



# Red Hat Enterprise Linux 7

## SELinux User's and Administrator's Guide

Basic and advanced configuration of Security-Enhanced Linux (SELinux)



# Red Hat Enterprise Linux 7 SELinux User's and Administrator's Guide

---

Basic and advanced configuration of Security-Enhanced Linux (SELinux)

Mirek Jahoda

Red Hat Customer Content Services

[mjahoda@redhat.com](mailto:mjahoda@redhat.com)

Barbora Ančincová

Red Hat Customer Content Services

Ioanna Gkioka

Red Hat Customer Content Services

Tomáš Čapek

Red Hat Customer Content Services

## Legal Notice

Copyright © 2019 Red Hat, Inc.

This document is licensed by Red Hat under the [Creative Commons Attribution-ShareAlike 3.0 Unported License](https://creativecommons.org/licenses/by-sa/3.0/). If you distribute this document, or a modified version of it, you must provide attribution to Red Hat, Inc. and provide a link to the original. If the document is modified, all Red Hat trademarks must be removed.

Red Hat, as the licensor of this document, waives the right to enforce, and agrees not to assert, Section 4d of CC-BY-SA to the fullest extent permitted by applicable law.

Red Hat, Red Hat Enterprise Linux, the Shadowman logo, the Red Hat logo, JBoss, OpenShift, Fedora, the Infinity logo, and RHCE are trademarks of Red Hat, Inc., registered in the United States and other countries.

Linux<sup>®</sup> is the registered trademark of Linus Torvalds in the United States and other countries.

Java<sup>®</sup> is a registered trademark of Oracle and/or its affiliates.

XFS<sup>®</sup> is a trademark of Silicon Graphics International Corp. or its subsidiaries in the United States and/or other countries.

MySQL<sup>®</sup> is a registered trademark of MySQL AB in the United States, the European Union and other countries.

Node.js<sup>®</sup> is an official trademark of Joyent. Red Hat is not formally related to or endorsed by the official Joyent Node.js open source or commercial project.

The OpenStack<sup>®</sup> Word Mark and OpenStack logo are either registered trademarks/service marks or trademarks/service marks of the OpenStack Foundation, in the United States and other countries and are used with the OpenStack Foundation's permission. We are not affiliated with, endorsed or sponsored by the OpenStack Foundation, or the OpenStack community.

All other trademarks are the property of their respective owners.

## Abstract

This book consists of two parts: SELinux and Managing Confined Services. The former describes the basics and principles upon which SELinux functions, the latter is more focused on practical tasks to set up and configure various services.

# Table of Contents

<b>PART I. SELINUX</b>	<b>6</b>
<b>CHAPTER 1. INTRODUCTION</b>	<b>7</b>
ADDITIONAL RESOURCES	8
1.1. BENEFITS OF RUNNING SELINUX	8
1.2. EXAMPLES	9
1.3. SELINUX ARCHITECTURE	9
1.4. SELINUX STATES AND MODES	10
1.5. ADDITIONAL RESOURCES	10
<b>CHAPTER 2. SELINUX CONTEXTS</b>	<b>12</b>
2.1. DOMAIN TRANSITIONS	13
2.2. SELINUX CONTEXTS FOR PROCESSES	14
2.3. SELINUX CONTEXTS FOR USERS	15
<b>CHAPTER 3. TARGETED POLICY</b>	<b>16</b>
3.1. CONFINED PROCESSES	16
3.2. UNCONFINED PROCESSES	18
3.3. CONFINED AND UNCONFINED USERS	21
<b>CHAPTER 4. WORKING WITH SELINUX</b>	<b>26</b>
4.1. SELINUX PACKAGES	26
4.2. WHICH LOG FILE IS USED	27
4.3. MAIN CONFIGURATION FILE	28
4.4. PERMANENT CHANGES IN SELINUX STATES AND MODES	28
4.5. CHANGING SELINUX MODES AT BOOT TIME	32
4.6. BOOLEANS	32
4.7. SELINUX CONTEXTS – LABELING FILES	35
4.8. THE FILE_T AND DEFAULT_T TYPES	41
4.9. MOUNTING FILE SYSTEMS	41
4.10. MAINTAINING SELINUX LABELS	44
4.11. INFORMATION GATHERING TOOLS	51
4.12. PRIORITIZING AND DISABLING SELINUX POLICY MODULES	53
4.13. MULTI-LEVEL SECURITY (MLS)	54
4.14. FILE NAME TRANSITION	59
4.15. DISABLING PTRACE()	60
4.16. THUMBNAIL PROTECTION	61
<b>CHAPTER 5. THE SEPOLICY SUITE</b>	<b>63</b>
5.1. THE SEPOLICY PYTHON BINDINGS	63
5.2. GENERATING SELINUX POLICY MODULES: SEPOLICY GENERATE	64
5.3. UNDERSTANDING DOMAIN TRANSITIONS: SEPOLICY TRANSITION	64
5.4. GENERATING MANUAL PAGES: SEPOLICY MANPAGE	65
<b>CHAPTER 6. CONFINING USERS</b>	<b>67</b>
6.1. LINUX AND SELINUX USER MAPPINGS	67
6.2. CONFINING NEW LINUX USERS: USERADD	67
6.3. CONFINING EXISTING LINUX USERS: SEMANAGE LOGIN	69
6.4. CHANGING THE DEFAULT MAPPING	70
6.5. XGUEST: KIOSK MODE	71
6.6. BOOLEANS FOR USERS EXECUTING APPLICATIONS	71
<b>CHAPTER 7. SECURING PROGRAMS USING SANDBOX</b>	<b>73</b>

7.1. RUNNING AN APPLICATION USING SANDBOX	73
<b>CHAPTER 8. SVIRT</b>	<b>74</b>
Non-Virtualized Environment	74
Virtualized Environment	74
8.1. SECURITY AND VIRTUALIZATION	74
8.2. SVIRT LABELING	75
<b>CHAPTER 9. SECURE LINUX CONTAINERS</b>	<b>77</b>
<b>CHAPTER 10. SELINUX SYSTEMD ACCESS CONTROL</b>	<b>78</b>
10.1. SELINUX ACCESS PERMISSIONS FOR SERVICES	78
10.2. SELINUX AND JOURNALD	82
<b>CHAPTER 11. TROUBLESHOOTING</b>	<b>84</b>
11.1. WHAT HAPPENS WHEN ACCESS IS DENIED	84
11.2. TOP THREE CAUSES OF PROBLEMS	85
11.3. FIXING PROBLEMS	87
<b>CHAPTER 12. FURTHER INFORMATION</b>	<b>99</b>
12.1. CONTRIBUTORS	99
12.2. OTHER RESOURCES	99
<b>PART II. MANAGING CONFINED SERVICES</b>	<b>101</b>
<b>CHAPTER 13. INTRODUCTION</b>	<b>102</b>
<b>CHAPTER 14. THE APACHE HTTP SERVER</b>	<b>103</b>
14.1. THE APACHE HTTP SERVER AND SELINUX	103
14.2. TYPES	105
14.3. BOOLEANS	108
14.4. CONFIGURATION EXAMPLES	110
<b>CHAPTER 15. SAMBA</b>	<b>118</b>
15.1. SAMBA AND SELINUX	118
15.2. TYPES	119
15.3. BOOLEANS	119
15.4. CONFIGURATION EXAMPLES	120
<b>CHAPTER 16. FILE TRANSFER PROTOCOL</b>	<b>125</b>
16.1. TYPES	125
16.2. BOOLEANS	125
<b>CHAPTER 17. NETWORK FILE SYSTEM</b>	<b>128</b>
17.1. NFS AND SELINUX	128
17.2. TYPES	128
17.3. BOOLEANS	129
17.4. CONFIGURATION EXAMPLES	130
<b>CHAPTER 18. BERKELEY INTERNET NAME DOMAIN</b>	<b>132</b>
18.1. BIND AND SELINUX	132
18.2. TYPES	132
18.3. BOOLEANS	133
18.4. CONFIGURATION EXAMPLES	134
<b>CHAPTER 19. CONCURRENT VERSIONING SYSTEM</b>	<b>135</b>
19.1. CVS AND SELINUX	135

19.2. TYPES	135
19.3. BOOLEANS	135
19.4. CONFIGURATION EXAMPLES	136
<b>CHAPTER 20. SQUID CACHING PROXY</b>	<b>139</b>
20.1. SQUID CACHING PROXY AND SELINUX	139
20.2. TYPES	141
20.3. BOOLEANS	142
20.4. CONFIGURATION EXAMPLES	142
<b>CHAPTER 21. MARIADB (A REPLACEMENT FOR MYSQL)</b>	<b>145</b>
21.1. MARIADB AND SELINUX	145
21.2. TYPES	146
21.3. BOOLEANS	146
21.4. CONFIGURATION EXAMPLES	147
<b>CHAPTER 22. POSTGRESQL</b>	<b>150</b>
22.1. POSTGRESQL AND SELINUX	150
22.2. TYPES	151
22.3. BOOLEANS	152
22.4. CONFIGURATION EXAMPLES	152
<b>CHAPTER 23. RSYNC</b>	<b>155</b>
23.1. RSYNC AND SELINUX	155
23.2. TYPES	155
23.3. BOOLEANS	156
23.4. CONFIGURATION EXAMPLES	156
<b>CHAPTER 24. POSTFIX</b>	<b>160</b>
24.1. POSTFIX AND SELINUX	160
24.2. TYPES	161
24.3. BOOLEANS	161
24.4. CONFIGURATION EXAMPLES	162
<b>CHAPTER 25. DHCP</b>	<b>164</b>
25.1. DHCP AND SELINUX	164
25.2. TYPES	164
<b>CHAPTER 26. OPENSIFT BY RED HAT</b>	<b>166</b>
26.1. OPENSIFT AND SELINUX	166
26.2. TYPES	166
26.3. BOOLEANS	167
26.4. CONFIGURATION EXAMPLES	168
<b>CHAPTER 27. IDENTITY MANAGEMENT</b>	<b>170</b>
27.1. IDENTITY MANAGEMENT AND SELINUX	170
27.2. CONFIGURATION EXAMPLES	170
<b>CHAPTER 28. RED HAT GLUSTER STORAGE</b>	<b>172</b>
28.1. RED HAT GLUSTER STORAGE AND SELINUX	172
28.2. TYPES	172
28.3. BOOLEANS	173
28.4. CONFIGURATION EXAMPLES	174
<b>CHAPTER 29. REFERENCES</b>	<b>176</b>

APPENDIX A. REVISION HISTORY ..... 178



## PART I. SELINUX

# CHAPTER 1. INTRODUCTION

Security Enhanced Linux (SELinux) provides an additional layer of system security. SELinux fundamentally answers the question: "May <subject> do <action> to <object>", for example: "May a web server access files in users' home directories?".

The standard access policy based on the user, group, and other permissions, known as Discretionary Access Control (DAC), does not enable system administrators to create comprehensive and fine-grained security policies, such as restricting specific applications to only viewing log files, while allowing other applications to append new data to the log files

SELinux implements Mandatory Access Control (MAC). Every process and system resource has a special security label called a *SELinux context*. A SELinux context, sometimes referred to as a *SELinux label*, is an identifier which abstracts away the system-level details and focuses on the security properties of the entity. Not only does this provide a consistent way of referencing objects in the SELinux policy, but it also removes any ambiguity that can be found in other identification methods; for example, a file can have multiple valid path names on a system that makes use of bind mounts.

The SELinux policy uses these contexts in a series of rules which define how processes can interact with each other and the various system resources. By default, the policy does not allow any interaction unless a rule explicitly grants access.



## NOTE

It is important to remember that SELinux policy rules are checked after DAC rules. SELinux policy rules are not used if DAC rules deny access first, which means that no SELinux denial is logged if the traditional DAC rules prevent the access.

SELinux contexts have several fields: user, role, type, and security level. The SELinux type information is perhaps the most important when it comes to the SELinux policy, as the most common policy rule which defines the allowed interactions between processes and system resources uses SELinux types and not the full SELinux context. SELinux types usually end with **\_t**. For example, the type name for the web server is **httpd\_t**. The type context for files and directories normally found in **/var/www/html/** is **httpd\_sys\_content\_t**. The type contexts for files and directories normally found in **/tmp** and **/var/tmp/** is **tmp\_t**. The type context for web server ports is **http\_port\_t**.

For example, there is a policy rule that permits Apache (the web server process running as **httpd\_t**) to access files and directories with a context normally found in **/var/www/html/** and other web server directories (**httpd\_sys\_content\_t**). There is no allow rule in the policy for files normally found in **/tmp** and **/var/tmp/**, so access is not permitted. With SELinux, even if Apache is compromised, and a malicious script gains access, it is still not able to access the **/tmp** directory.

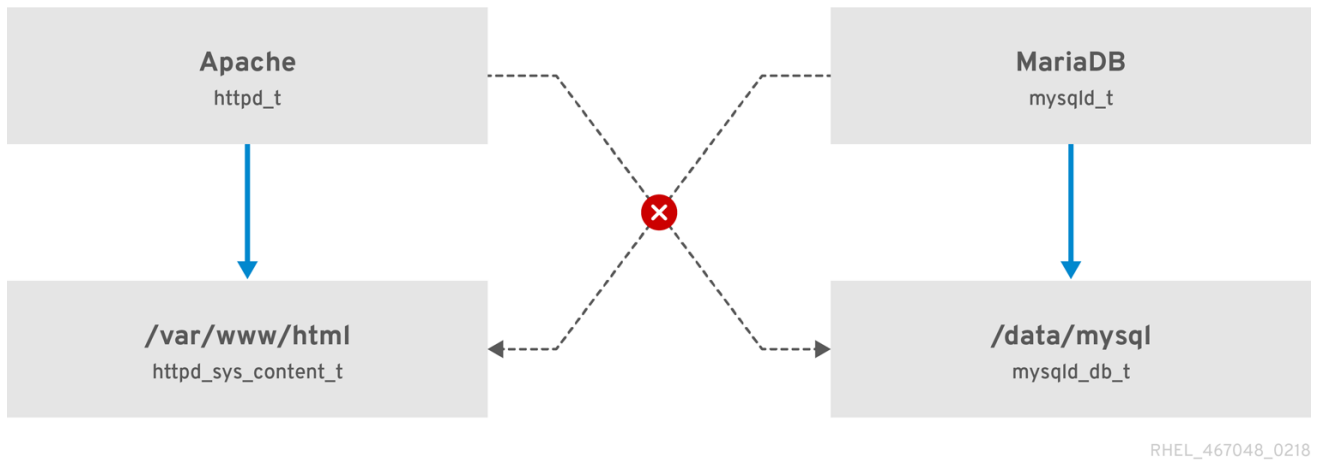


Figure 1.1. SELinux allows the Apache process running as `httpd_t` to access the `/var/www/html/` directory and it denies the same process to access the `/data/mysql/` directory because there is no allow rule for the `httpd_t` and `mysqld_db_t` type contexts). On the other hand, the MariaDB process running as `mysqld_t` is able to access the `/data/mysql/` directory and SELinux also correctly denies the process with the `mysqld_t` type to access the `/var/www/html/` directory labeled as `httpd_sys_content_t`.

## ADDITIONAL RESOURCES

For more information, see the following documentation:

- The **`selinux(8)`** man page and man pages listed by the **`apropos selinux`** command.
- Man pages listed by the **`man -k selinux`** command when the `selinux-policy-doc` package is installed. See [Section 11.3.3, “Manual Pages for Services”](#) for more information.
- [The SELinux Coloring Book](#)
- [SELinux Wiki FAQ](#)

## 1.1. BENEFITS OF RUNNING SELINUX

SELinux provides the following benefits:

- All processes and files are labeled. SELinux policy rules define how processes interact with files, as well as how processes interact with each other. Access is only allowed if an SELinux policy rule exists that specifically allows it.
- Fine-grained access control. Stepping beyond traditional UNIX permissions that are controlled at user discretion and based on Linux user and group IDs, SELinux access decisions are based on all available information, such as an SELinux user, role, type, and, optionally, a security level.
- SELinux policy is administratively-defined and enforced system-wide.
- Improved mitigation for privilege escalation attacks. Processes run in domains, and are therefore separated from each other. SELinux policy rules define how processes access files and other processes. If a process is compromised, the attacker only has access to the normal functions of that process, and to files the process has been configured to have access to. For example, if the Apache HTTP Server is compromised, an attacker cannot use that process to read files in user home directories, unless a specific SELinux policy rule was added or configured to allow such access.

- SELinux can be used to enforce data confidentiality and integrity, as well as protecting processes from untrusted inputs.

However, SELinux is not:

- antivirus software,
- replacement for passwords, firewalls, and other security systems,
- all-in-one security solution.

SELinux is designed to enhance existing security solutions, not replace them. Even when running SELinux, it is important to continue to follow good security practices, such as keeping software up-to-date, using hard-to-guess passwords, or firewalls.

## 1.2. EXAMPLES

The following examples demonstrate how SELinux increases security:

- The default action is deny. If an SELinux policy rule does not exist to allow access, such as for a process opening a file, access is denied.
- SELinux can confine Linux users. A number of confined SELinux users exist in the SELinux policy. Linux users can be mapped to confined SELinux users to take advantage of the security rules and mechanisms applied to them. For example, mapping a Linux user to the SELinux **user\_u** user, results in a Linux user that is not able to run (unless configured otherwise) set user ID (setuid) applications, such as **sudo** and **su**, as well as preventing them from executing files and applications in their home directory. If configured, this prevents users from executing malicious files from their home directories. See [Section 3.3, “Confined and Unconfined Users”](#) for more information.
- Increased process and data separation. Processes run in their own domains, preventing processes from accessing files used by other processes, as well as preventing processes from accessing other processes. For example, when running SELinux, unless otherwise configured, an attacker cannot compromise a Samba server, and then use that Samba server as an attack vector to read and write to files used by other processes, such as MariaDB databases.
- SELinux helps mitigate the damage made by configuration mistakes. Domain Name System (DNS) servers often replicate information between each other in what is known as a zone transfer. Attackers can use zone transfers to update DNS servers with false information. When running the Berkeley Internet Name Domain (BIND) as a DNS server in Red Hat Enterprise Linux, even if an administrator forgets to limit which servers can perform a zone transfer, the default SELinux policy prevents zone files <sup>[1]</sup> from being updated using zone transfers, by the BIND **named** daemon itself, and by other processes.
- See the [NetworkWorld.com](#) article, [A seatbelt for server software: SELinux blocks real-world exploits<sup>\[2\]</sup>](#), for background information about SELinux, and information about various exploits that SELinux has prevented.

## 1.3. SELINUX ARCHITECTURE

SELinux is a Linux Security Module (LSM) that is built into the Linux kernel. The SELinux subsystem in the kernel is driven by a security policy which is controlled by the administrator and loaded at boot. All security-relevant, kernel-level access operations on the system are intercepted by SELinux and

examined in the context of the loaded security policy. If the loaded policy allows the operation, it continues. Otherwise, the operation is blocked and the process receives an error.

SELinux decisions, such as allowing or disallowing access, are cached. This cache is known as the Access Vector Cache (AVC). When using these cached decisions, SELinux policy rules need to be checked less, which increases performance. Remember that SELinux policy rules have no effect if DAC rules deny access first.

## 1.4. SELINUX STATES AND MODES

SELinux can run in one of three modes: disabled, permissive, or enforcing.

Disabled mode is strongly discouraged; not only does the system avoid enforcing the SELinux policy, it also avoids labeling any persistent objects such as files, making it difficult to enable SELinux in the future.

In permissive mode, the system acts as if SELinux is enforcing the loaded security policy, including labeling objects and emitting access denial entries in the logs, but it does not actually deny any operations. While not recommended for production systems, permissive mode can be helpful for SELinux policy development.

Enforcing mode is the default, and recommended, mode of operation; in enforcing mode SELinux operates normally, enforcing the loaded security policy on the entire system.

Use the **setenforce** utility to change between enforcing and permissive mode. Changes made with **setenforce** do not persist across reboots. To change to enforcing mode, enter the **setenforce 1** command as the Linux root user. To change to permissive mode, enter the **setenforce 0** command. Use the **getenforce** utility to view the current SELinux mode:

```
~]# getenforce
Enforcing
```

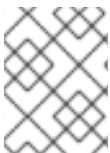
```
~]# setenforce 0
~]# getenforce
Permissive
```

```
~]# setenforce 1
~]# getenforce
Enforcing
```

In Red Hat Enterprise Linux, you can set individual domains to permissive mode while the system runs in enforcing mode. For example, to make the **httpd\_t** domain permissive:

```
~]# semanage permissive -a httpd_t
```

See [Section 11.3.4, “Permissive Domains”](#) for more information.



### NOTE

Persistent states and modes changes are covered in [Section 4.4, “Permanent Changes in SELinux States and Modes”](#).

## 1.5. ADDITIONAL RESOURCES

Red Hat Identity Management (IdM) provides a centralized solution to define SELinux user maps. For details, see [Defining SELinux User Maps in the Linux Domain Identity, Authentication, and Policy Guide](#) .

---

[1] Text files that include information, such as host name to IP address mappings, that are used by DNS servers.

[2] Marti, Don. "A seatbelt for server software: SELinux blocks real-world exploits". Published 24 February 2008. Accessed 27 August 2009: <http://www.networkworld.com/article/2283723/lan-wan/a-seatbelt-for-server-software--selinux-blocks-real-world-exploits.html>.

## CHAPTER 2. SELINUX CONTEXTS

Processes and files are labeled with an SELinux context that contains additional information, such as an SELinux user, role, type, and, optionally, a level. When running SELinux, all of this information is used to make access control decisions. In Red Hat Enterprise Linux, SELinux provides a combination of Role-Based Access Control (RBAC), Type Enforcement (TE), and, optionally, Multi-Level Security (MLS).

