Set the appropriate permissions and SELinux context for copied files on the target system:
   ```
   # restorecon -vr /var/lib/mysql
   ```

5. Start the MariaDB server on the target system:
   ```
   # systemctl start mariadb.service
   ```

6. Run the `mysql_upgrade` command to check and repair internal tables:
   ```
   # systemctl mysql_upgrade
   ```

7. When the upgrade is complete, make sure that all configuration files within the `/etc/my.cnf.d/` directory include only valid options for MariaDB 10.3.
8.2.6. Replicating MariaDB with Galera

This section describes how to replicate a MariaDB database using the Galera solution.

8.2.6.1. Introduction to MariaDB Galera Cluster

Galera replication is based on creation of a synchronous multi-master MariaDB Galera Cluster consisting of multiple MariaDB servers.

The interface between Galera replication and a MariaDB database is defined by the write set replication API (wsrep API).

The main features of MariaDB Galera Cluster are:

- Synchronous replication
- Active-active multi-master topology
- Read and write to any cluster node
- Automatic membership control, failed nodes drop from the cluster
- Automatic node joining
- Parallel replication on row level
- Direct client connections (Users can log on to the cluster nodes, and work with the nodes directly while the replication runs.)

Synchronous replication means that a server replicates a transaction at commit time by broadcasting the write set associated with the transaction to every node in the cluster. The client (user application) connects directly to the Database Management System (DBMS), and experiences behavior that is similar to native MariaDB.

Synchronous replication guarantees that a change that happened on one node in the cluster happens on other nodes in the cluster at the same time.

Therefore, synchronous replication has the following advantages over asynchronous replication:

- No delay in propagation of the changes between particular cluster nodes
- All cluster nodes are always consistent
- The latest changes are not lost if one of the cluster nodes crashes
- Transactions on all cluster nodes are executed in parallel
- Causality across the whole cluster

Additional resources
For more detailed information, see the upstream documentation:

- About Galera replication
- What is MariaDB Galera Cluster
- Getting started with MariaDB Galera Cluster

### 8.2.6.2. Components to build MariaDB Galera Cluster

To be able to build **MariaDB Galera Cluster**, the following packages must be installed on your system:

- `mariadb-server-galera`
- `mariadb-server`
- `galera`

The `mariadb-server-galera` package contains support files and scripts for **MariaDB Galera Cluster**.

MariaDB upstream patches the `mariadb-server` package to include the write set replication API (**wsrep API**). This API provides the interface between Galera replication and MariaDB.

MariaDB upstream also patches the `galera` package to add full support for **MariaDB**. The `galera` package contains the **Galera Replication Library** and the **Galera Arbitrator** tool. **Galera Replication Library** provides the whole replication functionality. **Galera Arbitrator** can be used as a cluster member that participates in voting in split-brain scenarios. However, **Galera Arbitrator** cannot participate in the actual replication.

**Additional resources**

For more detailed information, see upstream documentation:

- **Galera Replication Library**
- **Galera Arbitrator**
- **mysql-wsrep project**

### 8.2.6.3. Deploying MariaDB Galera Cluster

**Prerequisites**

- All software necessary to build **MariaDB Galera Cluster** must be installed on the system. To ensure this, install the `galera` profile of the `mariadb:10.3` module:

  ```
  # yum module install mariadb:10.3/galera
  ```

  As a result, the following packages are installed:

  - `mariadb-server-galera`
  - `mariadb-server`
  - `galera`
The **mariadb-server-galera** package pulls the **mariadb-server** and **galera** packages as its dependency.

For more information on components to build **MariaDB Galera Cluster**, see Section 8.2.6.2, “Components to build MariaDB Galera Cluster”.

- The MariaDB server replication configuration must be updated before the system is added to a cluster for the first time.  
The default configuration is shipped in the `/etc/my.cnf.d/galera.cnf` file.

Before deploying **MariaDB Galera Cluster**, set the **wsrep_cluster_address** option in the `/etc/my.cnf.d/galera.cnf` file on all nodes to start with the following string:

```bash
| gcomm://
```

For the initial node, it is possible to set **wsrep_cluster_address** as an empty list:

```bash
| wsrep_cluster_address="gcomm://"
```

For all other nodes, set **wsrep_cluster_address** to include an address to any node which is already a part of the running cluster. For example:

```bash
| wsrep_cluster_address="gcomm://10.0.0.10"
```

For more information on how to set Galera Cluster address, see **Galera Cluster Address**.

**Procedure**

1. Bootstrap a first node of a new cluster by running the following wrapper on that node:

   ```bash
   $ galera_new_cluster
   ```

   This wrapper ensures that the MariaDB server daemon (**mysqld**) runs with the **--wsrep-new-cluster** option. This option provides the information that there is no existing cluster to connect to. Therefore, the node creates a new UUID to identify the new cluster.

   **NOTE**

   The **mariadb** service supports a systemd method for interacting with multiple **MariaDB** server processes. Therefore, in cases with multiple running **MariaDB** servers, you can bootstrap a specific instance by specifying the instance name as a suffix:

   ```bash
   $ galera_new_cluster mariadb@node1
   ```

2. Connect other nodes to the cluster by running the following command on each of the nodes:

   ```bash
   # systemctl start mariadb
   ```

   As a result, the node connects to the cluster, and synchronizes itself with the state of the cluster.

**Additional resources**
For more information, see Getting started with MariaDB Galera Cluster.

8.2.6.4. Adding a new node to MariaDB Galera Cluster

To add a new node to MariaDB Galera Cluster, use the following procedure.

Note that you can use this procedure also to reconnect an already existing node.

Procedure

- On the particular node, provide an address to one or more existing cluster members in the `wsrep_cluster_address` option within the `[mariadb]` section of the `/etc/my.cnf.d/galera.cnf` configuration file:

  ```
  [mariadb]
  wsrep_cluster_address="gcomm://192.168.0.1"
  ```

  When a new node connects to one of the existing cluster nodes, it is able to see all nodes in the cluster.