The following is an example showing SELinux context. SELinux contexts are used on processes, Linux users, and files, on Linux operating systems that run SELinux. Use the following command to view the SELinux context of files and directories:

```
~]$ ls -Z file1
-rwxrw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

SELinux contexts follow the *SELinux user:role:type:level* syntax. The fields are as follows:

### SELinux user

The SELinux user identity is an identity known to the policy that is authorized for a specific set of roles, and for a specific MLS/MCS range. Each Linux user is mapped to an SELinux user using SELinux policy. This allows Linux users to inherit the restrictions placed on SELinux users. The mapped SELinux user identity is used in the SELinux context for processes in that session, in order to define what roles and levels they can enter. Enter the following command as root to view a list of mappings between SELinux and Linux user accounts (you need to have the `policycoreutils-python` package installed):

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	unconfined_u	s0-s0:c0.c1023	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*

Output may differ slightly from system to system:

- The **Login Name** column lists Linux users.
- The **SELinux User** column lists which SELinux user the Linux user is mapped to. For processes, the SELinux user limits which roles and levels are accessible.
- The **MLS/MCS Range** column, is the level used by Multi-Level Security (MLS) and Multi-Category Security (MCS).
- The **Service** column determines the correct SELinux context, in which the Linux user is supposed to be logged in to the system. By default, the asterisk (\*) character is used, which stands for any service.

### role

Part of SELinux is the Role-Based Access Control (RBAC) security model. The role is an attribute of RBAC. SELinux users are authorized for roles, and roles are authorized for domains. The role serves as an intermediary between domains and SELinux users. The roles that can be entered determine which domains can be entered; ultimately, this controls which object types can be accessed. This helps reduce vulnerability to privilege escalation attacks.

### type

The type is an attribute of Type Enforcement. The type defines a domain for processes, and a type for files. SELinux policy rules define how types can access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

### *level*

The level is an attribute of MLS and MCS. An MLS range is a pair of levels, written as *lowlevel-highlevel* if the levels differ, or *lowlevel* if the levels are identical ( **s0-s0** is the same as **s0**). Each level is a sensitivity-category pair, with categories being optional. If there are categories, the level is written as *sensitivity:category-set*. If there are no categories, it is written as *sensitivity*.

If the category set is a contiguous series, it can be abbreviated. For example, **c0.c3** is the same as **c0,c1,c2,c3**. The `/etc/selinux/targeted/setrans.conf` file maps levels ( **s0:c0**) to human-readable form (that is **CompanyConfidential**). In Red Hat Enterprise Linux, targeted policy enforces MCS, and in MCS, there is just one sensitivity, **s0**. MCS in Red Hat Enterprise Linux supports 1024 different categories: **c0** through to **c1023**. **s0-s0:c0.c1023** is sensitivity **s0** and authorized for all categories.

MLS enforces the Bell-La Padula Mandatory Access Model, and is used in Labeled Security Protection Profile (LSPP) environments. To use MLS restrictions, install the `selinux-policy-mls` package, and configure MLS to be the default SELinux policy. The MLS policy shipped with Red Hat Enterprise Linux omits many program domains that were not part of the evaluated configuration, and therefore, MLS on a desktop workstation is unusable (no support for the X Window System); however, an MLS policy from the [upstream SELinux Reference Policy](#) can be built that includes all program domains. For more information on MLS configuration, see [Section 4.13, “Multi-Level Security \(MLS\)”](#).

## 2.1. DOMAIN TRANSITIONS

A process in one domain transitions to another domain by executing an application that has the **entrypoint** type for the new domain. The **entrypoint** permission is used in SELinux policy and controls which applications can be used to enter a domain. The following example demonstrates a domain transition:

### Procedure 2.1. An Example of a Domain Transition

1. A user wants to change their password. To do this, they run the **passwd** utility. The `/usr/bin/passwd` executable is labeled with the **passwd\_exec\_t** type:

```
~]$ ls -Z /usr/bin/passwd
-rwsr-xr-x root root system_u:object_r:passwd_exec_t:s0 /usr/bin/passwd
```

The **passwd** utility accesses `/etc/shadow`, which is labeled with the **shadow\_t** type:

```
~]$ ls -Z /etc/shadow
-r----- root root system_u:object_r:shadow_t:s0 /etc/shadow
```

2. An SELinux policy rule states that processes running in the **passwd\_t** domain are allowed to read and write to files labeled with the **shadow\_t** type. The **shadow\_t** type is only applied to files that are required for a password change. This includes `/etc/gshadow`, `/etc/shadow`, and their backup files.
3. An SELinux policy rule states that the **passwd\_t** domain has its **entrypoint** permission set to the **passwd\_exec\_t** type.

4. When a user runs the **passwd** utility, the user's shell process transitions to the **passwd\_t** domain. With SELinux, since the default action is to deny, and a rule exists that allows (among other things) applications running in the **passwd\_t** domain to access files labeled with the **shadow\_t** type, the **passwd** application is allowed to access **/etc/shadow**, and update the user's password.

This example is not exhaustive, and is used as a basic example to explain domain transition. Although there is an actual rule that allows subjects running in the **passwd\_t** domain to access objects labeled with the **shadow\_t** file type, other SELinux policy rules must be met before the subject can transition to a new domain. In this example, Type Enforcement ensures:

- The **passwd\_t** domain can only be entered by executing an application labeled with the **passwd\_exec\_t** type; can only execute from authorized shared libraries, such as the **lib\_t** type; and cannot execute any other applications.
- Only authorized domains, such as **passwd\_t**, can write to files labeled with the **shadow\_t** type. Even if other processes are running with superuser privileges, those processes cannot write to files labeled with the **shadow\_t** type, as they are not running in the **passwd\_t** domain.
- Only authorized domains can transition to the **passwd\_t** domain. For example, the **sendmail** process running in the **sendmail\_t** domain does not have a legitimate reason to execute **passwd**; therefore, it can never transition to the **passwd\_t** domain.
- Processes running in the **passwd\_t** domain can only read and write to authorized types, such as files labeled with the **etc\_t** or **shadow\_t** types. This prevents the **passwd** application from being tricked into reading or writing arbitrary files.

## 2.2. SELINUX CONTEXTS FOR PROCESSES

Use the **ps -eZ** command to view the SELinux context for processes. For example:

### Procedure 2.2. View the SELinux Context for the **passwd** Utility

1. Open a terminal, such as **Applications → System Tools → Terminal**.
2. Run the **passwd** utility. Do not enter a new password:

```
~]$ passwd
Changing password for user user_name.
Changing password for user_name.
(current) UNIX password:
```

3. Open a new tab, or another terminal, and enter the following command. The output is similar to the following:

```
~]$ ps -eZ | grep passwd
unconfined_u:unconfined_r:passwd_t:s0-s0:c0.c1023 13212 pts/1 00:00:00 passwd
```

4. In the first tab/terminal, press **Ctrl+C** to cancel the **passwd** utility.

In this example, when the **passwd** utility (labeled with the **passwd\_exec\_t** type) is executed, the user's shell process transitions to the **passwd\_t** domain. Remember that the type defines a domain for processes, and a type for files.

To view the SELinux contexts for all running processes, run the **ps** utility again. Note that below is a truncated example of the output, and may differ on your system:

```
]$ ps -eZ
system_u:system_r:dhcpc_t:s0      1869 ? 00:00:00 dhclient
system_u:system_r:sshd_t:s0-s0:c0.c1023 1882 ? 00:00:00 sshd
system_u:system_r:gpm_t:s0      1964 ? 00:00:00 gpm
system_u:system_r:crond_t:s0-s0:c0.c1023 1973 ? 00:00:00 crond
system_u:system_r:kerneloops_t:s0 1983 ? 00:00:05 kerneloops
system_u:system_r:crond_t:s0-s0:c0.c1023 1991 ? 00:00:00 atd
```

The **system\_r** role is used for system processes, such as daemons. Type Enforcement then separates each domain.

## 2.3. SELINUX CONTEXTS FOR USERS

Use the following command to view the SELinux context associated with your Linux user:

```
~]$ id -Z
unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```

In Red Hat Enterprise Linux, Linux users run unconfined by default. This SELinux context shows that the Linux user is mapped to the SELinux **unconfined\_u** user, running as the **unconfined\_r** role, and is running in the **unconfined\_t** domain. **s0-s0** is an MLS range, which in this case, is the same as just **s0**. The categories the user has access to is defined by **c0.c1023**, which is all categories (**c0** through to **c1023**).

## CHAPTER 3. TARGETED POLICY

Targeted policy is the default SELinux policy used in Red Hat Enterprise Linux. When using targeted policy, processes that are targeted run in a confined domain, and processes that are not targeted run in an unconfined domain. For example, by default, logged-in users run in the **unconfined\_t** domain, and system processes started by init run in the **unconfined\_service\_t** domain; both of these domains are unconfined.

Executable and writable memory checks may apply to both confined and unconfined domains. However, by default, subjects running in an unconfined domain can allocate writable memory and execute it. These memory checks can be enabled by setting Booleans, which allow the SELinux policy to be modified at runtime. Boolean configuration is discussed later.

### 3.1. CONFINED PROCESSES

Almost every service that listens on a network, such as **sshd** or **httpd**, is confined in Red Hat Enterprise Linux. Also, most processes that run as the root user and perform tasks for users, such as the **passwd** utility, are confined. When a process is confined, it runs in its own domain, such as the **httpd** process running in the **httpd\_t** domain. If a confined process is compromised by an attacker, depending on SELinux policy configuration, an attacker's access to resources and the possible damage they can do is limited.

Complete this procedure to ensure that SELinux is enabled and the system is prepared to perform the following example:

#### Procedure 3.1. How to Verify SELinux Status

1. Confirm that SELinux is enabled, is running in enforcing mode, and that targeted policy is being used. The correct output should look similar to the output below:

```
~]$ sestatus
SELinux status:                enabled
SELinuxfs mount:              /sys/fs/selinux
SELinux root directory:       /etc/selinux
Loaded policy name:            targeted
Current mode:                  enforcing
Mode from config file:         enforcing
Policy MLS status:             enabled
Policy deny_unknown status:    allowed
Max kernel policy version:     30
```

See [Section 4.4, “Permanent Changes in SELinux States and Modes”](#) for detailed information about changing SELinux modes.

2. As root, create a file in the **/var/www/html/** directory:

```
~]# touch /var/www/html/testfile
```

3. Enter the following command to view the SELinux context of the newly created file:

```
~]$ ls -Z /var/www/html/testfile
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 /var/www/html/testfile
```

By default, Linux users run unconfined in Red Hat Enterprise Linux, which is why the **testfile** file

is labeled with the SELinux **unconfined\_u** user. RBAC is used for processes, not files. Roles do not have a meaning for files; the **object\_r** role is a generic role used for files (on persistent storage and network file systems). Under the **/proc** directory, files related to processes may use the **system\_r** role. The **httpd\_sys\_content\_t** type allows the **httpd** process to access this file.

The following example demonstrates how SELinux prevents the Apache HTTP Server (**httpd**) from reading files that are not correctly labeled, such as files intended for use by Samba. This is an example, and should not be used in production. It assumes that the **httpd** and **wget** packages are installed, the SELinux targeted policy is used, and that SELinux is running in enforcing mode.

### Procedure 3.2. An Example of Confined Process

1. As root, start the **httpd** daemon:

```
~]# systemctl start httpd.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]$ systemctl status httpd.service
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: active (running) since Mon 2013-08-05 14:00:55 CEST; 8s ago
```

2. Change into a directory where your Linux user has write access to, and enter the following command. Unless there are changes to the default configuration, this command succeeds:

```
~]$ wget http://localhost/testfile
--2009-11-06 17:43:01-- http://localhost/testfile
Resolving localhost... 127.0.0.1
Connecting to localhost[127.0.0.1]:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 0 [text/plain]
Saving to: `testfile'

[ <=>                ] 0  --.-K/s  in 0s

2009-11-06 17:43:01 (0.00 B/s) - `testfile' saved [0/0]
```

3. The **chcon** command relabels files; however, such label changes do not survive when the file system is relabeled. For permanent changes that survive a file system relabel, use the **semanage** utility, which is discussed later. As root, enter the following command to change the type to a type used by Samba:

```
~]# chcon -t samba_share_t /var/www/html/testfile
```

Enter the following command to view the changes:

```
~]$ ls -Z /var/www/html/testfile
-rw-r--r-- root root unconfined_u:object_r:samba_share_t:s0 /var/www/html/testfile
```

- Note that the current DAC permissions allow the **httpd** process access to **testfile**. Change into a directory where your user has write access to, and enter the following command. Unless there are changes to the default configuration, this command fails:

```
~]$ wget http://localhost/testfile
--2009-11-06 14:11:23-- http://localhost/testfile
Resolving localhost... 127.0.0.1
Connecting to localhost[127.0.0.1]:80... connected.
HTTP request sent, awaiting response... 403 Forbidden
2009-11-06 14:11:23 ERROR 403: Forbidden.
```

- As root, remove **testfile**:

```
~]# rm -i /var/www/html/testfile
```

- If you do not require **httpd** to be running, as root, enter the following command to stop it:

```
~]# systemctl stop httpd.service
```

This example demonstrates the additional security added by SELinux. Although DAC rules allowed the **httpd** process access to **testfile** in step 2, because the file was labeled with a type that the **httpd** process does not have access to, SELinux denied access.

If the **auditd** daemon is running, an error similar to the following is logged to **/var/log/audit/audit.log**:

```
type=AVC msg=audit(1220706212.937:70): avc: denied { getattr } for pid=1904 comm="httpd"
path="/var/www/html/testfile" dev=sda5 ino=247576 scontext=unconfined_u:system_r:httpd_t:s0
tcontext=unconfined_u:object_r:samba_share_t:s0 tclass=file
```

```
type=SYSCALL msg=audit(1220706212.937:70): arch=400000003 syscall=196 success=no exit=-13
a0=b9e21da0 a1=bf9581dc a2=555ff4 a3=2008171 items=0 ppid=1902 pid=1904 auid=500 uid=48
gid=48 euid=48 suid=48 fsuid=48 egid=48 sgid=48 fsgid=48 tty=(none) ses=1 comm="httpd"
exe="/usr/sbin/httpd" subj=unconfined_u:system_r:httpd_t:s0 key=(null)
```

Also, an error similar to the following is logged to **/var/log/httpd/error\_log**:

```
[Wed May 06 23:00:54 2009] [error] [client 127.0.0.1] (13)Permission denied: access to /testfile
denied
```

## 3.2. UNCONFINED PROCESSES

Unconfined processes run in unconfined domains, for example, unconfined services executed by **init** end up running in the **unconfined\_service\_t** domain, unconfined services executed by kernel end up running in the **kernel\_t** domain, and unconfined services executed by unconfined Linux users end up running in the **unconfined\_t** domain. For unconfined processes, SELinux policy rules are applied, but policy rules exist that allow processes running in unconfined domains almost all access. Processes running in unconfined domains fall back to using DAC rules exclusively. If an unconfined process is compromised, SELinux does not prevent an attacker from gaining access to system resources and data, but of course, DAC rules are still used. SELinux is a security enhancement on top of DAC rules – it does not replace them.

To ensure that SELinux is enabled and the system is prepared to perform the following example, complete the [Procedure 3.1, “How to Verify SELinux Status”](#) described in [Section 3.1, “Confined Processes”](#).

The following example demonstrates how the Apache HTTP Server (**httpd**) can access data intended for use by Samba, when running unconfined. Note that in Red Hat Enterprise Linux, the **httpd** process runs in the confined **httpd\_t** domain by default. This is an example, and should not be used in production. It assumes that the **httpd**, **wget**, **dbus** and **audit** packages are installed, that the SELinux targeted policy is used, and that SELinux is running in enforcing mode.

### Procedure 3.3. An Example of Unconfined Process

1. The **chcon** command relabels files; however, such label changes do not survive when the file system is relabeled. For permanent changes that survive a file system relabel, use the **semanage** utility, which is discussed later. As the root user, enter the following command to change the type to a type used by Samba:

```
~]# chcon -t samba_share_t /var/www/html/testfile
```

View the changes:

```
~]$ ls -Z /var/www/html/testfile
-rw-r--r-- root root unconfined_u:object_r:samba_share_t:s0 /var/www/html/testfile
```

2. Enter the following command to confirm that the **httpd** process is not running:

```
~]$ systemctl status httpd.service
httpd.service - The Apache HTTP Server
Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
Active: inactive (dead)
```

If the output differs, enter the following command as root to stop the **httpd** process:

```
~]# systemctl stop httpd.service
```

3. To make the **httpd** process run unconfined, enter the following command as root to change the type of the **/usr/sbin/httpd** file, to a type that does not transition to a confined domain:

```
~]# chcon -t bin_t /usr/sbin/httpd
```

4. Confirm that **/usr/sbin/httpd** is labeled with the **bin\_t** type:

```
~]$ ls -Z /usr/sbin/httpd
-rwxr-xr-x. root root system_u:object_r:bin_t:s0 /usr/sbin/httpd
```

5. As root, start the **httpd** process and confirm, that it started successfully:

```
~]# systemctl start httpd.service
```

```
~]# systemctl status httpd.service
httpd.service - The Apache HTTP Server
Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
```

Active: active (running) since Thu 2013-08-15 11:17:01 CEST; 5s ago

6. Enter the following command to view **httpd** running in the **unconfined\_service\_t** domain:

```
~]$ ps -eZ | grep httpd
system_u:system_r:unconfined_service_t:s0 11884 ? 00:00:00 httpd
system_u:system_r:unconfined_service_t:s0 11885 ? 00:00:00 httpd
system_u:system_r:unconfined_service_t:s0 11886 ? 00:00:00 httpd
system_u:system_r:unconfined_service_t:s0 11887 ? 00:00:00 httpd
system_u:system_r:unconfined_service_t:s0 11888 ? 00:00:00 httpd
system_u:system_r:unconfined_service_t:s0 11889 ? 00:00:00 httpd
```

7. Change into a directory where your Linux user has write access to, and enter the following command. Unless there are changes to the default configuration, this command succeeds:

```
~]$ wget http://localhost/testfile
--2009-05-07 01:41:10-- http://localhost/testfile
Resolving localhost... 127.0.0.1
Connecting to localhost[127.0.0.1]:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 0 [text/plain]
Saving to: `testfile'
```

```
[ <=>          ]--.-K/s  in 0s
```

```
2009-05-07 01:41:10 (0.00 B/s) - `testfile' saved [0/0]
```

Although the **httpd** process does not have access to files labeled with the **samba\_share\_t** type, **httpd** is running in the unconfined **unconfined\_service\_t** domain, and falls back to using DAC rules, and as such, the **wget** command succeeds. Had **httpd** been running in the confined **httpd\_t** domain, the **wget** command would have failed.

8. The **restorecon** utility restores the default SELinux context for files. As root, enter the following command to restore the default SELinux context for **/usr/sbin/httpd**:

```
~]# restorecon -v /usr/sbin/httpd
restorecon reset /usr/sbin/httpd context system_u:object_r:unconfined_exec_t:s0-
>system_u:object_r:httpd_exec_t:s0
```

Confirm that **/usr/sbin/httpd** is labeled with the **httpd\_exec\_t** type:

```
~]$ ls -Z /usr/sbin/httpd
-rwxr-xr-x root root system_u:object_r:httpd_exec_t:s0 /usr/sbin/httpd
```

9. As root, enter the following command to restart **httpd**. After restarting, confirm that **httpd** is running in the confined **httpd\_t** domain:

```
~]# systemctl restart httpd.service
```

```
~]$ ps -eZ | grep httpd
system_u:system_r:httpd_t:s0 8883 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 8884 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 8885 ? 00:00:00 httpd
```

```
system_u:system_r:httpd_t:s0 8886 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 8887 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 8888 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 8889 ? 00:00:00 httpd
```

10. As root, remove **testfile**:

```
~]# rm -i /var/www/html/testfile
rm: remove regular empty file `/var/www/html/testfile'? y
```

11. If you do not require **httpd** to be running, as root, enter the following command to stop **httpd**:

```
~]# systemctl stop httpd.service
```

The examples in these sections demonstrate how data can be protected from a compromised confined-process (protected by SELinux), as well as how data is more accessible to an attacker from a compromised unconfined-process (not protected by SELinux).

### 3.3. CONFINED AND UNCONFINED USERS

Each Linux user is mapped to an SELinux user using SELinux policy. This allows Linux users to inherit the restrictions on SELinux users. This Linux user mapping is seen by running the **semanage login -l** command as root:

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	unconfined_u	s0-s0:c0.c1023	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*

In Red Hat Enterprise Linux, Linux users are mapped to the SELinux **\_\_default\_\_** login by default, which is mapped to the SELinux **unconfined\_u** user. The following line defines the default mapping:

```
__default__      unconfined_u      s0-s0:c0.c1023
```

The following procedure demonstrates how to add a new Linux user to the system and how to map that user to the SELinux **unconfined\_u** user. It assumes that the root user is running unconfined, as it does by default in Red Hat Enterprise Linux:

#### Procedure 3.4. Mapping a New Linux User to the SELinux **unconfined\_u** User

1. As root, enter the following command to create a new Linux user named **newuser**:

```
~]# useradd newuser
```

2. To assign a password to the Linux **newuser** user. Enter the following command as root:

```
~]# passwd newuser
Changing password for user newuser.
New UNIX password: Enter a password
```

Retype new UNIX password: *Enter the same password again*  
 passwd: all authentication tokens updated successfully.

- Log out of your current session, and log in as the Linux **newuser** user. When you log in, the **pam\_selinux** PAM module automatically maps the Linux user to an SELinux user (in this case, **unconfined\_u**), and sets up the resulting SELinux context. The Linux user's shell is then launched with this context. Enter the following command to view the context of a Linux user:

```
[newuser@localhost ~]$ id -Z
unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```



## NOTE

If you no longer need the **newuser** user on your system, log out of the Linux **newuser**'s session, log in with your account, and run the **userdel -r newuser** command as root. It will remove **newuser** along with their home directory.

Confined and unconfined Linux users are subject to executable and writable memory checks, and are also restricted by MCS or MLS.

To list the available SELinux users, enter the following command:

```
~]$seinfo -u
Users: 8
  sysadm_u
  system_u
  xguest_u
  root
  guest_u
  staff_u
  user_u
  unconfined_u
```

Note that the **seinfo** command is provided by the **setools-console** package, which is not installed by default.

If an unconfined Linux user executes an application that SELinux policy defines as one that can transition from the **unconfined\_t** domain to its own confined domain, the unconfined Linux user is still subject to the restrictions of that confined domain. The security benefit of this is that, even though a Linux user is running unconfined, the application remains confined. Therefore, the exploitation of a flaw in the application can be limited by the policy.

Similarly, we can apply these checks to confined users. Each confined Linux user is restricted by a confined user domain. The SELinux policy can also define a transition from a confined user domain to its own target confined domain. In such a case, confined Linux users are subject to the restrictions of that target confined domain. The main point is that special privileges are associated with the confined users according to their role. In the table below, you can see examples of basic confined domains for Linux users in Red Hat Enterprise Linux:

**Table 3.1. SELinux User Capabilities**

User	Role	Domain	X Window System	su or sudo	Execute in home directory and /tmp (default)	Networking
sysadm_u	sysadm_r	sysadm_t	yes	<b>su</b> and <b>sudo</b>	yes	yes
staff_u	staff_r	staff_t	yes	only <b>sudo</b>	yes	yes
user_u	user_r	user_t	yes	no	yes	yes
guest_u	guest_r	guest_t	no	no	yes	no
xguest_u	xguest_r	xguest_t	yes	no	yes	Firefox only

- Linux users in the **user\_t**, **guest\_t**, and **xguest\_t** domains can only run set user ID (setuid) applications if SELinux policy permits it (for example, **passwd**). These users cannot run the **su** and **sudo** setuid applications, and therefore cannot use these applications to become root.
- Linux users in the **sysadm\_t**, **staff\_t**, **user\_t**, and **xguest\_t** domains can log in using the X Window System and a terminal.
- By default, Linux users in the **staff\_t**, **user\_t**, **guest\_t**, and **xguest\_t** domains can execute applications in their home directories and **/tmp**. To prevent them from executing applications, which inherit users' permissions, in directories they have write access to, set the **guest\_exec\_content** and **xguest\_exec\_content** booleans to **off**. This helps prevent flawed or malicious applications from modifying users' files.

See [Section 6.6, “Booleans for Users Executing Applications”](#) for information about allowing and preventing users from executing applications in their home directories and **/tmp**.

- The only network access Linux users in the **xguest\_t** domain have is **Firefox** connecting to web pages.

Note that **system\_u** is a special user identity for system processes and objects. It must never be associated to a Linux user. Also, **unconfined\_u** and **root** are unconfined users. For these reasons, they are not included in the aforementioned table of SELinux user capabilities.

Alongside with the already mentioned SELinux users, there are special roles, that can be mapped to those users. These roles determine what SELinux allows the user to do:

- **webadm\_r** can only administrate SELinux types related to the Apache HTTP Server. See [Section 14.2, “Types”](#) for further information.
- **dbadm\_r** can only administrate SELinux types related to the MariaDB database and the PostgreSQL database management system. See [Section 21.2, “Types”](#) and [Section 22.2, “Types”](#) for further information.
- **logadm\_r** can only administrate SELinux types related to the **syslog** and **auditlog** processes.
- **secadm\_r** can only administrate SELinux.
- **auditadm\_r** can only administrate processes related to the **audit** subsystem.

To list all available roles, enter the following command:

```
~]$ seinfo -r
```

As mentioned before, the **seinfo** command is provided by the `setools-console` package, which is not installed by default.

### 3.3.1. The sudo Transition and SELinux Roles

In certain cases, confined users need to perform an administrative task that require root privileges. To do so, such a confined user has to gain a *confined administrator* SELinux role using the **sudo** command. The **sudo** command is used to give trusted users administrative access. When users precede an administrative command with **sudo**, they are prompted for their *own* password. Then, when they have been authenticated and assuming that the command is permitted, the administrative command is executed as if they were the root user.

As shown in [Table 3.1, "SELinux User Capabilities"](#), only the **staff\_u** and **sysadm\_u** SELinux confined users are permitted to use **sudo** by default. When such users execute a command with **sudo**, their role can be changed based on the rules specified in the `/etc/sudoers` configuration file or in a respective file in the `/etc/sudoers.d/` directory if such a file exists.

For more information about **sudo**, see the *Gaining Privileges* section in the [Red Hat Enterprise Linux 7 System Administrator's Guide](#).

#### Procedure 3.5. Configuring the sudo Transition

This procedure shows how to set up **sudo** to transition a newly-created `SELinux_user_u` confined user from a `default_role_t` to a `administrator_r` administrator role. To configure a confined administrator role for an already existing SELinux user, skip the first two steps. Also, note that the following commands must be run as the root user. To better understand the placeholders in the following procedure, such as `default_role_t` or `administrator_r`, see the example in step 6.

1. Create a new SELinux user and specify the default SELinux role and a supplementary confined administrator role for this user:

```
~]# semanage user -a -r s0-s0:c0.c1023 -R "default_role_r administrator_r" SELinux_user_u
```

2. Set up the default SELinux policy context file. For example, to have the same SELinux rules as the **staff\_u** SELinux user, copy the **staff\_u** context file:

```
~]# cp /etc/selinux/targeted/contexts/users/staff_u  
/etc/selinux/targeted/contexts/users/SELinux_user_u
```

3. Map the newly-created SELinux user to an existing Linux user:

```
semanage login -a -s SELinux_user_u -rs0:c0.c1023 linux_user
```

4. Create a new configuration file with the same name as your Linux user in the `/etc/sudoers.d/` directory and add the following string to it:

```
~]# echo "linux_user ALL=(ALL) TYPE=administrator_t ROLE=administrator_r /bin/sh " >  
/etc/sudoers.d/linux_user
```

5. Use the **restorecon** utility to relabel the *linux\_user* home directory:

```
~]# restorecon -FR -v /home/linux_user
```

6. When you log in to the system as the newly-created Linux user, the user is labeled with the default SELinux role:

```
~]$ id -Z
SELinux_user_u:default_role_r.SELinux_user_t:s0:c0.c1023
```

After running **sudo**, the user's SELinux context changes to the supplementary SELinux role as specified in **/etc/sudoers.d/linux\_user**. The **-i** option used with **sudo** caused that an interactive shell is executed:

```
~]$ sudo -i
~]# id -Z
SELinux_user_u:administrator_r.administrator_t:s0-s0:c0.c1023
```

For the **SELinux\_user\_u** user from the example specified in the first step the output looks like below:

```
~]$ id -Z
confined_u:staff_r:staff_t:s0:c0.c1023
~]$ sudo -i
~]# id -Z
confined_u:webadm_r:webadm_t:s0:c0.c1023
```

In the example bellow, we will create a new SELinux user **confined\_u** with default assigned role **staff\_r** and with **sudo** configured to change the role of **confined\_u** from **staff\_r** to **webadm\_r**.