  However, preferably list all nodes of the cluster in `wsrep_cluster_address`.

  As a result, any node can join a cluster by connecting to any other cluster node, even if one or more cluster nodes are down. When all members agree on the membership, the cluster’s state is changed. If the new node’s state is different from that of the cluster, it requests either an Incremental State Transfer (IST) or a State Snapshot Transfer (SST) to make itself consistent with the other nodes.

Additional resources

- For more information, see Getting started with MariaDB Galera Cluster.

- For detailed information on State Snapshot Transfers (SSTs), see Introduction to State Snapshot Transfers.

8.2.6.5. Restarting MariaDB Galera Cluster

If you shut down all nodes at the same time, you terminate the cluster, and the running cluster no longer exists. However, the cluster’s data still exist.

To restart the cluster, bootstrap a first node as described in Section 8.2.6.3, “Deploying MariaDB Galera Cluster”.

**WARNING**

If the cluster is not bootstrapped, and `mysqld` on the first node is started just with the `systemctl start mariadb` command, the node tries to connect to at least one of the nodes listed in the `wsrep_cluster_address` option in the `/etc/my.cnf.d/galera.cnf` file. If no nodes are currently running, the restart fails.
Additional resources
For more information, see Getting started with MariaDB Galera Cluster.

8.3. USING POSTGRESQL

8.3.1. Getting started with PostgreSQL

The PostgreSQL server is an open source robust and highly-extensible database server based on the SQL language. It provides an object-relational database system, which allows to manage extensive datasets and a high number of concurrent users. For these reasons, the PostgreSQL servers can be used in clusters to manage high amounts of data.

The PostgreSQL server includes features for ensuring data integrity, building fault-tolerant environments or building applications. It allows to extend a database with user’s own data types, custom functions, or code from different programming languages without the need to recompile the database.

This section describes how to install PostgreSQL in Installing PostgreSQL or how to migrate to a different version of PostgreSQL in Migrating to a RHEL 8 version of PostgreSQL. One of the prerequisites of migration is performing a data backup.

8.3.2. Installing PostgreSQL

In RHEL 8, the PostgreSQL server is available in several versions, each provided by a separate stream:

- PostgreSQL 10 - the default stream
- PostgreSQL 9.6
- PostgreSQL 12 - available since RHEL 8.1.1

**NOTE**

By design, it is impossible to install more than one version (stream) of the same module in parallel. Thus you need to choose only one of the available streams from the postgresql module. Parallel installation of components is possible in Red Hat Software Collections for RHEL 7 and RHEL 6. In RHEL 8, different versions of database servers can be used in containers.

To install PostgreSQL:

1. Enable the stream (version) you wish to install:

```
# yum module enable postgresql:stream
```

Replace stream with the selected version of the PostgreSQL server.

You can omit this step if you want to use the default stream, which provides PostgreSQL 10.

2. Ensure that the postgresql-server package, available in the AppStream repository, is installed on the required server:

```
# yum install postgresql-server
```
3. Initialize the data directory
   
   `postgresql-setup --initdb`

4. Start the `postgresql` service:
   
   `# systemctl start postgresql.service`

5. Enable the `postgresql` service to start at boot:
   
   `# systemctl enable postgresql.service`

For information about using module streams, see Installing, managing, and removing user-space components.

**IMPORTANT**

If you want to upgrade from an earlier `postgresql` stream within RHEL 8, follow both procedures described in Switching to a later stream and in Section 8.3.5, "Migrating to a RHEL 8 version of PostgreSQL".

### 8.3.3. Configuring PostgreSQL

To change the PostgreSQL configuration, use the `/var/lib/pgsql/data/postgresql.conf` file. Afterwards, restart the `postgresql` service so that the changes become effective:

```
systemctl restart postgresql.service
```

Apart from `/var/lib/pgsql/data/postgresql.conf`, other files to change PostgreSQL configuration exist:

- `postgresql.auto.conf`
- `pg_ident.conf`
- `pg_hba.conf`

The `postgresql.auto.conf` file holds basic PostgreSQL settings similarly to `/var/lib/pgsql/data/postgresql.conf`. However, this file is under the server control. It is edited by the `ALTER SYSTEM` queries, and cannot be edited manually.

The `pg_ident.conf` file is used for mapping user identities from external authentication mechanisms into the postgresql user identities.

The `pg_hba.conf` file is used for configuring detailed user permissions for PostgreSQL databases.

#### 8.3.3.1. Initializing a database cluster

In a PostgreSQL database, all data is stored a single directory, which is called a database cluster. You can choose where to store your data but Red Hat recommends to store the data in the default `/var/lib/pgsql/data` directory.

To initialize this data directory, run:

`postgresql-setup --initdb`
8.3.4. Backing up PostgreSQL data

To back up PostgreSQL data, use one of the following approaches:

- SQL dump
- File system level backup
- Continuous archiving

8.3.4.1. Backing up PostgreSQL data with an SQL dump

8.3.4.1.1. Performing an SQL dump

The SQL dump method is based on generating a file with SQL commands. When this file is uploaded back to the database server, it recreates the database in the same state as it was at the time of the dump. The SQL dump is ensured by the `pg_dump` utility, which is a PostgreSQL client application. The basic usage of the `pg_dump` command is such that the command writes its result into the standard output:

```
pg_dump dbname > dumpfile
```

The resulting SQL file can be either in a text format or in other different formats, which allows for parallelism and for more detailed control of object restoration.

You can perform the SQL dump from any remote host that has access to the database. The `pg_dump` utility does not operate with special permissions, but it must have a read access to all tables that you want to back up. To back up the entire database, you must run it as a database superuser.

To specify which database server `pg_dump` will contact, use the following command-line options:

- The `-h` option to define the host.
  The default host is either the local host or what is specified by the `PGHOST` environment variable.

- The `-p` option to define the port.
  The default port is indicated by the `PGPORT` environment variable or the compiled-in default.