```
~]# semanage user -a -r s0-s0:c0.c1023 -R "staff_r webadm_r" confined_u
~]# cp /etc/selinux/targeted/contexts/users/staff_u
/etc/selinux/targeted/contexts/users/confined_u
~]# semanage login -a -s confined_u -rs0:c0.c1023 linux_user
~]# restorecon -FR -v /home/linux_user
~]# echo "linux_user ALL=(ALL) TYPE=webadm_t ROLE=webadm_r /bin/sh " >
/etc/sudoers.d/linux_user
```

When you log in to the system as the newly-created Linux user, the user is labeled with the default SELinux role:

```
~]$ id -Z
confined_u:staff_r:staff_t:s0:c0.c1023
~]$ sudo -i
~]# id -Z
confined_u:webadm_r:webadm_t:s0:c0.c1023
```

## CHAPTER 4. WORKING WITH SELINUX

The following sections give a brief overview of the main SELinux packages in Red Hat Enterprise Linux; installing and updating packages; which log files are used; the main SELinux configuration file; enabling and disabling SELinux; SELinux modes; configuring Booleans; temporarily and persistently changing file and directory labels; overriding file system labels with the **mount** command; mounting NFS volumes; and how to preserve SELinux contexts when copying and archiving files and directories.

### 4.1. SELINUX PACKAGES

In Red Hat Enterprise Linux full installation, the SELinux packages are installed by default unless they are manually excluded during installation. If performing a minimal installation in text mode, the `policycoreutils-python` and the `policycoreutils-gui` package are not installed by default. Also, by default, SELinux runs in enforcing mode and the SELinux targeted policy is used. The following SELinux packages are installed on your system by default:

- `policycoreutils` provides utilities such as **restorecon**, **secon**, **setfiles**, **semodule**, **load\_policy**, and **setsebool**, for operating and managing SELinux.
- `selinux-policy` provides a basic directory structure, the **selinux-policy.conf** file, and RPM macros.
- `selinux-policy-targeted` provides the SELinux targeted policy.
- `libselinux` – provides an API for SELinux applications.
- `libselinux-utils` provides the **avcstat**, **getenforce**, **getsebool**, **matchpathcon**, **selinuxconlist**, **selinuxdefcon**, **selinuxenabled**, and **setenforce** utilities.
- `libselinux-python` provides Python bindings for developing SELinux applications.

The following packages are not installed by default but can be optionally installed by running the **yum install <package-name>** command:

- `selinux-policy-devel` provides utilities for creating a custom SELinux policy and policy modules.
- `selinux-policy-doc` provides manual pages that describe how to configure SELinux altogether with various services.
- `selinux-policy-mls` provides the MLS (Multi-Level Security) SELinux policy.
- `setroubleshoot-server` translates denial messages, produced when access is denied by SELinux, into detailed descriptions that can be viewed with the **sealert** utility, also provided in this package.
- `setools-console` provides the [Tresys Technology SETools distribution](#), a number of utilities and libraries for analyzing and querying policy, audit log monitoring and reporting, and file context management. The `setools` package is a meta-package for SETools. The `setools-gui` package provides the **apol** and **seaudit** utilities. The `setools-console` package provides the **sechecker**, **sediff**, **seinfo**, **sesearch**, and **findcon** command-line utilities. See the [Tresys Technology SETools](#) page for information about these utilities. Note that `setools` and `setools-gui` packages are available only when the Red Hat Network Optional channel is enabled. For further information, see [Scope of Coverage Details](#).
- `mcstrans` translates levels, such as **s0-s0:c0.c1023**, to a form that is easier to read, such as **SystemLow-SystemHigh**.

- `policycoreutils-python` provides utilities such as **semanage**, **audit2allow**, **audit2why**, and **chcat**, for operating and managing SELinux.
- `policycoreutils-gui` provides **system-config-selinux**, a graphical utility for managing SELinux.

## 4.2. WHICH LOG FILE IS USED

In Red Hat Enterprise Linux, the `dbus` and `audit` packages are installed by default, unless they are removed from the default package selection. The `setroubleshoot-server` must be installed using Yum (use the **`yum install setroubleshoot-server`** command).

If the **auditd** daemon is running, an SELinux denial message, such as the following, is written to `/var/log/audit/audit.log` by default:

```
type=AVC msg=audit(1223024155.684:49): avc: denied { getattr } for pid=2000 comm="httpd"
path="/var/www/html/file1" dev=dm-0 ino=399185 scontext=unconfined_u:system_r:httpd_t:s0
tcontext=system_u:object_r:samba_share_t:s0 tclass=file
```

In addition, a message similar to the one below is written to the `/var/log/message` file:

```
May 7 18:55:56 localhost setroubleshoot: SELinux is preventing httpd (httpd_t) "getattr" to
/var/www/html/file1 (samba_share_t). For complete SELinux messages. run sealert -l de7e30d6-
5488-466d-a606-92c9f40d316d
```

In Red Hat Enterprise Linux 7, **setroubleshootd** no longer constantly runs as a service. However, it is still used to analyze the AVC messages. Two new programs act as a method to start **setroubleshoot** when needed:

- The **sedispatch** utility runs as a part of the **audit** subsystem. When an AVC denial message is returned, **sedispatch** sends a message using **dbus**. These messages go straight to **setroubleshootd** if it is already running. If it is not running, **sedispatch** starts it automatically.
- The **seapplet** utility runs in the system toolbar, waiting for `dbus` messages in **setroubleshootd**. It launches the notification bubble, allowing the user to review AVC messages.

### Procedure 4.1. Starting Daemons Automatically

1. To configure the **auditd** and **rsyslog** daemons to automatically start at boot, enter the following commands as the root user:

```
~]# systemctl enable auditd.service
```

```
~]# systemctl enable rsyslog.service
```

2. To ensure that the daemons are enabled, type the following commands at the shell prompt:

```
~]$ systemctl is-enabled auditd
enabled
```

```
~]$ systemctl is-enabled rsyslog
enabled
```

Alternatively, use the **systemctl status service-name.service** command and search for the keyword **enabled** in the command output, for example:

```
~]$ systemctl status auditd.service | grep enabled
auditd.service - Security Auditing Service
Loaded: loaded (/usr/lib/systemd/system/auditd.service; enabled)
```

To learn more on how the **systemd** daemon manages system services, see the [Managing System Services](#) chapter in the System Administrator's Guide.

## 4.3. MAIN CONFIGURATION FILE

The **/etc/selinux/config** file is the main SELinux configuration file. It controls whether SELinux is enabled or disabled and which SELinux mode and SELinux policy is used:

```
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#   enforcing - SELinux security policy is enforced.
#   permissive - SELinux prints warnings instead of enforcing.
#   disabled - No SELinux policy is loaded.
SELINUX=enforcing
# SELINUXTYPE= can take one of these two values:
#   targeted - Targeted processes are protected,
#   mls - Multi Level Security protection.
SELINUXTYPE=targeted
```

### SELINUX=

The **SELINUX** option sets whether SELinux is disabled or enabled and in which mode - enforcing or permissive - it is running:

- When using **SELINUX=enforcing**, SELinux policy is enforced, and SELinux denies access based on SELinux policy rules. Denial messages are logged.
- When using **SELINUX=permissive**, SELinux policy is not enforced. SELinux does not deny access, but denials are logged for actions that would have been denied if running SELinux in enforcing mode.
- When using **SELINUX=disabled**, SELinux is disabled, the SELinux module is not registered with the Linux kernel, and only DAC rules are used.

### SELINUXTYPE=

The **SELINUXTYPE** option sets the SELinux policy to use. Targeted policy is the default policy. Only change this option if you want to use the MLS policy. For information on how to enable the MLS policy, see [Section 4.13.2, "Enabling MLS in SELinux"](#).

## 4.4. PERMANENT CHANGES IN SELINUX STATES AND MODES

As discussed in [Section 1.4, "SELinux States and Modes"](#), SELinux can be enabled or disabled. When enabled, SELinux has two modes: enforcing and permissive.

Use the **getenforce** or **sestatus** commands to check in which mode SELinux is running. The **getenforce** command returns **Enforcing**, **Permissive**, or **Disabled**.

The **sestatus** command returns the SELinux status and the SELinux policy being used:

```
~]$ sestatus
SELinux status:      enabled
SELinuxfs mount:    /sys/fs/selinux
SELinux root directory: /etc/selinux
Loaded policy name:  targeted
Current mode:       enforcing
Mode from config file: enforcing
Policy MLS status:   enabled
Policy deny_unknown status: allowed
Max kernel policy version: 30
```



## NOTE

When systems run SELinux in permissive mode, users are able to label files incorrectly. Files created while SELinux is disabled are not labeled at all. This behavior causes problems when changing to enforcing mode because files are labeled incorrectly or are not labeled at all. To prevent incorrectly labeled and unlabeled files from causing problems, file systems are automatically relabeled when changing from the disabled state to permissive or enforcing mode.

### 4.4.1. Enabling SELinux

When enabled, SELinux can run in one of two modes: enforcing or permissive. The following sections show how to permanently change into these modes.

While enabling SELinux on systems that previously had it disabled, to avoid problems, such as systems unable to boot or process failures, Red Hat recommends to follow this procedure:

1. Enable SELinux in permissive mode. For more information, see [Section 4.4.1.1, “Permissive Mode”](#).
2. Reboot your system.
3. Check for SELinux denial messages. For more information, see [Section 11.3.5, “Searching For and Viewing Denials”](#).
4. If there are no denials, switch to enforcing mode. For more information, see [Section 4.4.1.2, “Enforcing Mode”](#).

To run custom applications with SELinux in enforcing mode, choose one of the following scenarios:

- Run your application in the **unconfined\_service\_t** domain. See [Section 3.2, “Unconfined Processes”](#) for more information.
- Write a new policy for your application. See the [Writing Custom SELinux Policy](#) Knowledgebase article for more information.

#### 4.4.1.1. Permissive Mode

When SELinux is running in permissive mode, SELinux policy is not enforced. The system remains operational and SELinux does not deny any operations but only logs AVC messages, which can be then used for troubleshooting, debugging, and SELinux policy improvements. Each AVC is logged only once in this case.

To permanently change mode to permissive, follow the procedure below:

#### Procedure 4.2. Changing to Permissive Mode

1. Edit the **/etc/selinux/config** file as follows:

```
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#   enforcing - SELinux security policy is enforced.
#   permissive - SELinux prints warnings instead of enforcing.
#   disabled - No SELinux policy is loaded.
SELINUX=permissive
# SELINUXTYPE= can take one of these two values:
#   targeted - Targeted processes are protected,
#   mls - Multi Level Security protection.
SELINUXTYPE=targeted
```

2. Reboot the system:

```
~]# reboot
```

#### 4.4.1.2. Enforcing Mode

When SELinux is running in enforcing mode, it enforces the SELinux policy and denies access based on SELinux policy rules. In Red Hat Enterprise Linux, enforcing mode is enabled by default when the system was initially installed with SELinux.

If SELinux was disabled, follow the procedure below to change mode to enforcing again:

#### Procedure 4.3. Changing to Enforcing Mode

This procedure assumes that the `selinux-policy-targeted`, `selinux-policy`, `libselinux`, `libselinux-python`, `libselinux-utils`, `policycoreutils`, and `policycoreutils-python` packages are installed. To verify that the packages are installed, use the following command:

```
rpm -q package_name
```

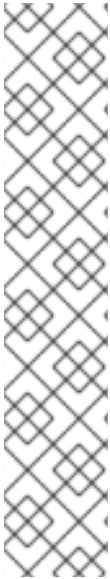
1. Edit the **/etc/selinux/config** file as follows:

```
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#   enforcing - SELinux security policy is enforced.
#   permissive - SELinux prints warnings instead of enforcing.
#   disabled - No SELinux policy is loaded.
SELINUX=enforcing
# SELINUXTYPE= can take one of these two values:
#   targeted - Targeted processes are protected,
#   mls - Multi Level Security protection.
SELINUXTYPE=targeted
```

2. Reboot the system:

```
~]# reboot
```

On the next boot, SELinux relabels all the files and directories within the system and adds SELinux context for files and directories that were created when SELinux was disabled.



## NOTE

After changing to enforcing mode, SELinux may deny some actions because of incorrect or missing SELinux policy rules. To view what actions SELinux denies, enter the following command as root:

```
~]# ausearch -m AVC,USER_AVC,SELINUX_ERR -ts today
```

Alternatively, with the `setroubleshoot-server` package installed, enter the following command as root:

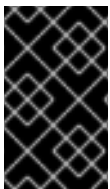
```
~]# grep "SELinux is preventing" /var/log/messages
```

If SELinux denies some actions, see [Chapter 11, Troubleshooting](#) for information about troubleshooting.

Temporary changes in modes are covered in [Section 1.4, "SELinux States and Modes"](#).

## 4.4.2. Disabling SELinux

When SELinux is disabled, SELinux policy is not loaded at all; it is not enforced and AVC messages are not logged. Therefore, all benefits of running SELinux listed in [Section 1.1, "Benefits of running SELinux"](#) are lost.



## IMPORTANT

Red Hat strongly recommends to use permissive mode instead of permanently disabling SELinux. See [Section 4.4.1.1, "Permissive Mode"](#) for more information about permissive mode.

To permanently disable SELinux, follow the procedure below:

### Procedure 4.4. Disabling SELinux

1. Configure **SELINUX=disabled** in the `/etc/selinux/config` file:

```
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#   enforcing - SELinux security policy is enforced.
#   permissive - SELinux prints warnings instead of enforcing.
#   disabled - No SELinux policy is loaded.
SELINUX=disabled
# SELINUXTYPE= can take one of these two values:
#   targeted - Targeted processes are protected,
#   mls - Multi Level Security protection.
SELINUXTYPE=targeted
```

2. Reboot your system. After reboot, confirm that the **getenforce** command returns **Disabled**:

```
~]$ getenforce
Disabled
```

## 4.5. CHANGING SELINUX MODES AT BOOT TIME

On boot, you can set several kernel parameters to change the way SELinux runs:

### enforcing=0

Setting this parameter causes the system to start in permissive mode, which is useful when troubleshooting issues. Using permissive mode might be the only option to detect a problem if your file system is too corrupted. Moreover, in permissive mode, the system continues to create the labels correctly. The AVC messages that are created in this mode can be different than in enforcing mode.

In permissive mode, only the first denial from a series of the same denials is reported. However, in enforcing mode, you might get a denial related to reading a directory, and an application stops. In permissive mode, you get the same AVC message, but the application continues reading files in the directory and you get an AVC for each denial in addition.

### selinux=0

This parameter causes the kernel to not load any part of the SELinux infrastructure. The init scripts notice that the system booted with the **selinux=0** parameter and touch the **/.autorelabel** file. This causes the system to automatically relabel the next time you boot with SELinux enabled.



### IMPORTANT

Red Hat does not recommend using the **selinux=0** parameter. To debug your system, prefer using permissive mode.

### autorelabel=1

This parameter forces the system to relabel similarly to the following commands:

```
~]# touch /.autorelabel
~]# reboot
```

If the system labeling contains a large amount of errors, you might need to boot in permissive mode in order that the autorelabel succeeds.

For additional SELinux-related kernel boot parameters, such as **checkreqprot**, see the **/usr/share/doc/kernel-doc-*<KERNEL\_VER>*/Documentation/kernel-parameters.txt** file. This documentation is installed with the kernel-doc package. Replace the *<KERNEL\_VER>* string with the version number of the installed kernel, for example:

```
~]# yum install kernel-doc
~]$ less /usr/share/doc/kernel-doc-3.10.0/Documentation/kernel-parameters.txt
```

## 4.6. BOOLEANS

Booleans allow parts of SELinux policy to be changed at runtime, without any knowledge of SELinux policy writing. This allows changes, such as allowing services access to NFS volumes, without reloading or recompiling SELinux policy.

### 4.6.1. Listing Booleans

For a list of Booleans, an explanation of what each one is, and whether they are on or off, run the **semanage boolean -l** command as the Linux root user. The following example does not list all Booleans and the output is shortened for brevity:

```
~]# semanage boolean -l
SELinux boolean      State  Default Description

smartmon_3ware        (off , off) Determine whether smartmon can...
mpd_enable_homedirs    (off , off) Determine whether mpd can traverse...
```



#### NOTE

To have more detailed descriptions, install the `selinux-policy-devel` package.

The **SELinux boolean** column lists Boolean names. The **Description** column lists whether the Booleans are on or off, and what they do.

The **getsebool -a** command lists Booleans, whether they are on or off, but does not give a description of each one. The following example does not list all Booleans:

```
~]$ getsebool -a
cvs_read_shadow --> off
daemons_dump_core --> on
```

Run the **getsebool *boolean-name*** command to only list the status of the *boolean-name* Boolean:

```
~]$ getsebool cvs_read_shadow
cvs_read_shadow --> off
```

Use a space-separated list to list multiple Booleans:

```
~]$ getsebool cvs_read_shadow daemons_dump_core
cvs_read_shadow --> off
daemons_dump_core --> on
```

### 4.6.2. Configuring Booleans

Run the **setsebool** utility in the **setsebool *boolean\_name* on/off** form to enable or disable Booleans.

The following example demonstrates configuring the **httpd\_can\_network\_connect\_db** Boolean:

#### Procedure 4.5. Configuring Booleans

1. By default, the **httpd\_can\_network\_connect\_db** Boolean is off, preventing Apache HTTP Server scripts and modules from connecting to database servers:

```
~]$ getsebool httpd_can_network_connect_db
httpd_can_network_connect_db --> off
```

2. To temporarily enable Apache HTTP Server scripts and modules to connect to database servers, enter the following command as root:

```
~]# setsebool httpd_can_network_connect_db on
```

3. Use the **getsebool** utility to verify the Boolean has been enabled:

```
~]$ getsebool httpd_can_network_connect_db
httpd_can_network_connect_db --> on
```

This allows Apache HTTP Server scripts and modules to connect to database servers.

4. This change is not persistent across reboots. To make changes persistent across reboots, run the **setsebool -P *boolean-name* on** command as root: <sup>[3]</sup>

```
~]# setsebool -P httpd_can_network_connect_db on
```

### 4.6.3. Shell Auto-Completion

It is possible to use shell auto-completion with the **getsebool**, **setsebool**, and **semanage** utilities. Use the auto-completion with **getsebool** and **setsebool** to complete both command-line parameters and Booleans. To list only the command-line parameters, add the hyphen character ("-") after the command name and hit the **Tab** key:

```
~]# setsebool -[Tab]
-P
```

To complete a Boolean, start writing the Boolean name and then hit **Tab**:

```
~]$ getsebool samba_[Tab]
samba_create_home_dirs  samba_export_all_ro    samba_run_unconfined
samba_domain_controller samba_export_all_rw    samba_share_fusefs
samba_enable_home_dirs  samba_portmapper      samba_share_nfs
```

```
~]# setsebool -P virt_use_[Tab]
virt_use_comm    virt_use_nfs    virt_use_sanlock
virt_use_execmem virt_use_rawip  virt_use_usb
virt_use_fusefs  virt_use_samba  virt_use_xserver
```

The **semanage** utility is used with several command-line arguments that are completed one by one. The first argument of a **semanage** command is an option, which specifies what part of SELinux policy is managed:

```
~]# semanage [Tab]
boolean  export  import  login  node  port
dontaudit fcontext interface module permissive user
```

Then, one or more command-line parameters follow:

```
~]# semanage fcontext -[Tab]
-a      -D      --equal  --help  -m      -o
--add    --delete  -f      -l      --modify -S
```

```
-C      --deleteall --ftype    --list    -n      -t
-d      -e          -h          --localist --noheading --type
```

Finally, complete the name of a particular SELinux entry, such as a Boolean, SELinux user, domain, or another. Start typing the entry and hit **Tab**:

```
~]# semanage fcontext -a -t samba<tab>
samba_etc_t          samba_secrets_t
sambagui_exec_t      samba_share_t
samba_initrc_exec_t  samba_unconfined_script_exec_t
samba_log_t          samba_unit_file_t
samba_net_exec_t
```

Command-line parameters can be chained in a command:

```
~]# semanage port -a -t http_port_t -p tcp 81
```

## 4.7. SELINUX CONTEXTS – LABELING FILES

On systems running SELinux, all processes and files are labeled in a way that represents security-relevant information. This information is called the SELinux context. For files, this is viewed using the **ls -Z** command:

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

In this example, SELinux provides a user (**unconfined\_u**), a role (**object\_r**), a type (**user\_home\_t**), and a level (**s0**). This information is used to make access control decisions. On DAC systems, access is controlled based on Linux user and group IDs. SELinux policy rules are checked after DAC rules. SELinux policy rules are not used if DAC rules deny access first.

### NOTE

By default, newly-created files and directories inherit the SELinux type of their parent directories. For example, when creating a new file in the **/etc** directory that is labeled with the **etc\_t** type, the new file inherits the same type:

```
~]$ ls -dZ - /etc
drwxr-xr-x. root root system_u:object_r:etc_t:s0 /etc
```

```
~]# touch /etc/file1
```

```
~]# ls -lZ /etc/file1
-rw-r--r--. root root unconfined_u:object_r:etc_t:s0 /etc/file1
```

There are multiple commands for managing the SELinux context for files, such as **chcon**, **semanage fcontext**, and **restorecon**.

### 4.7.1. Temporary Changes: chcon

The **chcon** command changes the SELinux context for files. However, changes made with the **chcon**

command do not survive a file system relabel, or the execution of the **restorecon** command. SELinux policy controls whether users are able to modify the SELinux context for any given file. When using **chcon**, users provide all or part of the SELinux context to change. An incorrect file type is a common cause of SELinux denying access.

## Quick Reference

- Run the **chcon -t *type* *file-name*** command to change the file type, where *type* is an SELinux type, such as **httpd\_sys\_content\_t**, and *file-name* is a file or directory name:

```
~]$ chcon -t httpd_sys_content_t file-name
```

- Run the **chcon -R -t *type* *directory-name*** command to change the type of the directory and its contents, where *type* is an SELinux type, such as **httpd\_sys\_content\_t**, and *directory-name* is a directory name:

```
~]$ chcon -R -t httpd_sys_content_t directory-name
```

## Procedure 4.6. Changing a File's or Directory's Type

The following procedure demonstrates changing the type, and no other attributes of the SELinux context. The example in this section works the same for directories, for example, if **file1** was a directory.

1. Change into your home directory.
2. Create a new file and view its SELinux context:

```
~]$ touch file1
```

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

In this example, the SELinux context for **file1** includes the SELinux **unconfined\_u** user, **object\_r** role, **user\_home\_t** type, and the **s0** level. For a description of each part of the SELinux context, see [Chapter 2, SELinux Contexts](#).

3. Enter the following command to change the type to **samba\_share\_t**. The **-t** option only changes the type. Then view the change:

```
~]$ chcon -t samba_share_t file1
```

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:samba_share_t:s0 file1
```

4. Use the following command to restore the SELinux context for the **file1** file. Use the **-v** option to view what changes:

```
~]$ restorecon -v file1
restorecon reset file1 context unconfined_u:object_r:samba_share_t:s0-
>system_u:object_r:user_home_t:s0
```

In this example, the previous type, **samba\_share\_t**, is restored to the correct, **user\_home\_t** type. When using targeted policy (the default SELinux policy in Red Hat Enterprise Linux), the

**restorecon** command reads the files in the `/etc/selinux/targeted/contexts/files/` directory, to see which SELinux context files should have.

### Procedure 4.7. Changing a Directory and its Contents Types

The following example demonstrates creating a new directory, and changing the directory's file type along with its contents to a type used by the Apache HTTP Server. The configuration in this example is used if you want Apache HTTP Server to use a different document root (instead of `/var/www/html/`):

1. As the root user, create a new **web/** directory and then 3 empty files (**file1**, **file2**, and **file3**) within this directory. The **web/** directory and files in it are labeled with the **default\_t** type:

```
~]# mkdir /web
```

```
~]# touch /web/file{1,2,3}
```

```
~]# ls -dZ /web
drwxr-xr-x root root unconfined_u:object_r:default_t:s0 /web
```

```
~]# ls -lZ /web
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file3
```

2. As root, enter the following command to change the type of the **web/** directory (and its contents) to **httpd\_sys\_content\_t**:

```
~]# chcon -R -t httpd_sys_content_t /web/
```

```
~]# ls -dZ /web/
drwxr-xr-x root root unconfined_u:object_r:httpd_sys_content_t:s0 /web/
```

```
~]# ls -lZ /web/
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file3
```

3. To restore the default SELinux contexts, use the **restorecon** utility as root:

```
~]# restorecon -R -v /web/
restorecon reset /web context unconfined_u:object_r:httpd_sys_content_t:s0-
>system_u:object_r:default_t:s0
restorecon reset /web/file2 context unconfined_u:object_r:httpd_sys_content_t:s0-
>system_u:object_r:default_t:s0
restorecon reset /web/file3 context unconfined_u:object_r:httpd_sys_content_t:s0-
>system_u:object_r:default_t:s0
restorecon reset /web/file1 context unconfined_u:object_r:httpd_sys_content_t:s0-
>system_u:object_r:default_t:s0
```

See the `chcon(1)` manual page for further information about **chcon**.

**NOTE**

Type Enforcement is the main permission control used in SELinux targeted policy. For the most part, SELinux users and roles can be ignored.

### 4.7.2. Persistent Changes: **semanage fcontext**

The **semanage fcontext** command is used to change the SELinux context of files. To show contexts to newly created files and directories, enter the following command as root:

```
~]# semanage fcontext -C -l
```

Changes made by **semanage fcontext** are used by the following utilities. The **setfiles** utility is used when a file system is relabeled and the **restorecon** utility restores the default SELinux contexts. This means that changes made by **semanage fcontext** are persistent, even if the file system is relabeled. SELinux policy controls whether users are able to modify the SELinux context for any given file.

#### Quick Reference

To make SELinux context changes that survive a file system relabel:

1. Enter the following command, remembering to use the full path to the file or directory:

```
~]# semanage fcontext -a options file-name|directory-name
```

2. Use the **restorecon** utility to apply the context changes:

```
~]# restorecon -v file-name|directory-name
```

#### Procedure 4.8. Changing a File's or Directory 's Type

The following example demonstrates changing a file's type, and no other attributes of the SELinux context. This example works the same for directories, for instance if **file1** was a directory.

1. As the root user, create a new file in the **/etc** directory. By default, newly-created files in **/etc** are labeled with the **etc\_t** type:

```
~]# touch /etc/file1
```

```
~]$ ls -lZ /etc/file1
-rw-r--r-- root root unconfined_u:object_r:etc_t:s0 /etc/file1
```

To list information about a directory, use the following command:

```
~]$ ls -ldZ directory_name
```

2. As root, enter the following command to change the **file1** type to **samba\_share\_t**. The **-a** option adds a new record, and the **-t** option defines a type ( **samba\_share\_t**). Note that running this command does not directly change the type; **file1** is still labeled with the **etc\_t** type:

```
~]# semanage fcontext -a -t samba_share_t /etc/file1
```

```
~]# ls -Z /etc/file1
-rw-r--r-- root root unconfined_u:object_r:etc_t:s0 /etc/file1
```

```
~]$ semanage fcontext -C -l
/etc/file1 unconfined_u:object_r:samba_share_t:s0
```

3. As root, use the **restorecon** utility to change the type. Because **semanage** added an entry to **file\_contexts.local** for **/etc/file1**, **restorecon** changes the type to **samba\_share\_t**:

```
~]# restorecon -v /etc/file1
restorecon reset /etc/file1 context unconfined_u:object_r:etc_t:s0-
>system_u:object_r:samba_share_t:s0
```

### Procedure 4.9. Changing a Directory and its Contents Types

The following example demonstrates creating a new directory, and changing the directory's file type along with its contents to a type used by Apache HTTP Server. The configuration in this example is used if you want Apache HTTP Server to use a different document root instead of **/var/www/html/**:

1. As the root user, create a new **web/** directory and then 3 empty files (**file1**, **file2**, and **file3**) within this directory. The **web/** directory and files in it are labeled with the **default\_t** type:

```
~]# mkdir /web
```

```
~]# touch /web/file{1,2,3}
```

```
~]# ls -dZ /web
drwxr-xr-x root root unconfined_u:object_r:default_t:s0 /web
```

```
~]# ls -lZ /web
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file3
```

2. As root, enter the following command to change the type of the **web/** directory and the files in it, to **httpd\_sys\_content\_t**. The **-a** option adds a new record, and the **-t** option defines a type (**httpd\_sys\_content\_t**). The **"/web/(.\*)?"** regular expression causes **semanage** to apply changes to **web/**, as well as the files in it. Note that running this command does not directly change the type; **web/** and files in it are still labeled with the **default\_t** type:

```
~]# semanage fcontext -a -t httpd_sys_content_t "/web/(.*)?"
```

```
~]$ ls -dZ /web
drwxr-xr-x root root unconfined_u:object_r:default_t:s0 /web
```

```
~]$ ls -lZ /web
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:default_t:s0 file3
```

The **semanage fcontext -a -t httpd\_sys\_content\_t "/web(/.\*)"?** command adds the following entry to **/etc/selinux/targeted/contexts/files/file\_contexts.local**:

```
/web(/.*)"? system_u:object_r:httpd_sys_content_t:s0
```

3. As root, use the **restorecon** utility to change the type of **web/**, as well as all files in it. The **-R** is for recursive, which means all files and directories under **web/** are labeled with the **httpd\_sys\_content\_t** type. Since **semanage** added an entry to **file\_contexts.local** for **/web(/.\*)"?**, **restorecon** changes the types to **httpd\_sys\_content\_t**:

```
~]# restorecon -R -v /web
restorecon reset /web context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
restorecon reset /web/file2 context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
restorecon reset /web/file3 context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
restorecon reset /web/file1 context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
```

Note that by default, newly-created files and directories inherit the SELinux type of their parent directories.

#### Procedure 4.10. Deleting an added Context

The following example demonstrates adding and removing an SELinux context. If the context is part of a regular expression, for example, **/web(/.\*)"?**, use quotation marks around the regular expression:

```
~]# semanage fcontext -d "/web(/.*)"?
```

1. To remove the context, as root, enter the following command, where *file-name|directory-name* is the first part in **file\_contexts.local**:

```
~]# semanage fcontext -d file-name|directory-name
```

The following is an example of a context in **file\_contexts.local**:

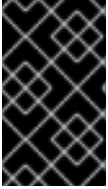
```
/test system_u:object_r:httpd_sys_content_t:s0
```

With the first part being **test**. To prevent the **test/** directory from being labeled with the **httpd\_sys\_content\_t** after running **restorecon**, or after a file system relabel, enter the following command as root to delete the context from **file\_contexts.local**:

```
~]# semanage fcontext -d /test
```

2. As root, use the **restorecon** utility to restore the default SELinux context.

See the **semanage(8)** manual page for further information about **semanage**.



## IMPORTANT

When changing the SELinux context with **semanage fcontext -a**, use the full path to the file or directory to avoid files being mislabeled after a file system relabel, or after the **restorecon** command is run.

## 4.8. THE FILE\_T AND DEFAULT\_T TYPES

When using a file system that supports extended attributes (EA), the **file\_t** type is the default type of a file that has not yet been assigned EA value. This type is only used for this purpose and does not exist on correctly-labeled file systems, because all files on a system running SELinux should have a proper SELinux context, and the **file\_t** type is never used in file-context configuration [4].

The **default\_t** type is used on files that do not match any pattern in file-context configuration, so that such files can be distinguished from files that do not have a context on disk, and generally are kept inaccessible to confined domains. For example, if you create a new top-level directory, such as **mydirectory/**, this directory may be labeled with the **default\_t** type. If services need access to this directory, you need to update the file-contexts configuration for this location. See [Section 4.7.2, “Persistent Changes: semanage fcontext”](#) for details on adding a context to the file-context configuration.

## 4.9. MOUNTING FILE SYSTEMS

By default, when a file system that supports extended attributes is mounted, the security context for each file is obtained from the *security.selinux* extended attribute of the file. Files in file systems that do not support extended attributes are assigned a single, default security context from the policy configuration, based on file system type.

Use the **mount -o context** command to override existing extended attributes, or to specify a different, default context for file systems that do not support extended attributes. This is useful if you do not trust a file system to supply the correct attributes, for example, removable media used in multiple systems. The **mount -o context** command can also be used to support labeling for file systems that do not support extended attributes, such as File Allocation Table (FAT) or NFS volumes. The context specified with the **context** option is not written to disk: the original contexts are preserved, and are seen when mounting without **context** if the file system had extended attributes in the first place.

For further information about file system labeling, see James Morris's "Filesystem Labeling in SELinux" article: <http://www.linuxjournal.com/article/7426>.

### 4.9.1. Context Mounts

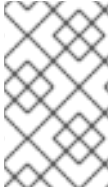
To mount a file system with the specified context, overriding existing contexts if they exist, or to specify a different, default context for a file system that does not support extended attributes, as the root user, use the **mount -o context=SELinux\_user:role:type:level** command when mounting the required file system. Context changes are not written to disk. By default, NFS mounts on the client side are labeled with a default context defined by policy for NFS volumes. In common policies, this default context uses the **nfs\_t** type. Without additional mount options, this may prevent sharing NFS volumes using other services, such as the Apache HTTP Server. The following example mounts an NFS volume so that it can be shared using the Apache HTTP Server:

```
~]# mount server:/export /local/mount/point -o \ context="system_u:object_r:httpd_sys_content_t:s0"
```

Newly-created files and directories on this file system appear to have the SELinux context specified with **-o context**. However, since these changes are not written to disk, the context specified with this

option does not persist between mounts. Therefore, this option must be used with the same context specified during every mount to retain the required context. For information about making context mount persistent, see [Section 4.9.5, "Making Context Mounts Persistent"](#).

Type Enforcement is the main permission control used in SELinux targeted policy. For the most part, SELinux users and roles can be ignored, so, when overriding the SELinux context with **-o context**, use the SELinux **system\_u** user and **object\_r** role, and concentrate on the type. If you are not using the MLS policy or multi-category security, use the **s0** level.



#### NOTE

When a file system is mounted with a **context** option, context changes by users and processes are prohibited. For example, running the **chcon** command on a file system mounted with a **context** option results in a **Operation not supported** error.

### 4.9.2. Changing the Default Context

As mentioned in [Section 4.8, "The file\\_t and default\\_t Types"](#), on file systems that support extended attributes, when a file that lacks an SELinux context on disk is accessed, it is treated as if it had a default context as defined by SELinux policy. In common policies, this default context uses the **file\_t** type. If it is desirable to use a different default context, mount the file system with the **defcontext** option.

The following example mounts a newly-created file system on **/dev/sda2** to the newly-created **test/** directory. It assumes that there are no rules in **/etc/selinux/targeted/contexts/files/** that define a context for the **test/** directory:

```
~]# mount /dev/sda2 /test/ -o defcontext="system_u:object_r:samba_share_t:s0"
```

In this example:

- the **defcontext** option defines that **system\_u:object\_r:samba\_share\_t:s0** is "the default security context for unlabeled files"<sup>[5]</sup>.
- when mounted, the root directory (**test/**) of the file system is treated as if it is labeled with the context specified by **defcontext** (this label is not stored on disk). This affects the labeling for files created under **test/**: new files inherit the **samba\_share\_t** type, and these labels are stored on disk.
- files created under **test/** while the file system was mounted with a **defcontext** option retain their labels.

### 4.9.3. Mounting an NFS Volume

By default, NFS mounts on the client side are labeled with a default context defined by policy for NFS volumes. In common policies, this default context uses the **nfs\_t** type. Depending on policy configuration, services, such as Apache HTTP Server and MariaDB, may not be able to read files labeled with the **nfs\_t** type. This may prevent file systems labeled with this type from being mounted and then read or exported by other services.

If you would like to mount an NFS volume and read or export that file system with another service, use the **context** option when mounting to override the **nfs\_t** type. Use the following context option to mount NFS volumes so that they can be shared using the Apache HTTP Server:

```
~]# mount server:/export /local/mount/point -o context="system_u:object_r:httpd_sys_content_t:s0"
```

Since these changes are not written to disk, the context specified with this option does not persist between mounts. Therefore, this option must be used with the same context specified during every mount to retain the required context. For information about making context mount persistent, see [Section 4.9.5, “Making Context Mounts Persistent”](#).

As an alternative to mounting file systems with **context** options, Booleans can be enabled to allow services access to file systems labeled with the **nfs\_t** type. See [Part II, “Managing Confined Services”](#) for instructions on configuring Booleans to allow services access to the **nfs\_t** type.

#### 4.9.4. Multiple NFS Mounts

When mounting multiple mounts from the same NFS export, attempting to override the SELinux context of each mount with a different context, results in subsequent mount commands failing. In the following example, the NFS server has a single export, **export/**, which has two subdirectories, **web/** and **database/**. The following commands attempt two mounts from a single NFS export, and try to override the context for each one:

```
~]# mount server:/export/web /local/web -o context="system_u:object_r:httpd_sys_content_t:s0"
```

```
~]# mount server:/export/database /local/database -o context="system_u:object_r:mysql_db_t:s0"
```

The second mount command fails, and the following is logged to **/var/log/messages**:

```
kernel: SELinux: mount invalid. Same superblock, different security settings for (dev 0:15, type nfs)
```

To mount multiple mounts from a single NFS export, with each mount having a different context, use the **-o nosharecache,context** options. The following example mounts multiple mounts from a single NFS export, with a different context for each mount (allowing a single service access to each one):

```
~]# mount server:/export/web /local/web -o  
nosharecache,context="system_u:object_r:httpd_sys_content_t:s0"
```

```
~]# mount server:/export/database /local/database -o \  
nosharecache,context="system_u:object_r:mysql_db_t:s0"
```

In this example, **server:/export/web** is mounted locally to the **/local/web/** directory, with all files being labeled with the **httpd\_sys\_content\_t** type, allowing Apache HTTP Server access.

**server:/export/database** is mounted locally to **/local/database/**, with all files being labeled with the **mysql\_db\_t** type, allowing MariaDB access. These type changes are not written to disk.



#### IMPORTANT

The **nosharecache** options allows you to mount the same subdirectory of an export multiple times with different contexts, for example, mounting **/export/web/** multiple times. Do not mount the same subdirectory from an export multiple times with different contexts, as this creates an overlapping mount, where files are accessible under two different contexts.

#### 4.9.5. Making Context Mounts Persistent

To make context mounts persistent across remounting and reboots, add entries for the file systems in the **/etc/fstab** file or an automounter map, and use the required context as a mount option. The following example adds an entry to **/etc/fstab** for an NFS context mount:

```
server:/export /local/mount/ nfs context="system_u:object_r:httpd_sys_content_t:s0" 0 0
```

## 4.10. MAINTAINING SELINUX LABELS

These sections describe what happens to SELinux contexts when copying, moving, and archiving files and directories. Also, it explains how to preserve contexts when copying and archiving.

### 4.10.1. Copying Files and Directories

When a file or directory is copied, a new file or directory is created if it does not exist. That new file or directory's context is based on default-labeling rules, not the original file or directory's context unless options were used to preserve the original context. For example, files created in user home directories are labeled with the **user\_home\_t** type:

```
~]$ touch file1
```

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

If such a file is copied to another directory, such as **/etc**, the new file is created in accordance to default-labeling rules for **/etc**. Copying a file without additional options may not preserve the original context:

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

```
~)# cp file1 /etc/
```

```
~]$ ls -Z /etc/file1
-rw-r--r-- root root unconfined_u:object_r:etc_t:s0 /etc/file1
```

When **file1** is copied to **/etc**, if **/etc/file1** does not exist, **/etc/file1** is created as a new file. As shown in the example above, **/etc/file1** is labeled with the **etc\_t** type, in accordance to default-labeling rules.

When a file is copied over an existing file, the existing file's context is preserved, unless the user specified **cp** options to preserve the context of the original file, such as **--preserve=context**. SELinux policy may prevent contexts from being preserved during copies.

#### Procedure 4.11. Copying Without Preserving SELinux Contexts

This procedure shows that when copying a file with the **cp** command, if no options are given, the type is inherited from the targeted, parent directory.

1. Create a file in a user's home directory. The file is labeled with the **user\_home\_t** type:

```
~]$ touch file1
```

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

2. The **/var/www/html/** directory is labeled with the **httpd\_sys\_content\_t** type, as shown with the following command:

```
~]$ ls -dZ /var/www/html/
drwxr-xr-x root root system_u:object_r:httpd_sys_content_t:s0 /var/www/html/
```

- When **file1** is copied to **/var/www/html/**, it inherits the **httpd\_sys\_content\_t** type:

```
~]# cp file1 /var/www/html/
```

```
~]$ ls -Z /var/www/html/file1
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 /var/www/html/file1
```

#### Procedure 4.12. Preserving SELinux Contexts When Copying

This procedure shows how to use the **--preserve=context** option to preserve contexts when copying.

- Create a file in a user's home directory. The file is labeled with the **user\_home\_t** type:

```
~]$ touch file1
```

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

- The **/var/www/html/** directory is labeled with the **httpd\_sys\_content\_t** type, as shown with the following command:

```
~]$ ls -dZ /var/www/html/
drwxr-xr-x root root system_u:object_r:httpd_sys_content_t:s0 /var/www/html/
```

- Using the **--preserve=context** option preserves SELinux contexts during copy operations. As shown below, the **user\_home\_t** type of **file1** was preserved when the file was copied to **/var/www/html/**:

```
~]# cp --preserve=context file1 /var/www/html/
```

```
~]$ ls -Z /var/www/html/file1
-rw-r--r-- root root unconfined_u:object_r:user_home_t:s0 /var/www/html/file1
```

#### Procedure 4.13. Copying and Changing the Context

This procedure show how to use the **--context** option to change the destination copy's context. The following example is performed in the user's home directory:

- Create a file in a user's home directory. The file is labeled with the **user\_home\_t** type:

```
~]$ touch file1
```

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

- Use the **--context** option to define the SELinux context:

```
~]$ cp --context=system_u:object_r:samba_share_t:s0 file1 file2
```

- Without **--context**, **file2** would be labeled with the **unconfined\_u:object\_r:user\_home\_t** context:

```
~]$ ls -Z file1 file2
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
-rw-rw-r-- user1 group1 system_u:object_r:samba_share_t:s0 file2
```

#### Procedure 4.14. Copying a File Over an Existing File

This procedure shows that when a file is copied over an existing file, the existing file's context is preserved unless an option is used to preserve contexts.

- As root, create a new file, **file1** in the **/etc** directory. As shown below, the file is labeled with the **etc\_t** type:

```
~]# touch /etc/file1
```

```
~]$ ls -Z /etc/file1
-rw-r--r-- root root unconfined_u:object_r:etc_t:s0 /etc/file1
```

- Create another file, **file2**, in the **/tmp** directory. As shown below, the file is labeled with the **user\_tmp\_t** type:

```
~]$ touch /tmp/file2
```

```
~$ ls -Z /tmp/file2
-rw-r--r-- root root unconfined_u:object_r:user_tmp_t:s0 /tmp/file2
```

- Overwrite **file1** with **file2**:

```
~]# cp /tmp/file2 /etc/file1
```

- After copying, the following command shows **file1** labeled with the **etc\_t** type, not the **user\_tmp\_t** type from **/tmp/file2** that replaced **/etc/file1**:

```
~]$ ls -Z /etc/file1
-rw-r--r-- root root unconfined_u:object_r:etc_t:s0 /etc/file1
```



#### IMPORTANT

Copy files and directories, rather than moving them. This helps ensure they are labeled with the correct SELinux contexts. Incorrect SELinux contexts can prevent processes from accessing such files and directories.

### 4.10.2. Moving Files and Directories

Files and directories keep their current SELinux context when they are moved. In many cases, this is incorrect for the location they are being moved to. The following example demonstrates moving a file

from a user's home directory to the **/var/www/html/** directory, which is used by the Apache HTTP Server. Since the file is moved, it does not inherit the correct SELinux context:

#### Procedure 4.15. Moving Files and Directories

1. Change into your home directory and create file in it. The file is labeled with the **user\_home\_t** type:

```
~]$ touch file1
```

```
~]$ ls -Z file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 file1
```

2. Enter the following command to view the SELinux context of the **/var/www/html/** directory:

```
~]$ ls -dZ /var/www/html/
drwxr-xr-x root root system_u:object_r:httpd_sys_content_t:s0 /var/www/html/
```

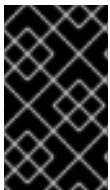
By default, **/var/www/html/** is labeled with the **httpd\_sys\_content\_t** type. Files and directories created under **/var/www/html/** inherit this type, and as such, they are labeled with this type.

3. As root, move **file1** to **/var/www/html/**. Since this file is moved, it keeps its current **user\_home\_t** type:

```
~]# mv file1 /var/www/html/
```

```
~]# ls -Z /var/www/html/file1
-rw-rw-r-- user1 group1 unconfined_u:object_r:user_home_t:s0 /var/www/html/file1
```

By default, the Apache HTTP Server cannot read files that are labeled with the **user\_home\_t** type. If all files comprising a web page are labeled with the **user\_home\_t** type, or another type that the Apache HTTP Server cannot read, permission is denied when attempting to access them using web browsers, such as **Mozilla Firefox**.



#### IMPORTANT

Moving files and directories with the **mv** command may result in the incorrect SELinux context, preventing processes, such as the Apache HTTP Server and Samba, from accessing such files and directories.