**NOTE**

Note that `pg_dump` dumps only a single database. It does not dump information about roles or tablespaces because such information is cluster-wide.

To back up each database in a given cluster and to preserve cluster-wide data, such as role and tablespace definitions, use the `pg_dumpall` command:

```
pg_dumpall > dumpfile
```

8.3.4.1.2. Restoring database from an SQL dump

To restore a database from an SQL dump:

1. Create a new database (dbname):
createdb dbname

2. Make sure that all users who own objects or were granted permissions on objects in the dumped database already exist. If such users do not exist, the restore fails to recreate the objects with the original ownership and permissions.

3. Run the `psql` utility to restore a text file dump created by the `pg_dump` utility:

   ```bash
   psql dbname < dumpfile
   ```

   where `dumpfile` is the output of the `pg_dump` command.

   If you want to restore a non-text file dump, use the `pg_restore` utility:

   ```bash
   pg_restore non-plain-text-file
   ```

8.3.4.1.2.1. Restoring a database on another server

Dumping a database directly from one server to another is possible because `pg_dump` and `psql` can write to and read from pipes.

To dump a database from one server to another, run:

```bash
pg_dump -h host1 dbname | psql -h host2 dbname
```

8.3.4.1.2.2. Handling SQL errors during restore

By default, `psql` continues to execute if an SQL error occurs. Consequently, the database is restored only partially.

If you want to change this default behavior, use one of the following approaches:

- Make `psql` exit with an exit status of 3 if an SQL error occurs by setting the `ON_ERROR_STOP` variable:
  ```bash
  psql --set ON_ERROR_STOP=on dbname < dumpfile
  ```

- Specify that the whole dump is restored as a single transaction so that the restore is either fully completed or canceled by using `psql` with one of the following options:
  ```bash
  psql -1
  ```
  or
  ```bash
  psql --single-transaction
  ```

  Note that when using this approach, even a minor error can cancel a restore operation that has already run for many hours.

8.3.4.1.3. Advantages and disadvantages of an SQL dump
An SQL dump has the following advantages compared to other PostgreSQL backup methods:

- An SQL dump is the only PostgreSQL backup method that is not server version-specific. The output of the `pg_dump` utility can be reloaded into later versions of PostgreSQL, which is not possible for file system level backups or continuous archiving.
- An SQL dump is the only method that works when transferring a database to a different machine architecture, such as going from a 32-bit to a 64-bit server.
- An SQL dump provides internally consistent dumps. A dump represents a snapshot of the database at the time `pg_dump` began running.
- The `pg_dump` utility does not block other operations on the database when it is running.

A disadvantage of an SQL dump is that it takes more time compared to file system level backup.

8.3.4.1.4. Additional resources

For more information about the SQL dump, see PostgreSQL Documentation.

8.3.4.2. Backing up PostgreSQL data with a file system level backup

8.3.4.2.1. Performing a file system level backup

To perform a file system level backup, you need to copy the files that PostgreSQL uses to store the data in the database to another location:

1. Choose the location of a database cluster and initialize this cluster as described in Section 8.3.3.1, “Initializing a database cluster”.

2. Stop the postgresql service:

   ```sh
   # systemctl stop postgresql.service
   ```

3. Use any method to make a file system backup, for example:

   ```sh
   tar -cf backup.tar /var/lib/pgsql/data
   ```

4. Start the postgresql service:

   ```sh
   # systemctl start postgresql.service
   ```

8.3.4.2.2. Advantages and disadvantages of a file system level backup

A file system level backup has the following advantage compared to other PostgreSQL backup methods:

- File system level backup is usually faster than SQL dump.

File system level backup has the following disadvantages compared to other PostgreSQL backup methods:
The backup is architecture-specific and Red Hat Enterprise Linux 7-specific. It can only be used as a backup to return to Red Hat Enterprise Linux 7 if the upgrade was not successful, but it cannot be used with PostgreSQL 10.0.

- The database server must be shut down before data backup and before data restore as well.
- Backup and restore of certain individual files or tables is impossible. The file system backups only work for a complete backup and restoration of an entire database cluster.

### 8.3.4.2.3. Alternative approaches to file system level backup

Alternative approaches to file system backup include:

- A consistent snapshot of the data directory
- The rsync utility

### 8.3.4.2.4. Additional resources

For more information about the file system level backup, see PostgreSQL Documentation.

### 8.3.4.3. Backing up PostgreSQL data by continuous archiving

#### 8.3.4.3.1. Introduction to continuous archiving

PostgreSQL records every change made to the database’s data files into a write ahead log (WAL) file that is available in the `pg_wal/` subdirectory of the cluster’s data directory. This log is intended primarily for a crash recovery. After a crash, the log entries made since the last checkpoint can be used for restoring the database to a consistency.

The continuous archiving method, also known as online backup, combines the WAL files with a file system level backup. If a database recovery is needed, you can restore the database from the file system backup and then replay log from the backed up WAL files to bring the system to the current state.

For this backup method, you need a continuous sequence of archived WAL files that extends back to the start time of your backup at least.

If you want to start using the continuous archiving backup method, make sure to set up and test your procedure for archiving WAL files before taking your first base backup.

**NOTE**

You cannot use `pg_dump` and `pg_dumpall` dumps as a part of a continuous archiving backup solution. These dumps produce logical backups, not file system level backups. As such, they do not contain enough information to be used by a WAL replay.

#### 8.3.4.3.2. Performing continuous archiving backup

To perform a database backup and restore using the continuous archiving method, follow these steps:

1. Section 8.3.4.3.2.1, “Making a base backup”
2. Section 8.3.4.3.2.2, “Restoring the database using a continuous archive backup”

#### 8.3.4.3.2.1. Making a base backup
To perform a base backup, use the `pg_basebackup` tool, which can create a base backup in the form of either individual files or a `tar` archive.

To use the base backup, you need to keep all the WAL segment files generated during and after the file system backup. The base backup process creates a backup history file that is stored into the WAL archive area and is named after the first WAL segment file that you need for the file system backup. When you have safely archived the file system backup and the WAL segment files used during the backup, which are specified in the backup history file, you can delete all archived WAL segments with names numerically less because they are no longer needed to recover the file system backup. However, consider keeping several backup sets to be certain that you can recover your data.

The backup history file is a small text file, which contains the label string that you gave to `pg_basebackup`, the starting and ending times, and WAL segments of the backup. If you used the label string to identify the associated dump file, then the archived history file is enough to tell you which dump file to restore.

With the continuous archiving method, you need to keep all the archived WAL files back to your last base backup. Thus the ideal frequency of base backups depends on:

- The storage volume available for archived WAL files.
- The maximum possible duration of data recovery in situations when recovery is necessary. In cases with long period since the last backup, the system replays more WAL segments, and the recovery thus takes more time.

For more information about making a base backup, see PostgreSQL Documentation.

8.3.4.3.2.2. Restoring the database using a continuous archive backup

To restore a database using a continuous backup:

1. Stop the server:
   ```
   # systemctl stop postgresql.service
   ```

2. Copy the necessary data to a temporary location.
   Preferably, copy the whole cluster data directory and any tablespaces. Note that this requires enough free space on your system to hold two copies of your existing database.

   If you do not have enough space, save the contents of the cluster’s `pg_wal` directory, which can contain logs that were not archived before the system went down.

3. Remove all existing files and subdirectories under the cluster data directory and under the root directories of any tablespaces you are using.

4. Restore the database files from your file system backup.
   Make sure that:
   - The files are restored with the correct ownership (the database system user, not `root`)
   - The files are restored with the correct permissions
   - The symbolic links in the `pg_tblspc/` subdirectory were restored correctly

5. Remove any files present in the `pg_wal/` subdirectory
These files resulted from the file system backup and are therefore obsolete. If you did not archive `pg_wal/`, recreate it with proper permissions.

6. Copy the unarchived WAL segment files that you saved in step 2 into `pg_wal/` if there are such files.

7. Create the `recovery.conf` recovery command file in the cluster data directory.

8. Start the server:

   ```bash
   # systemctl start postgresql.service
   ```

   The server will enter the recovery mode and proceed to read through the archived WAL files that it needs.

   If the recovery is terminated due to an external error, the server can simply be restarted and it will continue the recovery. When the recovery process is completed, the server renames `recovery.conf` to `recovery.done` to prevent accidental re-entering the recovery mode later, when the server starts normal database operations.

9. Check the contents of the database to make sure that the database has recovered into the required state.

   If the database has not recovered into the required state, return to step 1. If the database has recovered into the required state, allow the users to connect by restoring the `pg_hba.conf` file to normal.

For more information about restoring using the continuous backup, see PostgreSQL Documentation.

### 8.3.4.3.3. Advantages and disadvantages of continuous archiving

Continuous archiving has the following advantages compared to other PostgreSQL backup methods:

- With the continuous backup method, it is possible to use a file system backup that is not entirely consistent because any internal inconsistency in the backup is corrected by the log replay. A file system snapshot is not needed; `tar` or a similar archiving tool is sufficient.

- Continuous backup can be achieved by continuing to archive the WAL files because the sequence of WAL files for the log replay can be indefinitely long. This is particularly valuable for large databases.

- Continuous backup supports point-in-time recovery. It is not necessary to replay the WAL entries to the end. The replay can be stopped at any point and the database can be restored to its state at any time since the base backup was taken.

- If the series of WAL files are continuously available to another machine that has been loaded with the same base backup file, it is possible to restore the other machine with a nearly-current copy of the database at any point.

Continuous archiving has the following disadvantages compared to other PostgreSQL backup methods:

- Continuous backup method supports only restoration of an entire database cluster, not a subset.

- Continuous backup requires extensive archival storage.

### 8.3.4.3.4. Additional resources
For more information on continuous archiving method, see PostgreSQL Documentation.

8.3.5. Migrating to a RHEL 8 version of PostgreSQL

Red Hat Enterprise Linux 7 contains PostgreSQL 9.2 as the default version of the PostgreSQL server. In addition, several versions of PostgreSQL are provided as Software Collections for RHEL 7 and RHEL 6.

Red Hat Enterprise Linux 8 provides PostgreSQL 10 (the default postgresql stream), PostgreSQL 9.6, and PostgreSQL 12.

Users of PostgreSQL on Red Hat Enterprise Linux can use two migration paths for the database files:

- Fast upgrade using the pg_upgrade tool
- Dump and restore upgrade

Use preferably the fast upgrade method, which is faster than the dump and restore process.

However, in certain cases, the fast upgrade does not work, and you can only use the dump and restore process. Such cases include:

- Cross-architecture upgrades
- Systems using the plpython or plpython2 extensions. Note that RHEL 8 AppStream repository includes only the postgresql-plpython3 package, not the postgresql-plpython2 package.
- Fast upgrade is not supported for migration from Red Hat Software Collections versions of PostgreSQL.

As a prerequisite for migration to a later version of PostgreSQL, back up all your PostgreSQL databases.

Dumping the databases and performing backup of the SQL files is a necessary part of the dump and restore process. However, you are recommended to do so if performing the fast upgrade as well.

Before migrating to a later version of PostgreSQL, see the upstream compatibility notes for the version of PostgreSQL to which you want to migrate, as well as for all skipped PostgreSQL versions between the one you are migrating from and the target version.

8.3.5.1. Fast upgrade using the pg_upgrade tool

During a fast upgrade, you need to copy binary data files to the /var/lib/pgsql/data/ directory and use the pg_upgrade tool.

You can use this method for migrating data:

- From the RHEL 7 system version of PostgreSQL 9.2 to the RHEL 8 version of PostgreSQL 10
- From the RHEL 8 version of PostgreSQL 10 to the RHEL 8 version of PostgreSQL 12

If you want to upgrade from an earlier postgresql stream within RHEL 8, follow the procedure described in Switching to a later stream and then migrate your PostgreSQL data.