### 4.10.3. Checking the Default SELinux Context

Use the **matchpathcon** utility to check if files and directories have the correct SELinux context. This utility queries the system policy and then provides the default security context associated with the file path.<sup>[6]</sup> The following example demonstrates using **matchpathcon** to verify that files in **/var/www/html/** directory are labeled correctly:

#### Procedure 4.16. Checking the Default SELinux Context with **matchpathcon**

1. As the root user, create three files (**file1**, **file2**, and **file3**) in the **/var/www/html/** directory. These files inherit the **httpd\_sys\_content\_t** type from **/var/www/html/**:

```
~]# touch /var/www/html/file{1,2,3}
```

```
~]# ls -Z /var/www/html/
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file3
```

2. As root, change the **file1** type to **samba\_share\_t**. Note that the Apache HTTP Server cannot read files or directories labeled with the **samba\_share\_t** type.

```
~]# chcon -t samba_share_t /var/www/html/file1
```

3. The **matchpathcon -V** option compares the current SELinux context to the correct, default context in SELinux policy. Enter the following command to check all files in the **/var/www/html/** directory:

```
~]$ matchpathcon -V /var/www/html/*
/var/www/html/file1 has context unconfined_u:object_r:samba_share_t:s0, should be
system_u:object_r:httpd_sys_content_t:s0
/var/www/html/file2 verified.
/var/www/html/file3 verified.
```

The following output from the **matchpathcon** command explains that **file1** is labeled with the **samba\_share\_t** type, but should be labeled with the **httpd\_sys\_content\_t** type:

```
/var/www/html/file1 has context unconfined_u:object_r:samba_share_t:s0, should be
system_u:object_r:httpd_sys_content_t:s0
```

To resolve the label problem and allow the Apache HTTP Server access to **file1**, as root, use the **restorecon** utility:

```
~]# restorecon -v /var/www/html/file1
restorecon reset /var/www/html/file1 context unconfined_u:object_r:samba_share_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
```

#### 4.10.4. Archiving Files with tar

The **tar** utility does not retain extended attributes by default. Since SELinux contexts are stored in extended attributes, contexts can be lost when archiving files. Use the **tar --selinux** command to create archives that retain contexts and to restore files from the archives. If a **tar** archive contains files without extended attributes, or if you want the extended attributes to match the system defaults, use the **restorecon** utility:

```
~]$ tar -xvf archive.tar | restorecon -f -
```

Note that depending on the directory, you may need to be the root user to run the **restorecon**.

The following example demonstrates creating a **tar** archive that retains SELinux contexts:

#### Procedure 4.17. Creating a tar Archive

1. Change to the **/var/www/html/** directory and view its SELinux context:

```
~]$ cd /var/www/html/
```

```
html]$ ls -dZ /var/www/html/
drwxr-xr-x. root root system_u:object_r:httpd_sys_content_t:s0 .
```

- As root, create three files (**file1**, **file2**, and **file3**) in **/var/www/html/**. These files inherit the **httpd\_sys\_content\_t** type from **/var/www/html/**:

```
html)# touch file{1,2,3}
```

```
html]$ ls -Z /var/www/html/
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file3
```

- As root, enter the following command to create a **tar** archive named **test.tar**. Use the **--selinux** to retain the SELinux context:

```
html)# tar --selinux -cf test.tar file{1,2,3}
```

- As root, create a new directory named **test/**, and then allow all users full access to it:

```
~)# mkdir /test
```

```
~)# chmod 777 /test/
```

- Copy the **test.tar** file into **test/**:

```
~]$ cp /var/www/html/test.tar /test/
```

- Change into **test/** directory. Once in this directory, enter the following command to extract the **tar** archive. Specify the **--selinux** option again otherwise the SELinux context will be changed to **default\_t**:

```
~]$ cd /test/
```

```
test]$ tar --selinux -xvf test.tar
```

- View the SELinux contexts. The **httpd\_sys\_content\_t** type has been retained, rather than being changed to **default\_t**, which would have happened had the **--selinux** not been used:

```
test]$ ls -lZ /test/
-rw-r--r-- user1 group1 unconfined_u:object_r:httpd_sys_content_t:s0 file1
-rw-r--r-- user1 group1 unconfined_u:object_r:httpd_sys_content_t:s0 file2
-rw-r--r-- user1 group1 unconfined_u:object_r:httpd_sys_content_t:s0 file3
-rw-r--r-- user1 group1 unconfined_u:object_r:default_t:s0 test.tar
```

- If the **test/** directory is no longer required, as root, enter the following command to remove it, as well as all files in it:

```
~]# rm -ri /test/
```

See the `tar(1)` manual page for further information about **tar**, such as the **--xattrs** option that retains all extended attributes.

#### 4.10.5. Archiving Files with **star**

The **star** utility does not retain extended attributes by default. Since SELinux contexts are stored in extended attributes, contexts can be lost when archiving files. Use the **star -xattr -H=exustar** command to create archives that retain contexts. The **star** package is not installed by default. To install **star**, run the **yum install star** command as the root user.

The following example demonstrates creating a **star** archive that retains SELinux contexts:

##### Procedure 4.18. Creating a **star** Archive

1. As root, create three files (**file1**, **file2**, and **file3**) in the **/var/www/html/**. These files inherit the **httpd\_sys\_content\_t** type from **/var/www/html/**:

```
~]# touch /var/www/html/file{1,2,3}
```

```
~]# ls -Z /var/www/html/
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 file3
```

2. Change into **/var/www/html/** directory. Once in this directory, as root, enter the following command to create a **star** archive named **test.star**:

```
~]$ cd /var/www/html
```

```
html]# star -xattr -H=exustar -c -f=test.star file{1,2,3}
star: 1 blocks + 0 bytes (total of 10240 bytes = 10.00k).
```

3. As root, create a new directory named **test/**, and then allow all users full access to it:

```
~]# mkdir /test
```

```
~]# chmod 777 /test/
```

4. Enter the following command to copy the **test.star** file into **test/**:

```
~]$ cp /var/www/html/test.star /test/
```

5. Change into **test/**. Once in this directory, enter the following command to extract the **star** archive:

```
~]$ cd /test/
```

```
test]$ star -x -f=test.star
star: 1 blocks + 0 bytes (total of 10240 bytes = 10.00k).
```

6. View the SELinux contexts. The **httpd\_sys\_content\_t** type has been retained, rather than being changed to **default\_t**, which would have happened had the **-xattr -H=exustar** option not been used:

```
~]$ ls -lZ /test/
-rw-r--r-- user1 group1 unconfined_u:object_r:httpd_sys_content_t:s0 file1
-rw-r--r-- user1 group1 unconfined_u:object_r:httpd_sys_content_t:s0 file2
-rw-r--r-- user1 group1 unconfined_u:object_r:httpd_sys_content_t:s0 file3
-rw-r--r-- user1 group1 unconfined_u:object_r:default_t:s0 test.star
```

7. If the **test/** directory is no longer required, as root, enter the following command to remove it, as well as all files in it:

```
~]# rm -ri /test/
```

8. If **star** is no longer required, as root, remove the package:

```
~]# yum remove star
```

See the **star(1)** manual page for further information about **star**.

## 4.11. INFORMATION GATHERING TOOLS

The utilities listed below are command-line tools that provide well-formatted information, such as access vector cache statistics or the number of classes, types, or Booleans.

### avcstat

This command provides a short output of the access vector cache statistics since boot. You can watch the statistics in real time by specifying a time interval in seconds. This provides updated statistics since the initial output. The statistics file used is **/sys/fs/selinux/avc/cache\_stats**, and you can specify a different cache file with the **-f /path/to/file** option.

```
~]# avcstat
lookups   hits    misses  allocs  reclaims  frees
47517410  47504630  12780   12780   12176    12275
```

### seinfo

This utility is useful in describing the break-down of a policy, such as the number of classes, types, Booleans, allow rules, and others. **seinfo** is a command-line utility that uses a **policy.conf** file, a binary policy file, a modular list of policy packages, or a policy list file as input. You must have the **setools-console** package installed to use the **seinfo** utility.

The output of **seinfo** will vary between binary and source files. For example, the policy source file uses the **{ }** brackets to group multiple rule elements onto a single line. A similar effect happens with attributes, where a single attribute expands into one or many types. Because these are expanded and no longer relevant in the binary policy file, they have a return value of zero in the search results. However, the number of rules greatly increases as each formerly one line rule using brackets is now a number of individual lines.

Some items are not present in the binary policy. For example, neverallow rules are only checked during policy compile, not during runtime, and initial Security Identifiers (SIDs) are not part of the binary policy since they are required prior to the policy being loaded by the kernel during boot.

```
~]# seinfo
```

Statistics for policy file: /sys/fs/selinux/policy

Policy Version & Type: v.28 (binary, mls)

Classes:	77	Permissions:	229
Sensitivities:	1	Categories:	1024
Types:	3001	Attributes:	244
Users:	9	Roles:	13
Booleans:	158	Cond. Expr.:	193
Allow:	262796	Neverallow:	0
Auditallow:	44	Dontaudit:	156710
Type_trans:	10760	Type_change:	38
Type_member:	44	Role allow:	20
Role_trans:	237	Range_trans:	2546
Constraints:	62	Validatetrans:	0
Initial SIDs:	27	Fs_use:	22
Genfscon:	82	Portcon:	373
Netifcon:	0	Nodecon:	0
Permissives:	22	Polcap:	2

The **seinfo** utility can also list the number of types with the domain attribute, giving an estimate of the number of different confined processes:

```
~]# seinfo -adomain -x | wc -l
550
```

Not all domain types are confined. To look at the number of unconfined domains, use the **unconfined\_domain** attribute:

```
~]# seinfo -aunconfined_domain_type -x | wc -l
52
```

Permissive domains can be counted with the **--permissive** option:

```
~]# seinfo --permissive -x | wc -l
31
```

Remove the additional **| wc -l** command in the above commands to see the full lists.

## sesearch

You can use the **sesearch** utility to search for a particular rule in the policy. It is possible to search either policy source files or the binary file. For example:

```
~]$ sesearch --role_allow -t httpd_sys_content_t
Found 20 role allow rules:
allow system_r sysadm_r;
allow sysadm_r system_r;
allow sysadm_r staff_r;
allow sysadm_r user_r;
```

```
allow system_r git_shell_r;
allow system_r guest_r;
allow logadm_r system_r;
allow system_r logadm_r;
allow system_r nx_server_r;
allow system_r staff_r;
allow staff_r logadm_r;
allow staff_r sysadm_r;
allow staff_r unconfined_r;
allow staff_r webadm_r;
allow unconfined_r system_r;
allow system_r unconfined_r;
allow system_r user_r;
allow webadm_r system_r;
allow system_r webadm_r;
allow system_r xguest_r;
```

The **sesearch** utility can provide the number of *allow* rules:

```
~]# sesearch --allow | wc -l
262798
```

And the number of *dontaudit* rules:

```
~]# sesearch --dontaudit | wc -l
156712
```

## 4.12. PRIORITIZING AND DISABLING SELINUX POLICY MODULES

The SELinux module storage in **/etc/selinux/** allows using a priority on SELinux modules. Enter the following command as root to show two module directories with a different priority:

```
~]# ls /etc/selinux/targeted/active/modules
100 400 disabled
```

While the default priority used by **semodule** utility is 400, the priority used in `selinux-policy` packages is 100, so you can find most of the SELinux modules installed with the priority 100.

You can override an existing module with a modified module with the same name using a higher priority. When there are more modules with the same name and different priorities, only a module with the highest priority is used when the policy is built.

### Example 4.1. Using SELinux Policy Modules Priority

Prepare a new module with modified file context. Install the module with the **semodule -i** command and set the priority of the module to 400. We use **sandbox.pp** in the following example.

```
~]# semodule -X 400 -i sandbox.pp
~]# semodule --list-modules=full | grep sandbox
400 sandbox      pp
100 sandbox      pp
```

To return back to the default module, enter the **semodule -r** command as root:

```
-
```

```
~]# semodule -X 400 -r sandbox  
libsemanage.semanage_direct_remove_key: sandbox module at priority 100 is now active.
```

## Disabling a System Policy Module

To disable a system policy module, enter the following command as root:

```
semodule -d MODULE_NAME
```



### WARNING

If you remove a system policy module using the **semodule -r** command, it is deleted on your system's storage and you cannot load it again. To avoid unnecessary reinstallations of the selinux-policy-targeted package for restoring all system policy modules, use the **semodule -d** command instead.

## 4.13. MULTI-LEVEL SECURITY (MLS)

The Multi-Level Security technology refers to a security scheme that enforces the Bell-La Padula Mandatory Access Model. Under MLS, users and processes are called *subjects*, and files, devices, and other passive components of the system are called *objects*. Both subjects and objects are labeled with a security level, which entails a subject's clearance or an object's classification. Each security level is composed of a *sensitivity* and a *category*, for example, an internal release schedule is filed under the internal documents category with a confidential sensitivity.

Figure 4.1, “Levels of clearance” shows levels of clearance as originally designed by the US defense community. Relating to our internal schedule example above, only users that have gained the confidential clearance are allowed to view documents in the confidential category. However, users who only have the confidential clearance are not allowed to view documents that require higher levels or clearance; they are allowed read access only to documents with lower levels of clearance, and write access to documents with higher levels of clearance.



Figure 4.1. Levels of clearance

Figure 4.2, “Allowed data flows using MLS” shows all allowed data flows between a subject running under the “Secret” security level and various objects with different security levels. In simple terms, the Bell-LaPadula model enforces two properties: *no read up* and *no write down*.

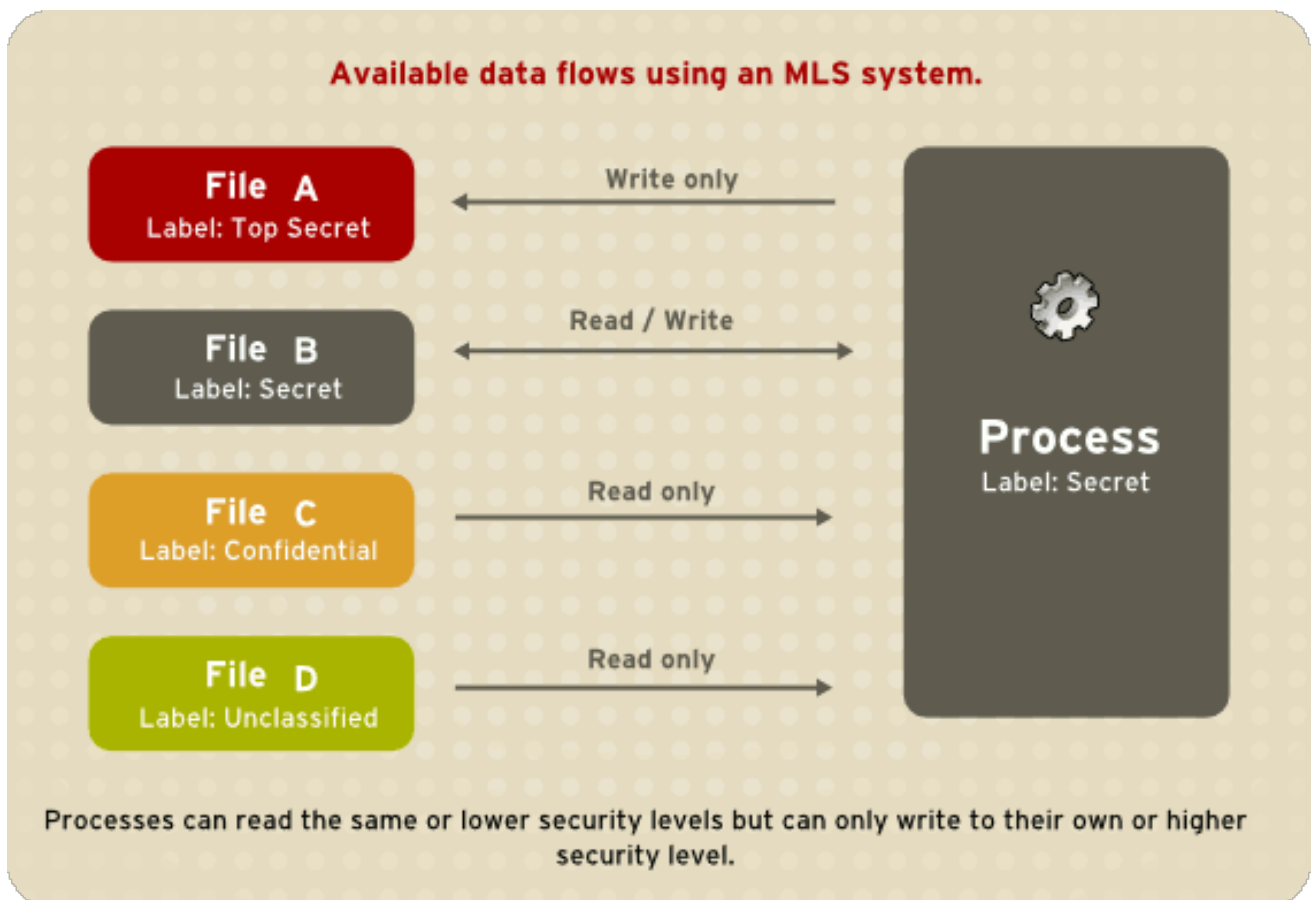


Figure 4.2. Allowed data flows using MLS

### 4.13.1. MLS and System Privileges

MLS access rules are always combined with conventional access permissions (file permissions). For example, if a user with a security level of "Secret" uses Discretionary Access Control (DAC) to block access to a file by other users, this also blocks access by users with a security level of "Top Secret". It is important to remember that SELinux MLS policy rules are checked *after* DAC rules. A higher security clearance does not automatically give permission to arbitrarily browse a file system.

Users with top-level clearances do not automatically acquire administrative rights on multi-level systems. While they may have access to all information on the computer, this is different from having administrative rights.

### 4.13.2. Enabling MLS in SELinux



#### NOTE

It is not recommended to use the MLS policy on a system that is running the X Window System.

Follow these steps to enable the SELinux MLS policy on your system.

#### Procedure 4.19. Enabling SELinux MLS Policy

1. Install the `selinux-policy-mls` package:

```
~]# yum install selinux-policy-mls
```

2. Before the MLS policy is enabled, each file on the file system must be relabeled with an MLS label. When the file system is relabeled, confined domains may be denied access, which may prevent your system from booting correctly. To prevent this from happening, configure **SELINUX=permissive** in the `/etc/selinux/config` file. Also, enable the MLS policy by configuring **SELINUXTYPE=mls**. Your configuration file should look like this:

```
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#   enforcing - SELinux security policy is enforced.
#   permissive - SELinux prints warnings instead of enforcing.
#   disabled - No SELinux policy is loaded.
SELINUX=permissive
# SELINUXTYPE= can take one of these two values:
#   targeted - Targeted processes are protected,
#   mls - Multi Level Security protection.
SELINUXTYPE=mls
```

3. Make sure SELinux is running in permissive mode:

```
~]# setenforce 0
```

```
~]$ getenforce
Permissive
```

4. Use the **fixfiles** script to create the **/.autorelabel** file containing the **-F** option to ensure that files are relabeled upon next reboot:

```
~]# fixfiles -F onboot
```

5. Reboot your system. During the next boot, all file systems will be relabeled according to the MLS policy. The label process labels all files with an appropriate SELinux context:

```
*** Warning -- SELinux mls policy relabel is required.
*** Relabeling could take a very long time, depending on file
*** system size and speed of hard drives.
*****
```

Each \* (asterisk) character on the bottom line represents 1000 files that have been labeled. In the above example, eleven \* characters represent 11000 files which have been labeled. The time it takes to label all files depends upon the number of files on the system, and the speed of the hard disk drives. On modern systems, this process can take as little as 10 minutes. Once the labeling process finishes, the system will automatically reboot.

6. In permissive mode, SELinux policy is not enforced, but denials are still logged for actions that would have been denied if running in enforcing mode. Before changing to enforcing mode, as root, enter the following command to confirm that SELinux did not deny actions during the last boot. If SELinux did not deny actions during the last boot, this command does not return any output. See [Chapter 11, Troubleshooting](#) for troubleshooting information if SELinux denied access during boot.

```
~]# grep "SELinux is preventing" /var/log/messages
```

7. If there were no denial messages in the **/var/log/messages** file, or you have resolved all existing denials, configure **SELINUX=enforcing** in the **/etc/selinux/config** file:

```
# This file controls the state of SELinux on the system.
# SELINUX= can take one of these three values:
#   enforcing - SELinux security policy is enforced.
#   permissive - SELinux prints warnings instead of enforcing.
#   disabled - No SELinux policy is loaded.
SELINUX=enforcing
# SELINUXTYPE= can take one of these two values:
#   targeted - Targeted processes are protected,
#   mls - Multi Level Security protection.
SELINUXTYPE=mls
```

8. Reboot your system and make sure SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

and the MLS policy is enabled:

```
~]# sestatus |grep mls
Policy from config file:      mls
```

### 4.13.3. Creating a User With a Specific MLS Range

Follow these steps to create a new Linux user with a specific MLS range:

#### Procedure 4.20. Creating a User With a Specific MLS Range

1. Add a new Linux user using the **useradd** command and map the new Linux user to an existing SELinux user (in this case, **staff\_u**):

```
~]# useradd -Z staff_u john
```

2. Assign the newly-created Linux user a password:

```
prompt~]# passwd john
```

3. Enter the following command as root to view the mapping between SELinux and Linux users. The output should be as follows:

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	user_u	s0-s0	*
john	staff_u	s0-s15:c0.c1023	*
root	root	s0-s15:c0.c1023	*
staff	staff_u	s0-s15:c0.c1023	*
sysadm	staff_u	s0-s15:c0.c1023	*
system_u	system_u	s0-s15:c0.c1023	*

4. Define a specific range for user **john**:

```
~]# semanage login --modify --range s2:c100 john
```

5. View the mapping between SELinux and Linux users again. Note that the user **john** now has a specific MLS range defined:

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	user_u	s0-s0	*
john	staff_u	s2:c100	*
root	root	s0-s15:c0.c1023	*
staff	staff_u	s0-s15:c0.c1023	*
sysadm	staff_u	s0-s15:c0.c1023	*
system_u	system_u	s0-s15:c0.c1023	*

6. To correct the label on john's home directory if needed, enter the following command:

```
~]# chcon -R -l s2:c100 /home/john
```

#### 4.13.4. Setting Up Polyinstantiated Directories

The **/tmp** and **/var/tmp/** directories are normally used for temporary storage by all programs, services, and users. Such setup, however, makes these directories vulnerable to race condition attacks, or an information leak based on file names. SELinux offers a solution in the form of *polyinstantiated*

directories. This effectively means that both **/tmp** and **/var/tmp/** are instantiated, making them appear private for each user. When instantiation of directories is enabled, each user's **/tmp** and **/var/tmp/** directory is automatically mounted under **/tmp-inst** and **/var/tmp/tmp-inst**.

Follow these steps to enable polyinstantiation of directories:

#### Procedure 4.21. Enabling Polyinstantiation Directories

1. Uncomment the last three lines in the **/etc/security/namespace.conf** file to enable instantiation of the **/tmp**, **/var/tmp/**, and users' home directories:

```
~]$ tail -n 3 /etc/security/namespace.conf
/tmp /tmp-inst/      level  root,adm
/var/tmp /var/tmp/tmp-inst/ level  root,adm
$HOME $HOME/$USER.inst/ level
```

2. Ensure that in the **/etc/pam.d/login** file, the **pam\_namespace.so** module is configured for session:

```
~]$ grep namespace /etc/pam.d/login
session required pam_namespace.so
```

3. Reboot your system.

## 4.14. FILE NAME TRANSITION

The *file name transition* feature allows policy writers to specify the file name when writing policy transition rules. It is possible to write a rule that states: If a process labeled **A\_t** creates a specified object class in a directory labeled **B\_t** and the specified object class is named **objectname**, it gets the label **C\_t**. This mechanism provides more fine-grained control over processes on the system.

Without file name transition, there are three possible ways how to label an object:

- By default, objects inherit labels from parent directories. For example, if the user creates a file in a directory labeled **etc\_t**, then the file is labeled also **etc\_t**. However, this method is useless when it is desirable to have multiple files within a directory with different labels.
- Policy writers can write a rule in policy that states: If a process with type **A\_t** creates a specified object class in a directory labeled **B\_t**, the object gets the new **C\_t** label. This practice is problematic if a single program creates multiple objects in the same directory where each object requires a separate label. Moreover, these rules provide only partial control, because names of the created objects are not specified.
- Certain applications have SELinux awareness that allow such an application to ask the system what the label of a certain path should be. These applications then request the kernel to create the object with the required label. Examples of applications with SELinux awareness are the **rpm** package manager, the **restorecon** utility, or the **udev** device manager. However, it is not possible to instruct every application that creates files or directories with SELinux awareness. It is often necessary to relabel objects with the correct label after creating. Otherwise, when a confined domain attempts to use the object, AVC messages are returned.