For migrating between other combinations of PostgreSQL versions within RHEL, and for migration from the Red Hat Software Collections versions of PostgreSQL to RHEL, use Dump and restore upgrade.
IMPORTANT

Before performing the upgrade, back up all your data stored in the PostgreSQL databases.

By default, all data is stored in the /var/lib/pgsql/data/ directory on both the RHEL 7 and RHEL 8 systems.

The following procedure describes migration from the RHEL 7 system version of Postgresql 9.2 to a RHEL 8 version of PostgreSQL.

To perform a fast upgrade:

1. On the RHEL 8 system, enable the stream (version) to which you wish to migrate:

   # yum module enable postgresql:stream

   Replace stream with the selected version of the PostgreSQL server.

   You can omit this step if you want to use the default stream, which provides PostgreSQL 10.

2. On the RHEL 8 system, install the postgresql-server and postgresql-upgrade packages:

   # yum install postgresql-server postgresql-upgrade

   Optionally, if you used any PostgreSQL server modules on RHEL 7, install them also on the RHEL 8 system in two versions, compiled both against PostgreSQL 9.2 (installed as the postgresql-upgrade package) and the target version of PostgreSQL (installed as the postgresql-server package). If you need to compile a third-party PostgreSQL server module, build it both against the postgresql-devel and postgresql-upgrade-devel packages.

3. Check the following items:

   - Basic configuration: On the RHEL 8 system, check whether your server uses the default /var/lib/pgsql/data directory and the database is correctly initialized and enabled. In addition, the data files must be stored in the same path as mentioned in the /usr/lib/systemd/system/postgresql.service file.

   - PostgreSQL servers: Your system can run multiple PostgreSQL servers. Make sure that the data directories for all these servers are handled independently.

   - PostgreSQL server modules: Ensure that the PostgreSQL server modules that you used on RHEL 7 are installed on your RHEL 8 system as well. Note that plug-ins are installed in the /usr/lib64/pgsql/ directory (or in the /usr/lib/pgsql/ directory on 32-bit systems).

4. Ensure that the postgresql service is not running on either of the source and target systems at the time of copying data.

   # systemctl stop postgresql.service

5. Copy the database files from the source location to the /var/lib/pgsql/data/ directory on the RHEL 8 system.

6. Perform the upgrade process by running the following command as the PostgreSQL user:

   $ /bin/postgresql-setup --upgrade
This launches the `pg_upgrade` process in the background.

In case of failure, `postgresql-setup` provides an informative error message.

7. Copy the prior configuration from `/var/lib/pgsql/data-old` to the new cluster.
   Note that the fast upgrade does not reuse the prior configuration in the newer data stack and the configuration is generated from scratch. If you want to combine the old and new configurations manually, use the `.conf` files in the data directories.

8. Start the new PostgreSQL server:

   ```bash
   # systemctl start postgresql.service
   ```

9. Run the `analyze_new_cluster.sh` script located in the PostgreSQL home directory:

   ```bash
   su postgres -c '~/analyze_new_cluster.sh'
   ```

10. If you want the new PostgreSQL server to be automatically started on boot, run:

    ```bash
    # systemctl enable postgresql.service
    ```

### 8.3.5.2. Dump and restore upgrade

When using the dump and restore upgrade, you need to dump all databases contents into an SQL file dump file.

Note that the dump and restore upgrade is slower than the fast upgrade method and it may require some manual fixing in the generated SQL file.

You can use this method for migrating data from:

- The Red Hat Enterprise Linux 7 system version of PostgreSQL 9.2
- Any earlier Red Hat Enterprise Linux 8 version of PostgreSQL
- An earlier or equal version of PostgreSQL from Red Hat Software Collections:
  - PostgreSQL 9.2 (no longer supported)
  - PostgreSQL 9.4 (no longer supported)
  - PostgreSQL 9.6
  - PostgreSQL 10
  - PostgreSQL 12

On Red Hat Enterprise Linux 7 and Red Hat Enterprise Linux 8 systems, PostgreSQL data is stored in the `/var/lib/pgsql/data/` directory by default. In case of Red Hat Software Collections versions of PostgreSQL, the default data directory is `/var/opt/rh/collection_name/lib/pgsql/data/` (with the exception of `postgresql92`, which uses the `/opt/rh/postgresql92/root/var/lib/pgsql/data/` directory).

If you want to upgrade from an earlier `postgresql` stream within RHEL 8, follow the procedure described in Switching to a later stream and then migrate your PostgreSQL data.
To perform the dump and restore upgrade, change the user to root.

The following procedure describes migration from the RHEL 7 system version of PostgreSQL 9.2 to a RHEL 8 version of PostgreSQL.

1. On your RHEL 7 system, start the PostgreSQL 9.2 server:
   # systemctl start postgresql.service

2. On the RHEL 7 system, dump all databases contents into the pgdump_file.sql file:
   su - postgres -c 'pg_dumpall > ~/pgdump_file.sql'

3. Make sure that the databases were dumped correctly:
   su - postgres -c 'less "$HOME/pgdump_file.sql"'
   As a result, the path to the dumped sql file is displayed: /var/lib/pgsql/pgdump_file.sql.

4. On the RHEL 8 system, enable the stream (version) to which you wish to migrate:
   # yum module enable postgresql:stream
   Replace stream with the selected version of the PostgreSQL server.
   You can omit this step if you want to use the default stream, which provides PostgreSQL 10.

5. On the RHEL 8 system, install the postgresql-server package:
   # yum install postgresql-server
   Optionally, if you used any PostgreSQL server modules on RHEL 7, install them also on the RHEL 8 system. If you need to compile a third-party PostgreSQL server module, build it against the postgresql-devel package.

6. On the RHEL 8 system, initialize the data directory for the new PostgreSQL server:
   # postgresql-setup --initdb

7. On the RHEL 8 system, copy the pgdump_file.sql into the PostgreSQL home directory, and check that the file was copied correctly:
   su - postgres -c 'test -e "$HOME/pgdump_file.sql" && echo exists'

8. Copy the configuration files from the RHEL 7 system:
   su - postgres -c 'ls -1 $PGDATA/*.conf'
   The configuration files to be copied are:
   - /var/lib/pgsql/data/pg_hba.conf
   - /var/lib/pgsql/data/pg_ident.conf
9. On the RHEL 8 system, start the new *PostgreSQL* server:

```
# systemctl start postgresql.service
```

10. On the RHEL 8 system, import data from the dumped sql file:

```
su - postgres -c \'psql -f ~/pgdump_file.sql postgres\'
```

**NOTE**

When upgrading from a Red Hat Software Collections version of *PostgreSQL*, adjust the commands to include `scl enable collection_name`. For example, to dump data from the *rh-postgresql96* Software Collection, use the following command:

```
su - postgres -c \'scl enable rh-postgresql96 \"pg_dumpall > ~/pgdump_file.sql\"\'
```
CHAPTER 9. CONFIGURING PRINTING

Printing on Red Hat Enterprise Linux 8 is based on the Common Unix Printing System (CUPS).

This documentation describes how to configure a machine to be able to operate as a CUPS server.

9.1. ACTIVATING THE CUPS SERVICE

This section describes how to activate the `cups` service on your system.

Prerequisites

- The `cups` package, which is available in the Appstream repository, must be installed on your system:

  # yum install cups

Procedure

1. Start the `cups` service:

   # systemctl start cups

2. Configure the `cups` service to be automatically started at boot time:

   # systemctl enable cups

3. Optionally, check the status of the `cups` service:

   $ systemctl status cups

9.2. PRINT SETTINGS TOOLS

To achieve various tasks related to printing, you can choose one of the following tools:

- CUPS web user interface (UI)
- GNOME Control center

WARNING

The Print Settings configuration tool, which was used in Red Hat Enterprise Linux 7, is no longer available.

Tasks that you can achieve by using these tools include:

- Adding and configuring a new printer
9.3. ACCESSING AND CONFIGURING THE CUPS WEB UI

This section describes accessing the CUPS web user interface (web UI) and configuring it to be able to manage printing through this interface.

Procedure

To access the CUPS web UI:

1. Allow the CUPS server to listen to connections from the network by setting Port 631 in the /etc/cups/cupsd.conf file:

```plaintext
#Listen localhost:631
Port 631
```

   **WARNING**

   Enabling the CUPS server to listen on port 631 opens this port for any address accessible by the server. Therefore, use this setting only in local networks that are unreachable from an external network. If a server needs to be accessible from an external network, but you want to open the port 631 only for your local network, set up the following in the /etc/cups/cupsd.conf file:

```plaintext
#Listen <server_local_IP_address>:631
```

   where `<server_local_IP_address>` is an IP address unreachable from an external network, but it is available for local machines.

2. Allow your system to access the CUPS server by including the following in the /etc/cups/cupsd.conf file:

```plaintext
<Location />
Allow from <your_ip_address>
Order allow,deny
</Location>
```

   where `<your_ip_address>` is the real IP address of your system. You can also use regular expressions for subnets.
3. Restart the cups.service:

   ```
   # systemctl restart cups
   ```


   All menus except for the Administration menu are now available.

   If you click on the Administration menu, you receive the Forbidden message:

   ![Forbidden](image)

   To acquire the access to the Administration menu, follow the instructions in Section 9.3.1, “Acquiring administration access to the CUPS web UI”.

### 9.3.1. Acquiring administration access to the CUPS web UI

This section describes how to acquire administration access to the CUPS web UI.

**Procedure**

1. To be able to access the Administration menu in the CUPS web UI, include the following in the `/etc/cups/cupsd.conf` file:
1. To allow access to configuration files in the CUPS web UI, include the following in the `/etc/cups/cupsd.conf` file:

```plaintext
<Location /admin/conf>
AuthType Default
Require user @SYSTEM
Allow from <your_ip_address>
Order allow,deny
</Location>
```

**NOTE**

Replace `<your_ip_address>` with the real IP address of your system.

2. To be able to access configuration files in the CUPS web UI, include the following in the `/etc/cups/cupsd.conf` file:

```plaintext
<Location /admin>
Allow from <your_ip_address>
Order allow,deny
</Location>
```

**NOTE**

Replace `<your_ip_address>` with the real IP address of your system.

3. To be able to access log files in the CUPS web UI, include the following in the `/etc/cups/cupsd.conf` file:

```plaintext
<Location /admin/log>
AuthType Default
Require user @SYSTEM
Allow from <your_ip_address>
Order allow,deny
</Location>
```

**NOTE**

Replace `<your_ip_address>` with the real IP address of your system.

4. To specify the use of encryption for authenticated requests in the CUPS web UI, include `DefaultEncryption` in the `/etc/cups/cupsd.conf` file:

```plaintext
DefaultEncryption IfRequested
```

With this setting, you will receive an authentication window to enter the username of a user allowed to add printers when you attempt to access the Administration menu. However, there are also other options how to set `DefaultEncryption`. For more details, see the `cupsd.conf` man page.

5. Restart the `cups` service:

```plaintext
# systemctl restart cups
```
**WARNING**

If you do not restart the **cups** service, the changes in `/etc/cups/cupsd.conf` will not be applied. Consequently, you will not be able to obtain administration access to the **CUPS web UI**.

---

**Additional resources**

- For more information on how to configure a CUPS server using the `/etc/cups/cupsd.conf` file, see the **cupsd.conf** man page.

---

### 9.4. ADDING A PRINTER IN THE CUPS WEB UI

This section describes how to add a new printer using the **CUPS web user interface**.

**Prerequisites**

- You have acquired administration access to the **CUPS web UI** as described in Section 9.3.1, “Acquiring administration access to the CUPS web UI”.