The file name transition feature decreases problems related to incorrect labeling and improves the system to be more secure. Policy writers are able to state properly that a certain application can only create a file with a specified name in a specified directory. The rules take into account the file name, not

the file path. This is the basename of the file path. Note that file name transition uses an exact match done by the **strcmp()** function. Use of regular expressions or wildcard characters is not considered.



#### NOTE

File paths can vary in the kernel and file name transition does not use the paths to determine labels. Consequently, this feature only affects initial file creation and does not fix incorrect labels of already created objects.

### Example 4.2. Examples of Policy Rules Written with File Name Transition

The example below shows a policy rule with file name transition:

```
filetrans_pattern(unconfined_t, admin_home_t, ssh_home_t, dir, ".ssh")
```

This rule states that if a process with the **unconfined\_t** type creates the **~/.ssh/** directory in a directory labeled **admin\_home\_t**, the **~/.ssh/** directory gets the label **ssh\_home\_t**.

Similar examples of policy rules written with file name transition are presented below:

```
filetrans_pattern(staff_t, user_home_dir_t, httpd_user_content_t, dir, "public_html")
filetrans_pattern(thumb_t, user_home_dir_t, thumb_home_t, file, "missfont.log")
filetrans_pattern(kernel_t, device_t, xserver_misc_device_t, chr_file, "nvidia0")
filetrans_pattern(puppet_t, etc_t, krb5_conf_t, file, "krb5.conf")
```



#### NOTE

The file name transition feature affects mainly policy writers, but users can notice that instead of file objects almost always created with the default label of the containing directory, some file objects have a different label as specified in policy.

## 4.15. DISABLING PTRACE()

The **ptrace()** system call allows one process to observe and control the execution of another process and change its memory and registers. This call is used primarily by developers during debugging, for example when using the **strace** utility. When **ptrace()** is not needed, it can be disabled to improve system security. This can be done by enabling the **deny\_ptrace** Boolean, which denies all processes, even those that are running in **unconfined\_t** domains, from being able to use **ptrace()** on other processes.

The **deny\_ptrace** Boolean is disabled by default. To enable it, run the **setsebool -P deny\_ptrace on** command as the root user:

```
~]# setsebool -P deny_ptrace on
```

To verify if this Boolean is enabled, use the following command:

```
~]$ getsebool deny_ptrace
deny_ptrace --> on
```

To disable this Boolean, run the **setsebool -P deny\_ptrace off** command as root:

```
~]# setsebool -P deny_ptrace off
```



## NOTE

The **setsebool -P** command makes persistent changes. Do not use the **-P** option if you do not want changes to persist across reboots.

This Boolean influences only packages that are part of Red Hat Enterprise Linux. Consequently, third-party packages could still use the **ptrace()** system call. To list all domains that are allowed to use **ptrace()**, enter the following command. Note that the `setools-console` package provides the **seseach** utility and that the package is not installed by default.

```
~]# seseach -A -p ptrace,sys_ptrace -C | grep -v deny_ptrace | cut -d ' ' -f 5
```

## 4.16. THUMBNAIL PROTECTION

The thumbnail icons can potentially allow an attacker to break into a locked machine using removable media, such as USB devices or CDs. When the system detects a removable media, the Nautilus file manager executes the thumbnail driver code to display thumbnail icons in an appropriate file browser even if the machine is locked. This behavior is unsafe because if the thumbnail executables were vulnerable, the attacker could use the thumbnail driver code to bypass the lock screen without entering the password.

Therefore, a new SELinux policy is used to prevent such attacks. This policy ensures that all thumbnail drivers are locked when the screen is locked. The thumbnail protection is enabled for both confined users and unconfined users. This policy affects the following applications:

- `/usr/bin/evince-thumbnailer`
- `/usr/bin/ffmpegthumbnailer`
- `/usr/bin/gnome-exe-thumbnailer.sh`
- `/usr/bin/gnome-nds-thumbnailer`
- `/usr/bin/gnome-xcf-thumbnailer`
- `/usr/bin/gsf-office-thumbnailer`
- `/usr/bin/raw-thumbnailer`
- `/usr/bin/shotwell-video-thumbnailer`
- `/usr/bin/totem-video-thumbnailer`
- `/usr/bin/whaaw-thumbnailer`
- `/usr/lib/tumbler-1/tumblerd`
- `/usr/lib64/tumbler-1/tumblerd`

[3] To temporarily revert to the default behavior, as the Linux root user, run the **setsebool httpd\_can\_network\_connect\_db off** command. For changes that persist across reboots, run the **setsebool -P httpd\_can\_network\_connect\_db off** command.

[4] Files in the **/etc/selinux/targeted/contexts/files/** directory define contexts for files and directories. Files in this directory are read by the **restorecon** and **setfiles** utilities to restore files and directories to their default contexts.

[5] Morris, James. "Filesystem Labeling in SELinux". Published 1 October 2004. Accessed 14 October 2008: <http://www.linuxjournal.com/article/7426>.

[6] See the **matchpathcon(8)** manual page for further information about **matchpathcon**.

## CHAPTER 5. THE SEPOLICY SUITE

The **sepolicy** utility provides a suite of features to query the installed SELinux policy. These features are either new or were previously provided by separate utilities, such as **sepolgen** or **setrans**. The suite allows you to generate transition reports, man pages, or even new policy modules, thus giving users easier access and better understanding of the SELinux policy.

The `policycoreutils-devel` package provides **sepolicy**. Enter the following command as the root user to install **sepolicy**:

```
~]# yum install policycoreutils-devel
```

The **sepolicy** suite provides the following features that are invoked as command-line parameters:

**Table 5.1. The **sepolicy** Features**

Feature	Description
booleans	Query the SELinux Policy to see description of Booleans
communicate	Query the SELinux policy to see if domains can communicate with each other
generate	Generate an SELinux policy module template
gui	Graphical User Interface for SELinux Policy
interface	List SELinux Policy interfaces
manpage	Generate SELinux man pages
network	Query SELinux policy network information
transition	Query SELinux policy and generate a process transition report

### 5.1. THE SEPOLICY PYTHON BINDINGS

In previous versions of Red Hat Enterprise Linux, the `setools` package included the **sesearch** and **seinfo** utilities. The **sesearch** utility is used for searching rules in a SELinux policy while the **seinfo** utility allows you to query various other components in the policy.

In Red Hat Enterprise Linux 7, Python bindings for **sesearch** and **seinfo** have been added so that you can use the functionality of these utilities through the **sepolicy** suite. See the example below:

```
> python
>>> import sepolicy
>>> sepolicy.info(sepolicy.ATTRIBUTE)
Returns a dictionary of all information about SELinux Attributes
>>> sepolicy.search([sepolicy.ALLOW])
Returns a dictionary of all allow rules in the policy.
```

## 5.2. GENERATING SELINUX POLICY MODULES: SEPOLICY GENERATE

In previous versions of Red Hat Enterprise Linux, the **sepolgen** or **selinux-polgengui** utilities were used for generating a SELinux policy. These tools have been merged to the **sepolicy** suite. In Red Hat Enterprise Linux 7, the **sepolicy generate** command is used to generate an initial SELinux policy module template.

Unlike **sepolgen**, it is not necessary to run **sepolicy generate** as the root user. This utility also creates an RPM spec file, which can be used to build an RPM package that installs the policy package file (**NAME.pp**) and the interface file (**NAME.if**) to the correct location, provides installation of the SELinux policy into the kernel, and fixes the labeling. The setup script continues to install SELinux policy and sets up the labeling. In addition, a manual page based on the installed policy is generated using the **sepolicy manpage** command. [7] Finally, **sepolicy generate** builds and compiles the SELinux policy and the manual page into an RPM package, ready to be installed on other systems.

When **sepolicy generate** is executed, the following files are produced:

### **NAME.te** – type enforcing file

This file defines all the types and rules for a particular domain.

### **NAME.if** – interface file

This file defines the default file context for the system. It takes the file types created in the **NAME.te** file and associates file paths to the types. Utilities, such as **restorecon** and **rpm**, use these paths to write labels.

### **NAME\_selinux.spec** – RPM spec file

This file is an RPM spec file that installs SELinux policy and sets up the labeling. This file also installs the interface file and a man page describing the policy. You can use the **sepolicy manpage -d NAME** command to generate the man page.

### **NAME.sh** – helper shell script

This script helps to compile, install, and fix the labeling on the system. It also generates a man page based on the installed policy, compiles, and builds an RPM package suitable to be installed on other systems.

If it is possible to generate an SELinux policy module, **sepolicy generate** prints out all generated paths from the source domain to the target domain. See the **sepolicy-generate(8)** manual page for further information about **sepolicy generate**.

## 5.3. UNDERSTANDING DOMAIN TRANSITIONS: SEPOLICY TRANSITION

Previously, the **setrans** utility was used to examine if transition between two domain or process types is possible and printed out all intermediary types that are used to transition between these domains or processes. In Red Hat Enterprise Linux 7, **setrans** is provided as part of the **sepolicy** suite and the **sepolicy transition** command is now used instead.

The **sepolicy transition** command queries a SELinux policy and creates a process transition report. The **sepolicy transition** command requires two command-line arguments – a source domain (specified by the **-s** option) and a target domain (specified by the **-t** option). If only the source domain is entered, **sepolicy transition** lists all possible domains that the source domain can transition to. The following output does not contain all entries. The "@" character means "execute":

```
~]$ sepolity transition -s httpd_t
httpd_t @ httpd_suexec_exec_t --> httpd_suexec_t
httpd_t @ mailman_cgi_exec_t --> mailman_cgi_t
httpd_t @ abrt_retrace_worker_exec_t --> abrt_retrace_worker_t
httpd_t @ dirsrvadmin_unconfined_script_exec_t --> dirsrvadmin_unconfined_script_t
httpd_t @ httpd_unconfined_script_exec_t --> httpd_unconfined_script_t
```

If the target domain is specified, **sepolity transition** examines SELinux policy for all transition paths from the source domain to the target domain and lists these paths. The output below is not complete:

```
~]$ sepolity transition -s httpd_t -t system_mail_t
httpd_t @ exim_exec_t --> system_mail_t
httpd_t @ courier_exec_t --> system_mail_t
httpd_t @ sendmail_exec_t --> system_mail_t
httpd_t ... httpd_suexec_t @ sendmail_exec_t --> system_mail_t
httpd_t ... httpd_suexec_t @ exim_exec_t --> system_mail_t
httpd_t ... httpd_suexec_t @ courier_exec_t --> system_mail_t
httpd_t ... httpd_suexec_t ... httpd_mojomojo_script_t @ sendmail_exec_t --> system_mail_t
```

See the `sepolity-transition(8)` manual page for further information about **sepolity transition**.

## 5.4. GENERATING MANUAL PAGES: SEPOLICY MANPAGE

The **sepolity manpage** command generates manual pages based on the SELinux policy that document process domains. As a result, such documentation is always up-to-date. Each name of automatically generated manual pages consists of the process domain name and the **\_selinux** suffix, for example **httpd\_selinux**.

The manual pages include several sections that provide information about various parts of the SELinux policy for confined domains:

- The **Entrypoints** section contains all executable files that need to be executed during a domain transition.
- The **Process Types** section lists all process types that begin with the same prefix as the target domain.
- The **Booleans** section lists Booleans associated with the domain.
- The **Port Types** section contains the port types matching the same prefix as the domain and describes the default port numbers assigned to these port types.
- The **Managed Files** section describes the types that the domain is allowed to write to and the default paths associated with these types.
- The **File Contexts** section contains all file types associated with the domain and describes how to use these file types along with the default path labeling on a system.
- The **Sharing Files** section explains how to use the domain sharing types, such as **public\_content\_t**.

See the `sepolity-manpage(8)` manual page for further information about **sepolity manpage**.

[7] See [Section 5.4, “Generating Manual Pages: \*\*sepolicy manpage\*\*”](#) for more information about **sepolicy manpage**.

## CHAPTER 6. CONFINING USERS

In Red Hat Enterprise Linux, users are mapped to the SELinux **unconfined\_u** user by default. All processes run by **unconfined\_u** are in the **unconfined\_t** domain. This means that users can access across the system within the limits of the standard Linux DAC policy. However, a number of confined SELinux users are available in Red Hat Enterprise Linux. This means that users can be restricted to limited set of capabilities. Each Linux user is mapped to an SELinux user using SELinux policy, allowing Linux users to inherit the restrictions placed on SELinux users, for example (depending on the user), not being able to:

- run the X Window System
- use networking
- run setuid applications (unless SELinux policy permits it)
- or run the **su** and **sudo** commands.

For example, processes run by the SELinux **user\_u** user are in the **user\_t** domain. Such processes can connect to network, but cannot run the **su** or **sudo** commands. This helps protect the system from the user. See [Section 3.3, “Confined and Unconfined Users”](#), [Table 3.1, “SELinux User Capabilities”](#) for further information about confined users and their capabilities.

### 6.1. LINUX AND SELINUX USER MAPPINGS

As root, enter the following command to view the mapping between Linux users and SELinux users:

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	unconfined_u	s0-s0:c0.c1023	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*

In Red Hat Enterprise Linux, Linux users are mapped to the SELinux **\_\_default\_\_** login by default (which is in turn mapped to the SELinux **unconfined\_u** user). When a Linux user is created with the **useradd** command, if no options are specified, they are mapped to the SELinux **unconfined\_u** user. The following defines the default-mapping:

```
__default__    unconfined_u    s0-s0:c0.c1023    *
```

### 6.2. CONFINING NEW LINUX USERS: USERADD

Linux users mapped to the SELinux **unconfined\_u** user run in the **unconfined\_t** domain. This is seen by running the **id -Z** command while logged-in as a Linux user mapped to **unconfined\_u**:

```
~]$ id -Z
unconfined_u:unconfined_r:unconfined_t:s0-s0:c0.c1023
```

When Linux users run in the **unconfined\_t** domain, SELinux policy rules are applied, but policy rules exist that allow Linux users running in the **unconfined\_t** domain almost all access. If unconfined Linux users execute an application that SELinux policy defines can transition from the **unconfined\_t** domain to its own confined domain, unconfined Linux users are still subject to the restrictions of that confined

domain. The security benefit of this is that, even though a Linux user is running unconfined, the application remains confined, and therefore, the exploitation of a flaw in the application can be limited by policy.



## NOTE

This does not protect the system from the user. Instead, the user and the system are being protected from possible damage caused by a flaw in the application.

When creating Linux users with the **useradd** command, use the **-Z** option to specify which SELinux user they are mapped to. The following example creates a new Linux user, **useruuser**, and maps that user to the SELinux **user\_u** user. Linux users mapped to the SELinux **user\_u** user run in the **user\_t** domain. In this domain, Linux users are unable to run **setuid** applications unless SELinux policy permits it (such as **passwd**), and cannot run the **su** or **sudo** command, preventing them from becoming the root user with these commands.

### Procedure 6.1. Confining a New Linux User to **user\_u** SELinux User

1. As root, create a new Linux user (**useruuser**) that is mapped to the SELinux **user\_u** user.

```
~]# useradd -Z user_u useruuser
```

2. To view the mapping between **useruuser** and **user\_u**, enter the following command as root:

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	unconfined_u	s0-s0:c0.c1023	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*
useruuser	user_u	s0	*

3. As root, assign a password to the Linux **useruuser** user:

```
~]# passwd useruuser
Changing password for user useruuser.
New password: Enter a password
Retype new password: Enter the same password again
passwd: all authentication tokens updated successfully.
```

4. Log out of your current session, and log in as the Linux **useruuser** user. When you log in, the **pam\_selinux** module maps the Linux user to an SELinux user (in this case, **user\_u**), and sets up the resulting SELinux context. The Linux user's shell is then launched with this context. Enter the following command to view the context of a Linux user:

```
~]$ id -Z
user_u:user_r:user_t:s0
```

5. Log out of the Linux **useruuser**'s session, and log back in with your account. If you do not want the Linux **useruuser** user, enter the following command as root to remove it, along with its home directory:

■

```
~]# userdel -Z -r useruuser
```

## 6.3. CONFINING EXISTING LINUX USERS: SEMANAGE LOGIN

If a Linux user is mapped to the SELinux **unconfined\_u** user (the default behavior), and you would like to change which SELinux user they are mapped to, use the **semanage login** command. The following example creates a new Linux user named **newuser**, then maps that Linux user to the SELinux **user\_u** user:

### Procedure 6.2. Mapping Linux Users to the SELinux Users

1. As root, create a new Linux user (**newuser**). Since this user uses the default mapping, it does not appear in the **semanage login -l** output:

```
~]# useradd newuser
```

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	unconfined_u	s0-s0:c0.c1023	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*

2. To map the Linux **newuser** user to the SELinux **user\_u** user, enter the following command as root:

```
~]# semanage login -a -s user_u newuser
```

The **-a** option adds a new record, and the **-s** option specifies the SELinux user to map a Linux user to. The last argument, **newuser**, is the Linux user you want mapped to the specified SELinux user.

3. To view the mapping between the Linux **newuser** user and **user\_u**, use the **semanage** utility again:

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	unconfined_u	s0-s0:c0.c1023	*
newuser	user_u	s0	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*

4. As root, assign a password to the Linux **newuser** user:

```
~]# passwd newuser
Changing password for user newuser.
New password: Enter a password
Retype new password: Enter the same password again
passwd: all authentication tokens updated successfully.
```

- Log out of your current session, and log in as the Linux **newuser** user. Enter the following command to view the **newuser**'s SELinux context:

```
~]$ id -Z
user_u:user_r:user_t:s0
```

- Log out of the Linux **newuser**'s session, and log back in with your account. If you do not want the Linux **newuser** user, enter the following command as root to remove it, along with its home directory:

```
~]# userdel -r newuser
```

As root, remove the mapping between the Linux **newuser** user and **user\_u**:

```
~]# semanage login -d newuser
```

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	unconfined_u	s0-s0:c0.c1023	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*

## 6.4. CHANGING THE DEFAULT MAPPING

In Red Hat Enterprise Linux, Linux users are mapped to the SELinux **\_\_default\_\_** login by default (which is in turn mapped to the SELinux **unconfined\_u** user). If you would like new Linux users, and Linux users not specifically mapped to an SELinux user to be confined by default, change the default mapping with the **semanage login** command.

For example, enter the following command as root to change the default mapping from **unconfined\_u** to **user\_u**:

```
~]# semanage login -m -S targeted -s "user_u" -r s0 __default__
```

Verify the **\_\_default\_\_** login is mapped to **user\_u**:

```
~]# semanage login -l
```

Login Name	SELinux User	MLS/MCS Range	Service
__default__	user_u	s0-s0:c0.c1023	*
root	unconfined_u	s0-s0:c0.c1023	*
system_u	system_u	s0-s0:c0.c1023	*

If a new Linux user is created and an SELinux user is not specified, or if an existing Linux user logs in and does not match a specific entry from the **semanage login -l** output, they are mapped to **user\_u**, as per the **\_\_default\_\_** login.

To change back to the default behavior, enter the following command as root to map the **\_\_default\_\_** login to the SELinux **unconfined\_u** user:

■

```
~]# semanage login -m -S targeted -s "unconfined_u" -r s0-s0:c0.c1023 __default__
```

## 6.5. XGUEST: KIOSK MODE

The `xguest` package provides a kiosk user account. This account is used to secure machines that people walk up to and use, such as those at libraries, banks, airports, information kiosks, and coffee shops. The kiosk user account is very limited: essentially, it only allows a user to log in and use **Firefox** to browse Internet websites. Guest user is assigned to `xguest_u`, see [Table 3.1, “SELinux User Capabilities”](#). Any changes made while logged in with this account, such as creating files or changing settings, are lost when you log out.

To set up the kiosk account:

1. As root, install the `xguest` package. Install dependencies as required:

```
~]# yum install xguest
```

2. In order to allow the kiosk account to be used by a variety of people, the account is not password-protected, and as such, the account can only be protected if SELinux is running in enforcing mode. Before logging in with this account, use the **getenforce** utility to confirm that SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

If this is not the case, see [Section 4.4, “Permanent Changes in SELinux States and Modes”](#) for information about changing to enforcing mode. It is not possible to log in with this account if SELinux is in permissive mode or disabled.

3. You can only log in to this account using the GNOME Display Manager (GDM). Once the `xguest` package is installed, a **Guest** account is added to the GDM login screen.

## 6.6. BOOLEANS FOR USERS EXECUTING APPLICATIONS

Not allowing Linux users to execute applications (which inherit users' permissions) in their home directories and the `/tmp` directory, which they have write access to, helps prevent flawed or malicious applications from modifying files that users own.

Booleans are available to change this behavior, and are configured with the **setsebool** utility, which must be run as root. The **setsebool -P** command makes persistent changes. Do not use the **-P** option if you do not want changes to persist across reboots:

### guest\_t

To *prevent* Linux users in the `guest_t` domain from executing applications in their home directories and `/tmp`:

```
~]# setsebool -P guest_exec_content off
```

### xguest\_t

To *prevent* Linux users in the `xguest_t` domain from executing applications in their home directories and `/tmp`:

```
~]# setsebool -P xguest_exec_content off
```

## **user\_t**

To *prevent* Linux users in the **user\_t** domain from executing applications in their home directories and **/tmp**:

```
~]# setsebool -P user_exec_content off
```

## **staff\_t**

To *prevent* Linux users in the **staff\_t** domain from executing applications in their home directories and **/tmp**:

```
~]# setsebool -P staff_exec_content off
```

To turn the **staff\_exec\_content** boolean on and to *allow* Linux users in the **staff\_t** domain to execute applications in their home directories and **/tmp**:

```
~]# setsebool -P staff_exec_content on
```

## CHAPTER 7. SECURING PROGRAMS USING SANDBOX

The **sandbox** security utility adds a set of SELinux policies that allow a system administrator to run an application within a tightly confined SELinux domain. Restrictions on permission to open new files or access to the network can be defined. This enables testing the processing characteristics of untrusted software securely, without risking damage to the system.

### 7.1. RUNNING AN APPLICATION USING SANDBOX

Before using the **sandbox** utility, the `policycoreutils-sandbox` package must be installed:

```
~]# yum install policycoreutils-sandbox
```

The basic syntax to confine an application is:

```
~]$ sandbox [options] application_under_test
```

To run a graphical application in a **sandbox**, use the **-X** option. For example:

```
~]$ sandbox -X evince
```

The **-X** tells **sandbox** to set up a confined secondary X Server for the application (in this case, **evince**), before copying the needed resources and creating a closed virtual environment in the user's **home** directory or in the **/tmp** directory.

To preserve data from one session to the next:

```
~]$ sandbox -H sandbox/home -T sandbox/tmp -X firefox
```

Note that **sandbox/home** is used for **/home** and **sandbox/tmp** is used for **/tmp**. Different applications are placed in different restricted environments. The application runs in full-screen mode and this prevents access to other functions. As mentioned before, you cannot open or create files except those which are labeled as **sandbox\_x\_file\_t**.

Access to the network is also initially impossible inside the **sandbox**. To allow access, use the **sandbox\_web\_t** label. For example, to launch **Firefox**:

```
~]$ sandbox -X -t sandbox_web_t firefox
```



#### WARNING

The **sandbox\_net\_t** label allows unrestricted, bi-directional network access to all network ports. The **sandbox\_web\_t** allows connections to ports required for web browsing only.

Use of **sandbox\_net\_t** should be made with caution and only when required.

See the **sandbox (8)** manual page for information, and a full list of available options.