**Procedure**

1. Start the **CUPS web UI** as described in Section 9.3, “Accessing and configuring the CUPS web UI”.

2. Go to **Adding Printers and Classes** - **Add printer**.

---

**CUPS 2.2.6**

CUPS is the standards-based, open source printing system developed by Apple Inc. for macOS® and other UNIX®-like operating systems.
3. Authenticate by username and password:

**IMPORTANT**

To be able to add a new printer by using the **CUPS web UI**, you must authenticate as one of the following users:

- Superuser
- Any user with the administration access provided by the `sudo` command (users listed within `/etc/sudoers`)
- Any user belonging to the `printadmin` group in `/etc/group`

4. If a local printer is connected, or CUPS finds a network printer available, select the printer. If neither local printer nor network printer is available, select one of the printer types from **Other Network Printers**, for example **APP Socket/HP Jet direct**, enter the IP address of the printer, and then click **Continue**.
5. If you have selected for example **APP Socket/HP Jet direct** as shown above, enter the IP address of the printer, and then click **Continue**.

   ![Add Printer](image)

6. You can add more details about the new printer, such as the name, description and location. To set a printer to be shared over the network, use **Share This Printer** as shown below.

   ![Add Printer](image)

7. Select the printer manufacturer, and then click **Continue**.
Alternatively, you can also provide a postscript printer description (PPD) file to be used as a driver for the printer, by click on **Browse...** at the bottom.

8. Select the model of the printer, and then click **Add Printer**.

9. After the printer has been added, the next window allows you to set the default print options.
After clicking **Set Default Options**, you will receive a confirmation that the new printer has been added successfully.

### 9.5. CONFIGURING A PRINTER IN THE CUPS WEB UI

This section describes how to configure a new printer, and how to maintain a configuration of a printer using the CUPS web UI.

**Prerequisites**

- You have acquired administration access to the **CUPS web UI** as described in [Section 9.3.1, “Acquiring administration access to the CUPS web UI”](#).

**Procedure**

1. Click the **Printers** menu to see available printers that you can configure.

2. Choose one printer that you want to configure.
3. Perform your selected task by using one of the available menus:

- **Go to Maintenance** for maintenance tasks.

- **Go to Administration** for administration tasks.

- You can also check completed print jobs or all active print jobs by clicking the **Show Completed Jobs** or **Show All Jobs** buttons.

**9.6. PRINTING A TEST PAGE USING THE CUPS WEB UI**
This section describes how to print a test page to make sure that the printer functions properly.

You might want to print a test page if one of the below conditions is met.

- A printer has been set up.
- A printer configuration has been changed.

**Prerequisites**

You have acquired administration access to the **CUPS web UI** as described in **Section 9.3.1, “Acquiring administration access to the CUPS web UI”**.

**Procedure**

- Go to **Printers** menu, and click **Maintenance → Print Test Page**.

---

**9.7. SETTING PRINT OPTIONS USING THE CUPS WEB UI**

This section describes how to set common print options, such as the media size and type, print quality or the color mode, in the **CUPS web UI**.

**Prerequisites**

You have acquired administration access to the **CUPS web UI** as described in **Section 9.3.1, “Acquiring administration access to the CUPS web UI”**.

**Procedure**

1. Go to **Administration** menu, and click **Maintenance → Set Default Options**.
2. Set the print options.

9.8. INSTALLING CERTIFICATES FOR A PRINT SERVER

To install certificates for a print server, you can choose one of the following options:

- Automatic installation using a self-signed certificate
- Manual installation using a certificate and a private key generated by a Certification Authority

Prerequisites

For the `cupsd` daemon on the server:

1. Set the following directive in the `/etc/cups/cupsd.conf` file to:
   
   **Encryption Required**

2. Restart the cups service:

   ```
   $ sudo systemctl restart cups
   ```

**Automatic installation using a self-signed certificate**

With this option, CUPS generates the certificate and the key automatically.
NOTE
The self-signed certificate does not provide as strong security as certificates generated by Identity Management (IdM), Active Directory (AD), or Red Hat Certificate System (RHCS) Certification Authorities, but it can be used for print servers located within a secure local network.

Procedure

1. To access the CUPS Web UI, open your browser and go to https://<server>:631 where <server> is either the server IP address or the server host name.

NOTE
When CUPS connects to a system for the first time, the browser shows a warning about the self-signed certificate being a potential security risk.

2. To confirm that it is safe to proceed, click Advanced…

Warning: Potential Security Risk Ahead
Firefox detected a potential security threat and did not continue to localhost. If you visit this site, attackers could try to steal information like your passwords, emails, or credit card details.

Learn more…

Go Back (Recommended)  Advanced…

Report errors like this to help Mozilla identify and block malicious sites

3. Click Accept the Risk and Continue.

Warning: Potential Security Risk Ahead
Firefox detected a potential security threat and did not continue to localhost. If you visit this site, attackers could try to steal information like your passwords, emails, or credit card details.

Learn more…

Go Back (Recommended)  Advanced…

Websites prove their identity via certificates. Firefox does not trust this site because it uses a certificate that is not valid for localhost:631.

Error code: MOZILLA_PKIX_ERROR_SELF_SIGNED_CERT
View Certificate

Go Back (Recommended)  Accept the Risk and Continue

Report errors like this to help Mozilla identify and block malicious sites
CUPS now starts to use the self-generated certificate and the key.

**NOTE**

When you access the CUPS Web UI after automatic installation, the browser displays a warning icon in the address bar. This is because you added the security exception by confirming the security risk warning. If you want to remove this warning icon permanently, perform the manual installation with a certificate and a private key generated by a Certification Authority.

**Manual installation using a certificate and a private key generated by a Certification Authority**

For print servers located within a public network or to permanently remove the warning in the browser, import the certificate and the key manually.

**Prerequisites**

- You have certificate and private key files generated by IdM, AD, or by RHCS Certification Authorities.