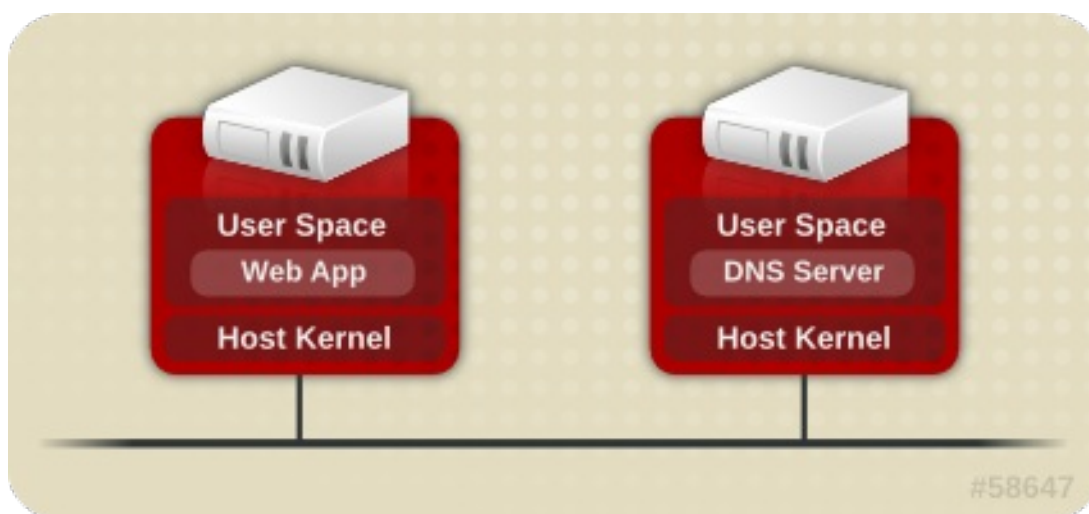
## CHAPTER 8. SVIRT

sVirt is a technology included in Red Hat Enterprise Linux that integrates SELinux and virtualization. sVirt applies Mandatory Access Control (MAC) to improve security when using virtual machines. The main reasons for integrating these technologies are to improve security and harden the system against bugs in the hypervisor that might be used as an attack vector aimed toward the host or to another virtual machine.

This chapter describes how sVirt integrates with virtualization technologies in Red Hat Enterprise Linux.

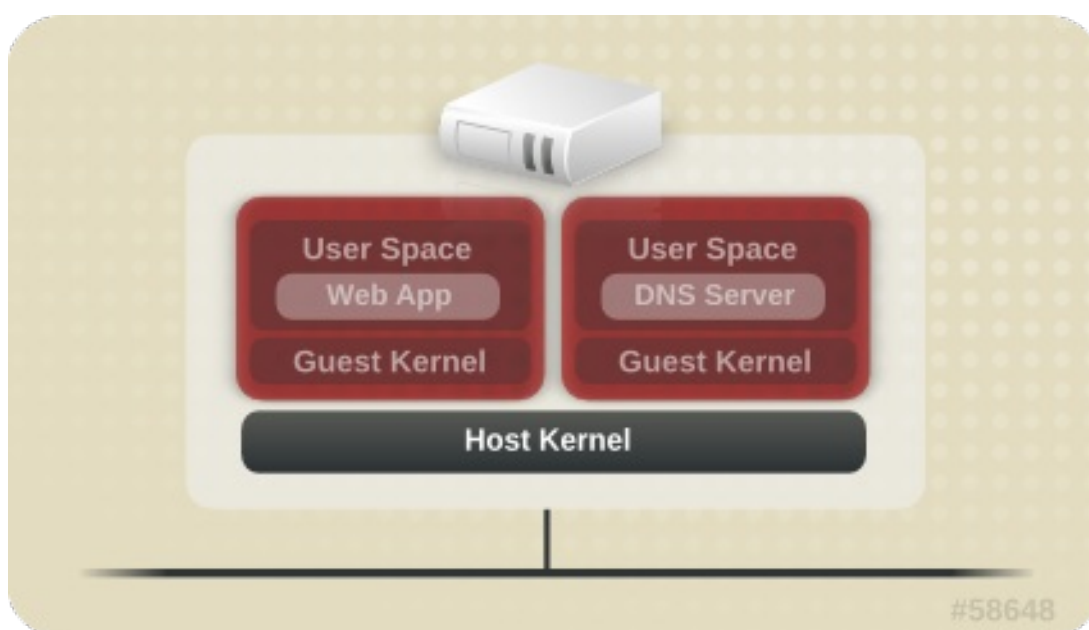
### Non-Virtualized Environment

In a non-virtualized environment, hosts are separated from each other physically and each host has a self-contained environment, consisting of services such as a Web server, or a DNS server. These services communicate directly to their own user space, host kernel and physical host, offering their services directly to the network. The following image represents a non-virtualized environment:



### Virtualized Environment

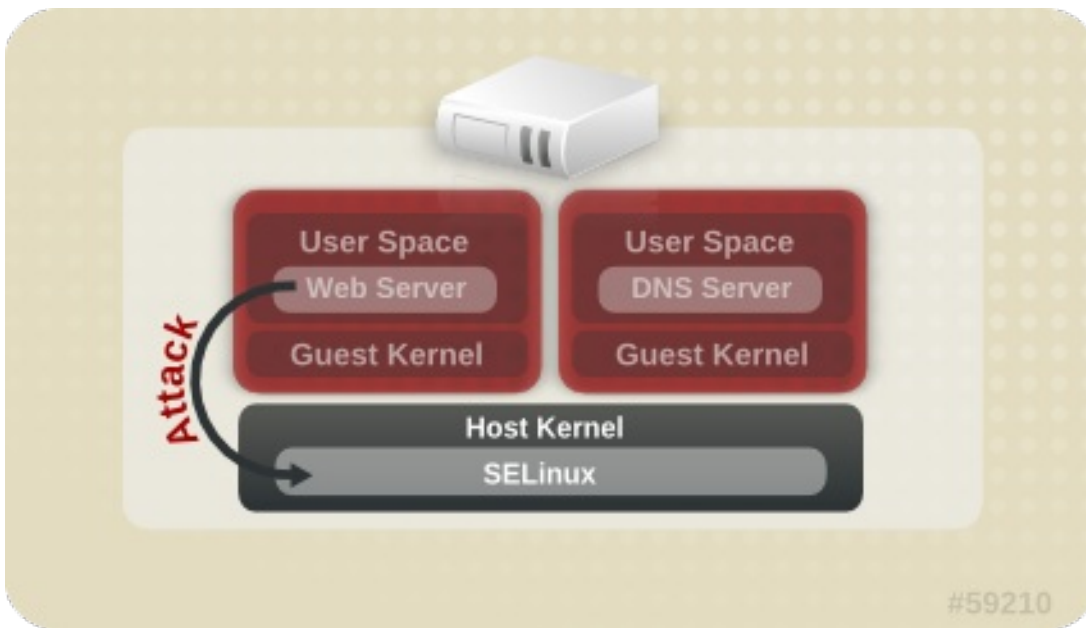
In a virtualized environment, several operating systems can be housed (as "guests") within a single host kernel and physical host. The following image represents a virtualized environment:



## 8.1. SECURITY AND VIRTUALIZATION

When services are not virtualized, machines are physically separated. Any exploit is usually contained to the affected machine, with the obvious exception of network attacks. When services are grouped together in a virtualized environment, extra vulnerabilities emerge in the system. If there is a security flaw in the hypervisor that can be exploited by a guest instance, this guest may be able to not only attack the host, but also other guests running on that host. This is not theoretical; attacks already exist on hypervisors. These attacks can extend beyond the guest instance and could expose other guests to attack.

sVirt is an effort to isolate guests and limit their ability to launch further attacks if exploited. This is demonstrated in the following image, where an attack cannot break out of the virtual machine and extend to another host instance:



SELinux introduces a pluggable security framework for virtualized instances in its implementation of Mandatory Access Control (MAC). The sVirt framework allows guests and their resources to be uniquely labeled. Once labeled, rules can be applied which can reject access between different guests.

## 8.2. SVIRT LABELING

Like other services under the protection of SELinux, sVirt uses process-based mechanisms and restrictions to provide an extra layer of security over guest instances. Under typical use, you should not even notice that sVirt is working in the background. This section describes the labeling features of sVirt.

As shown in the following output, when using sVirt, each Virtual Machine (VM) process is labeled and runs with a dynamically generated level. Each process is isolated from other VMs with different levels:

```
~]# ps -eZ | grep qemu
system_u:system_r:svirt_t:s0:c87,c520 27950 ? 00:00:17 qemu-kvm
system_u:system_r:svirt_t:s0:c639,c757 27989 ? 00:00:06 qemu-system-x86
```

The actual disk images are automatically labeled to match the processes, as shown in the following output:

```
~]# ls -lZ /var/lib/libvirt/images/*
system_u:object_r:svirt_image_t:s0:c87,c520 image1
```

The following table outlines the different labels that can be assigned when using sVirt:

**Table 8.1. sVirt Labels**

Type	SELinux Context	Description
Virtual Machine Processes	system_u:system_r:svirt_t:MCS1	MCS1 is a randomly selected MCS field. Currently approximately 500,000 labels are supported.
Virtual Machine Image	system_u:object_r:svirt_image_t:MCS1	Only processes labeled <i>svirt_t</i> with the same MCS fields are able to read/write these image files and devices.
Virtual Machine Shared Read/Write Content	system_u:object_r:svirt_image_t:s0	All processes labeled <i>svirt_t</i> are allowed to write to the <i>svirt_image_t:s0</i> files and devices.
Virtual Machine Image	system_u:object_r:virt_content_t:s0	System default label used when an image exits. No <i>svirt_t</i> virtual processes are allowed to read files/devices with this label.

It is also possible to perform static labeling when using sVirt. Static labels allow the administrator to select a specific label, including the MCS/MLS field, for a virtual machine. Administrators who run statically-labeled virtual machines are responsible for setting the correct label on the image files. The virtual machine will always be started with that label, and the sVirt system will never modify the label of a statically-labeled virtual machine's content. This allows the sVirt component to run in an MLS environment. You can also run multiple virtual machines with different sensitivity levels on a system, depending on your requirements.

## CHAPTER 9. SECURE LINUX CONTAINERS

Linux Containers (LXC) is a low-level virtualization feature that allows you to run multiple copies of the same service at the same time on a system. Compared to full virtualization, containers do not require an entire new system to boot, can use less memory, and can use the base operating system in a read-only manner. For example, LXC allow you to run multiple web servers simultaneously, each with their own data while sharing the system data, and even running as the root user. However, running a privileged process within a container could affect other processes running outside of the container or processes running in other containers. Secure Linux containers use the SELinux context, therefore preventing the processes running within them from interacting with each other or with the host.

The **Docker** application is the main utility for managing Linux Containers in Red Hat Enterprise Linux. As an alternative, you can also use the **virsh** command-line utility provided by the `libvirt` package.

For further details about Linux Containers, see [Getting Started with Containers](#).

## CHAPTER 10. SELINUX `SYSTEMD` ACCESS CONTROL

In Red Hat Enterprise Linux 7, system services are controlled by the **systemd** daemon. In previous releases of Red Hat Enterprise Linux, daemons could be started in two ways:

- At boot time, the System V **init** daemon launched an **init.rc** script and then this script launched the required daemon. For example, the Apache server, which was started at boot, got the following SELinux label:

```
system_u:system_r:httpd_t:s0
```

- An administrator launched the **init.rc** script manually, causing the daemon to run. For example, when the **service httpd restart** command was invoked on the Apache server, the resulting SELinux label looked as follows:

```
unconfined_u:system_r:httpd_t:s0
```

When launched manually, the process adopted the user portion of the SELinux label that started it, making the labeling in the two scenarios above inconsistent. With the **systemd** daemon, the transitions are very different. As **systemd** handles all the calls to start and stop daemons on the system, using the **init\_t** type, it can override the user part of the label when a daemon is restarted manually. As a result, the labels in both scenarios above are **system\_u:system\_r:httpd\_t:s0** as expected and the SELinux policy could be improved to govern which domains are able to control which units.

### 10.1. SELINUX ACCESS PERMISSIONS FOR SERVICES

In previous versions of Red Hat Enterprise Linux, an administrator was able to control, which users or applications were able to start or stop services based on the label of the System V Init script. Now, **systemd** starts and stops all services, and users and processes communicate with **systemd** using the **systemctl** utility. The **systemd** daemon has the ability to consult the SELinux policy and check the label of the calling process and the label of the unit file that the caller tries to manage, and then ask SELinux whether or not the caller is allowed the access. This approach strengthens access control to critical system capabilities, which include starting and stopping system services.

For example, previously, administrators had to allow NetworkManager to execute **systemctl** to send a D-Bus message to **systemd**, which would in turn start or stop whatever service NetworkManager requested. In fact, NetworkManager was allowed to do everything **systemctl** could do. It was also impossible to setup confined administrators so that they could start or stop just particular services.

To fix these issues, **systemd** also works as an SELinux Access Manager. It can retrieve the label of the process running **systemctl** or the process that sent a D-Bus message to **systemd**. The daemon then looks up the label of the unit file that the process wanted to configure. Finally, **systemd** can retrieve information from the kernel if the SELinux policy allows the specific access between the process label and the unit file label. This means a compromised application that needs to interact with **systemd** for a specific service can now be confined by SELinux. Policy writers can also use these fine-grained controls to confine administrators. Policy changes involve a new class called **service**, with the following permissions:

```
class service
{
    start
    stop
    status
    reload
```

```

kill
load
enable
disable
}

```

For example, a policy writer can now allow a domain to get the status of a service or start and stop a service, but not enable or disable a service. Access control operations in SELinux and **systemd** do not match in all cases. A mapping was defined to line up **systemd** method calls with SELinux access checks. [Table 10.1, “Mapping of systemd unit file method calls on SELinux access checks”](#) maps access checks on unit files while [Table 10.2, “Mapping of systemd general system calls on SELinux access checks”](#) covers access checks for the system in general. If no match is found in either table, then the **undefined** system check is called.

**Table 10.1. Mapping of systemd unit file method calls on SELinux access checks**

systemd unit file method	SELinux access check
DisableUnitFiles	disable
EnableUnitFiles	enable
GetUnit	status
GetUnitByPID	status
GetUnitFileState	status
Kill	stop
KillUnit	stop
LinkUnitFiles	enable
ListUnits	status
LoadUnit	status
MaskUnitFiles	disable
PresetUnitFiles	enable
ReenableUnitFiles	enable
Reexecute	start
Reload	reload
ReloadOrRestart	start

<b>systemd</b> unit file method	SELinux access check
ReloadOrRestartUnit	start
ReloadOrTryRestart	start
ReloadOrTryRestartUnit	start
ReloadUnit	reload
ResetFailed	stop
ResetFailedUnit	stop
Restart	start
RestartUnit	start
Start	start
StartUnit	start
StartUnitReplace	start
Stop	stop
StopUnit	stop
TryRestart	start
TryRestartUnit	start
UnmaskUnitFiles	enable

Table 10.2. Mapping of systemd general system calls on SELinux access checks

<b>systemd</b> general system call	SELinux access check
ClearJobs	reboot
FlushDevices	halt
Get	status
GetAll	status

systemd general system call	SELinux access check
GetJob	status
GetSeat	status
GetSession	status
GetSessionByPID	status
GetUser	status
Halt	halt
Introspect	status
KExec	reboot
KillSession	halt
KillUser	halt
ListJobs	status
ListSeats	status
ListSessions	status
ListUsers	status
LockSession	halt
PowerOff	halt
Reboot	reboot
SetUserLinger	halt
TerminateSeat	halt
TerminateSession	halt
TerminateUser	halt

### Example 10.1. SELinux Policy for a System Service

By using the **sesearch** utility, you can list policy rules for a system service. For example, calling the **sesearch -A -s NetworkManager\_t -c service** command returns:

```
allow NetworkManager_t dnsmasq_unit_file_t : service { start stop status reload kill load } ;
allow NetworkManager_t nscd_unit_file_t : service { start stop status reload kill load } ;
allow NetworkManager_t ntpd_unit_file_t : service { start stop status reload kill load } ;
allow NetworkManager_t pppd_unit_file_t : service { start stop status reload kill load } ;
allow NetworkManager_t polipo_unit_file_t : service { start stop status reload kill load } ;
```

## 10.2. SELINUX AND JOURNALD

In **systemd**, the **journald** daemon (also known as **systemd-journal**) is the alternative for the **syslog** utility, which is a system service that collects and stores logging data. It creates and maintains structured and indexed journals based on logging information that is received from the kernel, from user processes using the **libc syslog()** function, from standard and error output of system services, or using its native API. It implicitly collects numerous metadata fields for each log message in a secure way.

The **systemd-journal** service can be used with SELinux to increase security. SELinux controls processes by only allowing them to do what they were designed to do; sometimes even less, depending on the security goals of the policy writer. For example, SELinux prevents a compromised **ntpd** process from doing anything other than handle Network Time. However, the **ntpd** process sends **syslog** messages, so that SELinux would allow the compromised process to continue to send those messages. The compromised **ntpd** could format **syslog** messages to match other daemons and potentially mislead an administrator, or even worse, a utility that reads the **syslog** file into compromising the whole system.

The **systemd-journal** daemon verifies all log messages and, among other things, adds SELinux labels to them. It is then easy to detect inconsistencies in log messages and prevent an attack of this type before it occurs. You can use the **journalctl** utility to query logs of **systemd** journals. If no command-line arguments are specified, running this utility lists the full content of the journal, starting from the oldest entries. To see all logs generated on the system, including logs for system components, execute **journalctl** as root. If you execute it as a non-root user, the output will be limited only to logs related to the currently logged-in user.

### Example 10.2. Listing Logs with **journalctl**

It is possible to use **journalctl** for listing all logs related to a particular SELinux label. For example, the following command lists all logs logged under the **system\_u:system\_r:policykit\_t:s0** label:

```
~]# journalctl _SELINUX_CONTEXT=system_u:system_r:policykit_t:s0
Oct 21 10:22:42 localhost.localdomain polkitd[647]: Started polkitd version 0.112
Oct 21 10:22:44 localhost.localdomain polkitd[647]: Loading rules from directory /etc/polkit-1/rules.d
Oct 21 10:22:44 localhost.localdomain polkitd[647]: Loading rules from directory /usr/share/polkit-1/rules.d
Oct 21 10:22:44 localhost.localdomain polkitd[647]: Finished loading, compiling and executing 5 rules
Oct 21 10:22:44 localhost.localdomain polkitd[647]: Acquired the name org.freedesktop.PolicyKit1 on the system bus
Oct 21 10:23:10 localhost polkitd[647]: Registered Authentication Agent for unix-session:c1 (system bus name :1.49, object path /org/freedesktop/PolicyKit1/AuthenticationAgent, locale en_US.UTF-8) (disconnected from bus)
Oct 21 10:23:35 localhost polkitd[647]: Unregistered Authentication Agent for unix-session:c1 (system bus name :1.80 [/usr/bin/gnome-shell --mode=classic], object path /org/freedesktop/PolicyKit1/AuthenticationAgent, locale en_US.utf8)
```

■

For more information about **journalctl**, see the `journalctl(1)` manual page.

## CHAPTER 11. TROUBLESHOOTING

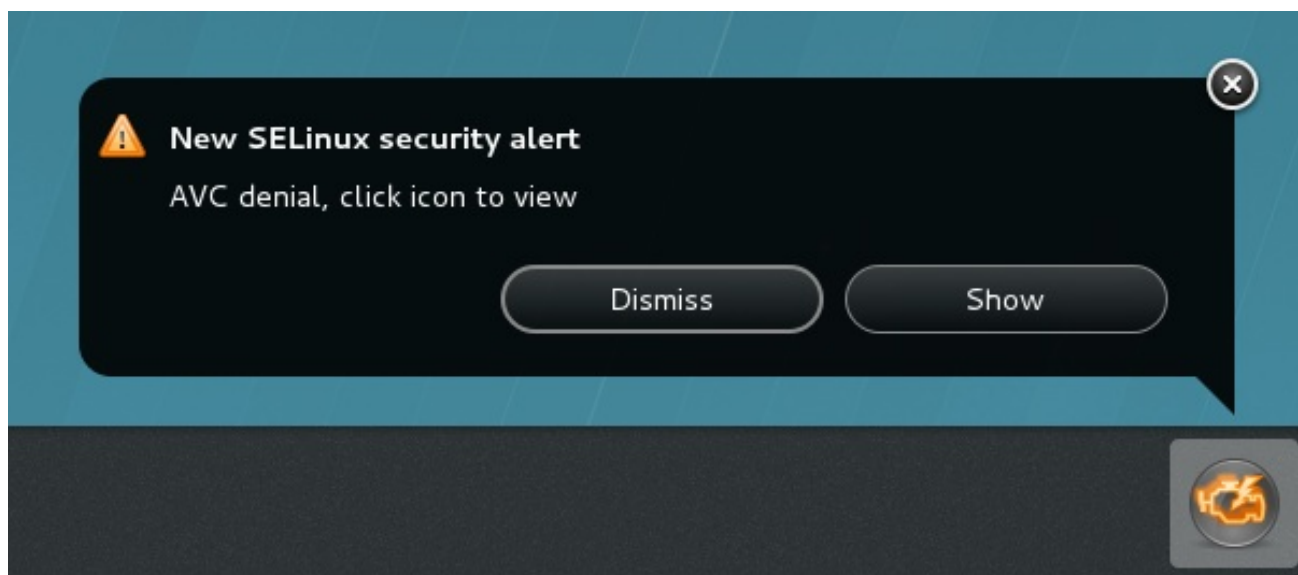
The following chapter describes what happens when SELinux denies access; the top three causes of problems; where to find information about correct labeling; analyzing SELinux denials; and creating custom policy modules with **audit2allow**.

### 11.1. WHAT HAPPENS WHEN ACCESS IS DENIED

SELinux decisions, such as allowing or disallowing access, are cached. This cache is known as the Access Vector Cache (AVC). Denial messages are logged when SELinux denies access. These denials are also known as "AVC denials", and are logged to a different location, depending on which daemons are running:

Daemon	Log Location
auditd on	<b>/var/log/audit/audit.log</b>
auditd off; rsyslogd on	<b>/var/log/messages</b>
setroubleshootd, rsyslogd, and auditd on	<b>/var/log/audit/audit.log</b> . Easier-to-read denial messages also sent to <b>/var/log/messages</b>

If you are running the X Window System, have the **setroubleshoot** and **setroubleshoot-server** packages installed, and the **setroubleshootd** and **auditd** daemons are running, a warning is displayed when access is denied by SELinux:



Clicking on **Show** presents a detailed analysis of why SELinux denied access, and a possible solution for allowing access. If you are not running the X Window System, it is less obvious when access is denied by SELinux. For example, users browsing your website may receive an error similar to the following:

Forbidden

You don't have permission to access *file name* on this server

For these situations, if DAC rules (standard Linux permissions) allow access, check **/var/log/messages** and **/var/log/audit/audit.log** for **"SELinux is preventing"** and **"denied"** errors respectively. This can be done by running the following commands as the root user:

```
~]# grep "SELinux is preventing" /var/log/messages
```

```
~]# grep "denied" /var/log/audit/audit.log
```

## 11.2. TOP THREE CAUSES OF PROBLEMS

The following sections describe the top three causes of problems: labeling problems, configuring Booleans and ports for services, and evolving SELinux rules.

### 11.2.1. Labeling Problems

On systems running SELinux, all processes and files are labeled with a label that contains security-relevant information. This information is called the SELinux context. If these labels are wrong, access may be denied. An incorrectly labeled application may cause an incorrect label to be assigned to its process. This may cause SELinux to deny access, and the process may create mislabeled files.

A common cause of labeling problems is when a non-standard directory is used for a service. For example, instead of using **/var/www/html/** for a website, an administrator wants to use **/srv/myweb/**. On Red Hat Enterprise Linux, the **/srv** directory is labeled with the **var\_t** type. Files and directories created in **/srv** inherit this type. Also, newly-created objects in top-level directories (such as **/myserver**) may be labeled with the **default\_t** type. SELinux prevents the Apache HTTP Server (**httpd**) from accessing both of these types. To allow access, SELinux must know that the files in **/srv/myweb/** are to be accessible to **httpd**:

```
~]# semanage fcontext -a -t httpd_sys_content_t "/srv/myweb(/.*)?"
```

This **semanage** command adds the context for the **/srv/myweb/** directory (and all files and directories under it) to the SELinux file-context configuration<sup>[8]</sup>. The **semanage** utility does not change the context. As root, run the **restorecon** utility to apply the changes:

```
~]# restorecon -R -v /srv/myweb
```

See [Section 4.7.2, "Persistent Changes: semanage fcontext"](#) for further information about adding contexts to the file-context configuration.