**Procedure**

1. Copy the `.crt` and `.key` files into the `/etc/cups/ssl` directory of the system on which you want to use the CUPS Web UI.

2. Rename the copied files to `<hostname>.crt` and `<hostname>.key`. Replace `<hostname>` with the host name of the system to which you want to connect the CUPS Web UI.

3. Set the following permissions to the renamed files:
   ```
   # chmod 644 /etc/cups/ssl/<hostname>.crt
   # chmod 644 /etc/cups/ssl/<hostname>.key
   # chown root:root /etc/cups/ssl/<hostname>.crt
   # chown root:root /etc/cups/ssl/<hostname>.key
   ```

4. Restart the cups service:
   ```
   # systemctl restart cupsd
   ```

9.9. **USING SAMBA TO PRINT TO A WINDOWS PRINT SERVER WITH KERBEROS AUTHENTICATION**

With the samba-krb5-printing wrapper, Active Directory (AD) users who are logged in to Red Hat Enterprise Linux can authenticate to Active Directory (AD) by using Kerberos and then print to a local CUPS print server that forwards the print job to a Windows print server.

The benefit of this configuration is that the administrator of CUPS on Red Hat Enterprise Linux does not need to store a fixed user name and password in the configuration. CUPS authenticates to AD with the Kerberos ticket of the user that sends the print job.
This section describes how to configure CUPS for this scenario.

NOTE

Red Hat only supports submitting print jobs to CUPS from your local system, and not to re-share a printer on a Samba print server.

Prerequisites

- The printer that you want to add to the local CUPS instance is shared on an AD print server.
- You joined the Red Hat Enterprise Linux host as a member to the AD. For details, see Section 3.5.1, “Joining a RHEL system to an AD domain”.
- CUPS is installed on Red Hat Enterprise Linux and the `cups` service is running. For details, see Section 9.1, “Activating the cups service”.
- The PostScript Printer Description (PPD) file for the printer is stored in the `/usr/share/cups/model/` directory.

Procedure

1. Install the `samba-krb5-printing`, `samba-client`, and `krb5-workstation` packages:

   ```
   # yum install samba-krb5-printing samba-client krb5-workstation
   ```

2. Optional: Authenticate as a domain administrator and display the list of printers that are shared on the Windows print server:

   ```
   # kinit administrator@AD_KERBEROS_REALM
   # smbclient -L win_print_srv.ad.example.com -k
   
   Sharename       Type      Comment
   ---------       ----      -------
   ...            Printer   Example
   ...
   ```

3. Optional: Display the list of CUPS models to identify the PPD name of your printer:

   ```
   ipinfo -m
   ...
   samsung.ppd Samsung M267x 287x Series PXL
   ...
   ```

   You require the name of the PPD file when you add the printer in the next step.

4. Add the printer to CUPS:

   ```
   # lpadmin -p "example_printer" -v smb://win_print_srv.ad.example.com/Example -m samsung.ppd -o auth-info-required=negotiate -E
   ```

   The command uses the following options:
- **-p printer\_name** sets the name of the printer in CUPS.

- **-v URL\_to\_Windows\_printer** sets the URI to the Windows printer. Use the following format: `smb://host\_name/printer\_share\_name`.

- **-m PPD\_file** sets the PPD file the printer uses.

- **-o auth\_info\_required=negotiate** configures CUPS to use Kerberos authentication when it forwards print jobs to the remote server.

- **-E** enables the printer and CUPS accepts jobs for the printer.

### Verification steps

1. Log into the Red Hat Enterprise Linux host as an AD domain user.

2. Authenticate as an AD domain user:
   ```bash
   # kinit domain\_user\_name@AD\_KERBEROS\_REALM
   ```

3. Print a file to the printer you added to the local CUPS print server:
   ```bash
   # lp -d example\_printer file
   ```

### 9.10. WORKING WITH CUPS LOGS

#### 9.10.1. Types of CUPS logs

CUPS provides three different kinds of logs:

- **Error log** - Stores error messages, warnings and debugging messages.

- **Access log** - Stores messages about how many times CUPS clients and web UI have been accessed.

- **Page log** - Stores messages about the total number of pages printed for each print job.

In Red Hat Enterprise Linux 8, all three types are logged centrally in systemd-journald together with logs from other programs.

**WARNING**

In Red Hat Enterprise Linux 8, the logs are no longer stored in specific files within the `/var/log/cups` directory, which was used in Red Hat Enterprise Linux 7.

#### 9.10.2. Accessing CUPS logs

This section describes how to access:
• All CUPS logs
• CUPS logs for a specific print job
• CUPS logs within a specific time frame

9.10.2.1. Accessing all CUPS logs

Procedure
• Filter CUPS logs from systemd-journald:

  $ journalctl -u cups

9.10.2.2. Accessing CUPS logs for a specific print job

Procedure
• Filter logs for a specific print job:

  $ journalctl -u cups JID=N

  Where N is a number of a print job.

9.10.2.3. Accessing CUPS logs by specific time frame

Procedure
• Filter logs within the specified time frame:

  $ journalctl -u cups --since=YYYY-MM-DD --until=YYYY-MM-DD

  Where YYYY is year, MM is month and DD is day.

9.10.2.4. Related information

For more detailed information on accessing CUPS logs, see the journalctl man page.

9.10.3. Configuring the CUPS log location

This section describes how to configure the location of CUPS logs.

In Red Hat Enterprise Linux 8, CUPS logs are by default logged into systemd-journald, which is ensured by the following default setting in the /etc/cups/cups-files.conf file:

  ErrorLog syslog

IMPORTANT

  Red Hat recommends to keep the default location of CUPS logs.
If you want to send the logs into a different location, you need to change the settings in the `/etc/cups/cups-files.conf` file as follows:

```
ErrorLog <your_required_location>
```

WARNING

If you change the default location of CUPS log, you may experience an unexpected behavior or SELinux issues.