#### 11.2.1.1. What is the Correct Context?

The **matchpathcon** utility checks the context of a file path and compares it to the default label for that path. The following example demonstrates using **matchpathcon** on a directory that contains incorrectly labeled files:

```
~]$ matchpathcon -V /var/www/html/*
/var/www/html/index.html has context unconfined_u:object_r:user_home_t:s0, should be
system_u:object_r:httpd_sys_content_t:s0
/var/www/html/page1.html has context unconfined_u:object_r:user_home_t:s0, should be
system_u:object_r:httpd_sys_content_t:s0
```

In this example, the **index.html** and **page1.html** files are labeled with the **user\_home\_t** type. This type is used for files in user home directories. Using the **mv** command to move files from your home directory

may result in files being labeled with the **user\_home\_t** type. This type should not exist outside of home directories. Use the **restorecon** utility to restore such files to their correct type:

```
~]# restorecon -v /var/www/html/index.html
restorecon reset /var/www/html/index.html context unconfined_u:object_r:user_home_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
```

To restore the context for all files under a directory, use the **-R** option:

```
~]# restorecon -R -v /var/www/html/
restorecon reset /var/www/html/page1.html context unconfined_u:object_r:samba_share_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
restorecon reset /var/www/html/index.html context unconfined_u:object_r:samba_share_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
```

See [Section 4.10.3, "Checking the Default SELinux Context"](#) for a more detailed example of **matchpathcon**.

### 11.2.2. How are Confined Services Running?

Services can be run in a variety of ways. To cater for this, you need to specify how you run your services. This can be achieved through Booleans that allow parts of SELinux policy to be changed at runtime, without any knowledge of SELinux policy writing. This allows changes, such as allowing services access to NFS volumes, without reloading or recompiling SELinux policy. Also, running services on non-default port numbers requires policy configuration to be updated using the **semanage** command.

For example, to allow the Apache HTTP Server to communicate with MariaDB, enable the **httpd\_can\_network\_connect\_db** Boolean:

```
~]# setsebool -P httpd_can_network_connect_db on
```

If access is denied for a particular service, use the **getsebool** and **grep** utilities to see if any Booleans are available to allow access. For example, use the **getsebool -a | grep ftp** command to search for FTP related Booleans:

```
~]$ getsebool -a | grep ftp
ftpd_anon_write --> off
ftpd_full_access --> off
ftpd_use_cifs --> off
ftpd_use_nfs --> off

ftpd_connect_db --> off
httpd_enable_ftp_server --> off
tftp_anon_write --> off
```

For a list of Booleans and whether they are on or off, run the **getsebool -a** command. For a list of Booleans, an explanation of what each one is, and whether they are on or off, run the **semanage boolean -l** command as root. See [Section 4.6, "Booleans"](#) for information about listing and configuring Booleans.

### Port Numbers

Depending on policy configuration, services may only be allowed to run on certain port numbers. Attempting to change the port a service runs on without changing policy may result in the service failing to start. For example, run the **semanage port -l | grep http** command as root to list **http** related ports:

```
~]# semanage port -l | grep http
http_cache_port_t      tcp    3128, 8080, 8118
http_cache_port_t      udp    3130
http_port_t            tcp    80, 443, 488, 8008, 8009, 8443
pegasus_http_port_t    tcp    5988
pegasus_https_port_t   tcp    5989
```

The **http\_port\_t** port type defines the ports Apache HTTP Server can listen on, which in this case, are TCP ports 80, 443, 488, 8008, 8009, and 8443. If an administrator configures **httpd.conf** so that **httpd** listens on port 9876 (**Listen 9876**), but policy is not updated to reflect this, the following command fails:

```
~]# systemctl start httpd.service
Job for httpd.service failed. See 'systemctl status httpd.service' and 'journalctl -xn' for details.
```

```
~]# systemctl status httpd.service
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: failed (Result: exit-code) since Thu 2013-08-15 09:57:05 CEST; 59s ago
   Process: 16874 ExecStop=/usr/sbin/httpd $OPTIONS -k graceful-stop (code=exited,
status=0/SUCCESS)
   Process: 16870 ExecStart=/usr/sbin/httpd $OPTIONS -DFOREGROUND (code=exited,
status=1/FAILURE)
```

An SELinux denial message similar to the following is logged to **/var/log/audit/audit.log**:

```
type=AVC msg=audit(1225948455.061:294): avc: denied { name_bind } for pid=4997
comm="httpd" src=9876 scontext=unconfined_u:system_r:httpd_t:s0
tcontext=system_u:object_r:port_t:s0 tclass=tcp_socket
```

To allow **httpd** to listen on a port that is not listed for the **http\_port\_t** port type, enter the **semanage port** command to add a port to policy configuration <sup>[9]</sup>:

```
~]# semanage port -a -t http_port_t -p tcp 9876
```

The **-a** option adds a new record; the **-t** option defines a type; and the **-p** option defines a protocol. The last argument is the port number to add.

### 11.2.3. Evolving Rules and Broken Applications

Applications may be broken, causing SELinux to deny access. Also, SELinux rules are evolving – SELinux may not have seen an application running in a certain way, possibly causing it to deny access, even though the application is working as expected. For example, if a new version of PostgreSQL is released, it may perform actions the current policy has not seen before, causing access to be denied, even though access should be allowed.

For these situations, after access is denied, use the **audit2allow** utility to create a custom policy module to allow access. See [Section 11.3.8, “Allowing Access: audit2allow”](#) for information about using **audit2allow**.

## 11.3. FIXING PROBLEMS

The following sections help troubleshoot issues. They go over: checking Linux permissions, which are checked before SELinux rules; possible causes of SELinux denying access, but no denials being logged;

manual pages for services, which contain information about labeling and Booleans; permissive domains, for allowing one process to run permissive, rather than the whole system; how to search for and view denial messages; analyzing denials; and creating custom policy modules with **audit2allow**.

### 11.3.1. Linux Permissions

When access is denied, check standard Linux permissions. As mentioned in [Chapter 1, Introduction](#), most operating systems use a Discretionary Access Control (DAC) system to control access, allowing users to control the permissions of files that they own. SELinux policy rules are checked after DAC rules. SELinux policy rules are not used if DAC rules deny access first.

If access is denied and no SELinux denials are logged, use the following command to view the standard Linux permissions:

```
~]$ ls -l /var/www/html/index.html
-rw-r----- 1 root root 0 2009-05-07 11:06 index.html
```

In this example, **index.html** is owned by the root user and group. The root user has read and write permissions (**-rw**), and members of the root group have read permissions (**-r-**). Everyone else has no access (**---**). By default, such permissions do not allow **httpd** to read this file. To resolve this issue, use the **chown** command to change the owner and group. This command must be run as root:

```
~]# chown apache:apache /var/www/html/index.html
```

This assumes the default configuration, in which **httpd** runs as the Linux Apache user. If you run **httpd** with a different user, replace **apache:apache** with that user.

See the [Fedora Documentation Project "Permissions"](#) draft for information about managing Linux permissions.

### 11.3.2. Possible Causes of Silent Denials

In certain situations, AVC denial messages may not be logged when SELinux denies access. Applications and system library functions often probe for more access than required to perform their tasks. To maintain the least privilege without filling audit logs with AVC denials for harmless application probing, the policy can silence AVC denials without allowing permission by using *dontaudit* rules. These rules are common in standard policy. The downside of *dontaudit* is that, although SELinux denies access, denial messages are not logged, making troubleshooting more difficult.

To temporarily disable *dontaudit* rules, allowing all denials to be logged, enter the following command as root:

```
~]# semodule -DB
```

The **-D** option disables *dontaudit* rules; the **-B** option rebuilds policy. After running **semodule -DB**, try exercising the application that was encountering permission problems, and see if SELinux denials – relevant to the application – are now being logged. Take care in deciding which denials should be allowed, as some should be ignored and handled by *dontaudit* rules. If in doubt, or in search of guidance, contact other SELinux users and developers on an SELinux list, such as [fedora-selinux-list](#).

To rebuild policy and enable **dontaudit** rules, enter the following command as root:

```
~]# semodule -B
```

This restores the policy to its original state. For a full list of dontaudit rules, run the **sesearch --dontaudit** command. Narrow down searches using the **-s domain** option and the **grep** command. For example:

```
~]$ sesearch --dontaudit -s smbd_t | grep squid
dontaudit smbd_t squid_port_t : tcp_socket name_bind ;
dontaudit smbd_t squid_port_t : udp_socket name_bind ;
```

See [Section 11.3.6, “Raw Audit Messages”](#) and [Section 11.3.7, “sealert Messages”](#) for information about analyzing denials.

### 11.3.3. Manual Pages for Services

Manual pages for services contain valuable information, such as what file type to use for a given situation, and Booleans to change the access a service has (such as **httpd** accessing NFS volumes). This information may be in the standard manual page or in the manual page that can be automatically generated from the SELinux policy for every service domain using the **sepolicy manpage** utility. Such manual pages are named in the **service-name\_selinux** format. Such manual pages are also shipped with the selinux-policy-doc package.

For example, the `httpd_selinux(8)` manual page has information about what file type to use for a given situation, as well as Booleans to allow scripts, sharing files, accessing directories inside user home directories, and so on. Other manual pages with SELinux information for services include:

- Samba: the `samba_selinux(8)` manual page for example describes that enabling the **samba\_enable\_home\_dirs** Boolean allows Samba to share users home directories.
- NFS: the `nfsd_selinux(8)` manual page describes SELinux `nfsd` policy that allows users to setup their `nfsd` processes in as secure a method as possible.

The information in manual pages helps you configure the correct file types and Booleans, helping to prevent SELinux from denying access.

See [Section 5.4, “Generating Manual Pages: \*\*sepolicy manpage\*\*”](#) for further information about **sepolicy manpage**.

### 11.3.4. Permissive Domains

When SELinux is running in permissive mode, SELinux does not deny access, but denials are logged for actions that would have been denied if running in enforcing mode. Previously, it was not possible to make a single domain permissive (remember: processes run in domains). In certain situations, this led to making the whole system permissive to troubleshoot issues.

Permissive domains allow an administrator to configure a single process (domain) to run permissive, rather than making the whole system permissive. SELinux checks are still performed for permissive domains; however, the kernel allows access and reports an AVC denial for situations where SELinux would have denied access.

Permissive domains have the following uses:

- They can be used for making a single process (domain) run permissive to troubleshoot an issue without putting the entire system at risk by making it permissive.
- They allow an administrator to create policies for new applications. Previously, it was recommended that a minimal policy be created, and then the entire machine put into permissive mode, so that the application could run, but SELinux denials still logged. The **audit2allow** could

then be used to help write the policy. This put the whole system at risk. With permissive domains, only the domain in the new policy can be marked permissive, without putting the whole system at risk.

#### 11.3.4.1. Making a Domain Permissive

To make a domain permissive, run the **semanage permissive -a *domain*** command, where *domain* is the domain you want to make permissive. For example, enter the following command as root to make the **httpd\_t** domain (the domain the Apache HTTP Server runs in) permissive:

```
~]# semanage permissive -a httpd_t
```

To view a list of domains you have made permissive, run the **semodule -l | grep permissive** command as root. For example:

```
~]# semodule -l | grep permissive
permissive_httpd_t    (null)
permissivedomains    (null)
```

If you no longer want a domain to be permissive, run the **semanage permissive -d *domain*** command as root. For example:

```
~]# semanage permissive -d httpd_t
```

#### 11.3.4.2. Disabling Permissive Domains

The **permissivedomains.pp** module contains all of the permissive domain declarations that are presented on the system. To disable all permissive domains, enter the following command as root:

```
~]# semodule -d permissivedomains
```

#### NOTE

Once a policy module is disabled through the **semodule -d** command, it is no longer showed in the output of the **semodule -l** command. To see all policy modules including disabled, enter the following command as root:

```
~]# semodule --list-modules=full
```

#### 11.3.4.3. Denials for Permissive Domains

The **SYSCALL** message is different for permissive domains. The following is an example AVC denial (and the associated system call) from the Apache HTTP Server:

```
type=AVC msg=audit(1226882736.442:86): avc: denied { getattr } for pid=2427 comm="httpd"
path="/var/www/html/file1" dev=dm-0 ino=284133 scontext=unconfined_u:system_r:httpd_t:s0
tcontext=unconfined_u:object_r:samba_share_t:s0 tclass=file
```

```
type=SYSCALL msg=audit(1226882736.442:86): arch=40000003 syscall=196 success=no exit=-13
a0=b9a1e198 a1=bfc2921c a2=54dff4 a3=2008171 items=0 ppid=2425 pid=2427 auid=502 uid=48
gid=48 euid=48 suid=48 fsuid=48 egid=48 sgid=48 fsgid=48 tty=(none) ses=4 comm="httpd"
exe="/usr/sbin/httpd" subj=unconfined_u:system_r:httpd_t:s0 key=(null)
```

By default, the **httpd\_t** domain is not permissive, and as such, the action is denied, and the **SYSCALL** message contains **success=no**. The following is an example AVC denial for the same situation, except the **semanage permissive -a httpd\_t** command has been run to make the **httpd\_t** domain permissive:

```
type=AVC msg=audit(1226882925.714:136): avc: denied { read } for pid=2512 comm="httpd"
name="file1" dev=dm-0 ino=284133 scontext=unconfined_u:system_r:httpd_t:s0
tcontext=unconfined_u:object_r:samba_share_t:s0 tclass=file
```

```
type=SYSCALL msg=audit(1226882925.714:136): arch=400000003 syscall=5 success=yes exit=11
a0=b962a1e8 a1=8000 a2=0 a3=8000 items=0 ppid=2511 pid=2512 auid=502 uid=48 gid=48
euid=48 suid=48 fsuid=48 egid=48 sgid=48 fsgid=48 tty=(none) ses=4 comm="httpd"
exe="/usr/sbin/httpd" subj=unconfined_u:system_r:httpd_t:s0 key=(null)
```

In this case, although an AVC denial was logged, access was not denied, as shown by **success=yes** in the **SYSCALL** message.

See Dan Walsh's "[Permissive Domains](#)" blog entry for further information about permissive domains.

### 11.3.5. Searching For and Viewing Denials

This section assumes the **setroubleshoot**, **setroubleshoot-server**, **dbus** and **audit** packages are installed, and that the **auditd**, **rsyslogd**, and **setroubleshootd** daemons are running. See [Section 4.2, "Which Log File is Used"](#) for information about starting these daemons. A number of utilities are available for searching for and viewing SELinux AVC messages, such as **ausearch**, **aureport**, and **sealert**.

#### ausearch

The **audit** package provides the **ausearch** utility that can query the **audit** daemon logs for events based on different search criteria.<sup>[10]</sup> The **ausearch** utility accesses **/var/log/audit/audit.log**, and as such, must be run as the root user:

Searching For	Command
all denials	<b>ausearch -m avc,user_avc,selinux_err,user_selinux_err</b>
denials for that today	<b>ausearch -m avc -ts today</b>
denials from the last 10 minutes	<b>ausearch -m avc -ts recent</b>

To search for SELinux AVC messages for a particular service, use the **-c comm-name** option, where **comm-name** is the executable's name, for example, **httpd** for the Apache HTTP Server, and **smbd** for Samba:

```
~]# ausearch -m avc -c httpd
```

```
~]# ausearch -m avc -c smbd
```

With each **ausearch** command, it is advised to use either the **--interpret (-i)** option for easier readability, or the **--raw (-r)** option for script processing. See the **ausearch(8)** manual page for further **ausearch** options.

## aureport

The audit package provides the **aureport** utility, which produces summary reports of the audit system logs. <sup>[11]</sup> The **aureport** utility accesses **/var/log/audit/audit.log**, and as such, must be run as the root user. To view a list of SELinux denial messages and how often each one occurred, run the **aureport -a** command. The following is example output that includes two denials:

```
~]# aureport -a
```

### AVC Report

```
=====
# date time comm subj syscall class permission obj event
=====
1. 05/01/2009 21:41:39 httpd unconfined_u:system_r:httpd_t:s0 195 file getattr
system_u:object_r:samba_share_t:s0 denied 2
2. 05/03/2009 22:00:25 vsftpd unconfined_u:system_r:ftpd_t:s0 5 file read
unconfined_u:object_r:cifs_t:s0 denied 4
```

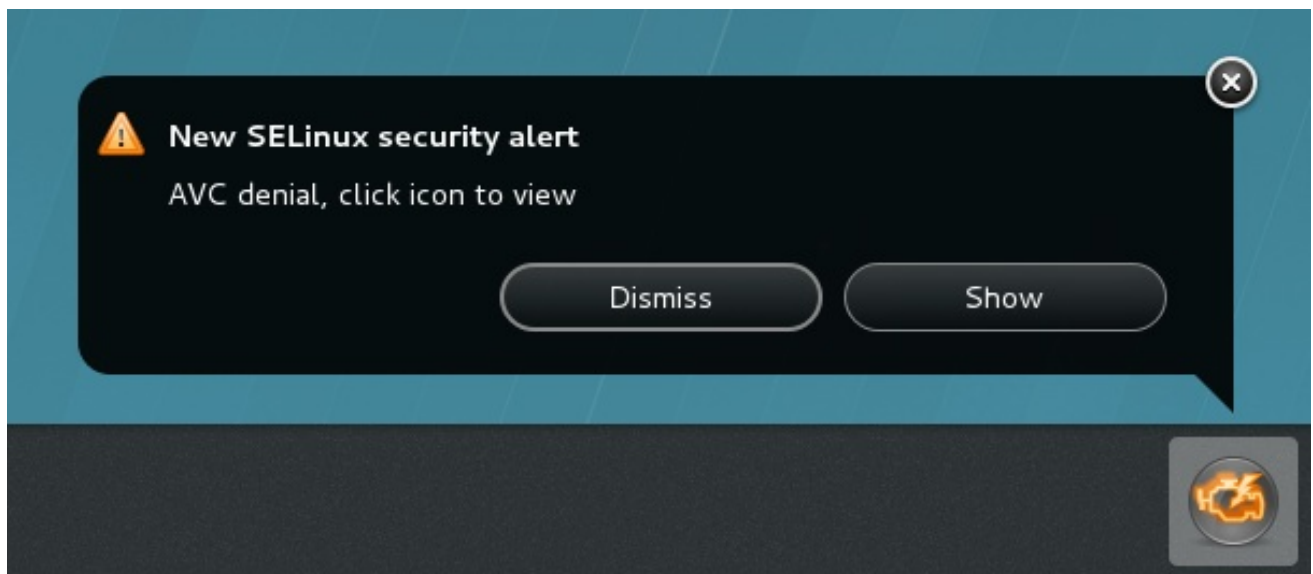
## sealert

The setroubleshoot-server package provides the **sealert** utility, which reads denial messages translated by setroubleshoot-server. <sup>[12]</sup> Denials are assigned IDs, as seen in **/var/log/messages**. The following is an example denial from **messages**:

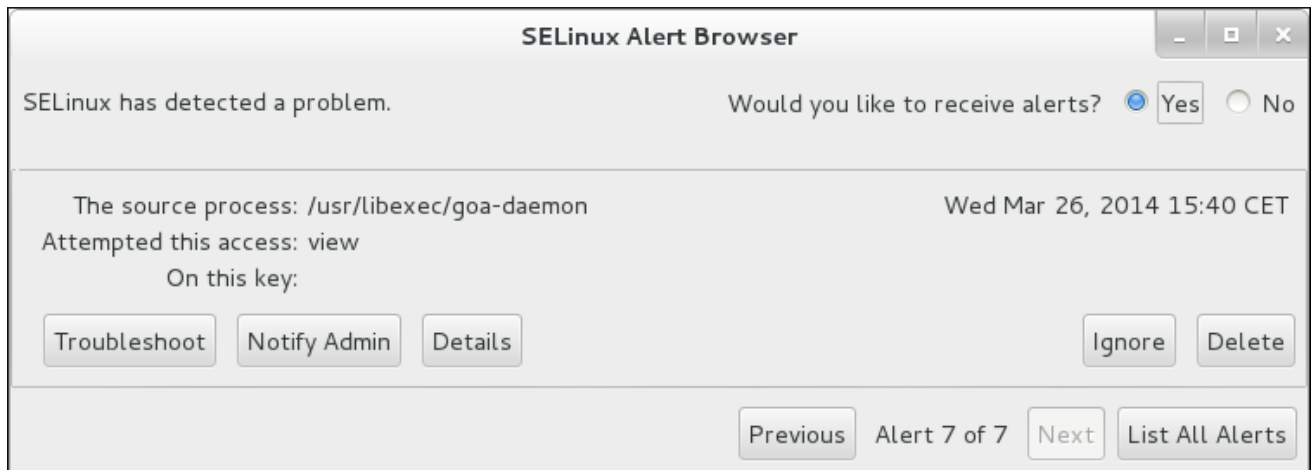
```
setroubleshoot: SELinux is preventing /usr/sbin/httpd from name_bind access on the tcp_socket. For complete SELinux messages. run sealert -l 8c123656-5dda-4e5d-8791-9e3bd03786b7
```

In this example, the denial ID is **8c123656-5dda-4e5d-8791-9e3bd03786b7**. The **-l** option takes an ID as an argument. Running the **sealert -l 8c123656-5dda-4e5d-8791-9e3bd03786b7** command presents a detailed analysis of why SELinux denied access, and a possible solution for allowing access.

If you are running the X Window System, have the setroubleshoot and setroubleshoot-server packages installed, and the **setroubleshootd**, **dbus** and **auditd** daemons are running, a warning is displayed when access is denied by SELinux:



Clicking on **Show** launches the **sealert** GUI, which allows you to troubleshoot the problem:



Alternatively, run the **sealert -b** command to launch the **sealert** GUI. To view a detailed analysis of all denial messages, run the **sealert -l \*** command.

### 11.3.6. Raw Audit Messages

Raw audit messages are logged to **/var/log/audit/audit.log**. The following is an example AVC denial message (and the associated system call) that occurred when the Apache HTTP Server (running in the **httpd\_t** domain) attempted to access the **/var/www/html/file1** file (labeled with the **samba\_share\_t** type):

```
type=AVC msg=audit(1226874073.147:96): avc: denied { getattr } for pid=2465 comm="httpd"
path="/var/www/html/file1" dev=dm-0 ino=284133 scontext=unconfined_u:system_r:httpd_t:s0
tcontext=unconfined_u:object_r:samba_share_t:s0 tclass=file
```

```
type=SYSCALL msg=audit(1226874073.147:96): arch=40000003 syscall=196 success=no exit=-13
a0=b98df198 a1=bfec85dc a2=54dff4 a3=2008171 items=0 ppid=2463 pid=2465 auid=502 uid=48
gid=48 euid=48 suid=48 fsuid=48 egid=48 sgid=48 fsgid=48 tty=(none) ses=6 comm="httpd"
exe="/usr/sbin/httpd" subj=unconfined_u:system_r:httpd_t:s0 key=(null)
```

#### **{ getattr }**

The item in the curly brackets indicates the permission that was denied. The **getattr** entry indicates the source process was trying to read the target file's status information. This occurs before reading files. This action is denied due to the file being accessed having a wrong label. Commonly seen permissions include **getattr**, **read**, and **write**.

#### **comm="httpd"**

The executable that launched the process. The full path of the executable is found in the **exe=** section of the system call (**SYSCALL**) message, which in this case, is **exe="/usr/sbin/httpd"**.

#### **path="/var/www/html/file1"**

The path to the object (target) the process attempted to access.

#### **scontext="unconfined\_u:system\_r:httpd\_t:s0"**

The SELinux context of the process that attempted the denied action. In this case, it is the SELinux context of the Apache HTTP Server, which is running in the **httpd\_t** domain.

#### **tcontext="unconfined\_u:object\_r:samba\_share\_t:s0"**

The SELinux context of the object (target) the process attempted to access. In this case, it is the SELinux context of **file1**. Note that the **samba\_share\_t** type is not accessible to processes running in the **httpd\_t** domain.

In certain situations, the **tcontext** may match the **scontext**, for example, when a process attempts to execute a system service that will change characteristics of that running process, such as the user ID. Also, the **tcontext** may match the **scontext** when a process tries to use more resources (such as memory) than normal limits allow, resulting in a security check to see if that process is allowed to break those limits.

From the system call (**SYSCALL**) message, two items are of interest:

- **success=no**: indicates whether the denial (AVC) was enforced or not. **success=no** indicates the system call was not successful (SELinux denied access). **success=yes** indicates the system call was successful. This can be seen for permissive domains or unconfined domains, such as **unconfined\_service\_t** and **kernel\_t**.
- **exe="/usr/sbin/httpd"**: the full path to the executable that launched the process, which in this case, is **exe="/usr/sbin/httpd"**.

An incorrect file type is a common cause for SELinux denying access. To start troubleshooting, compare the source context (**scontext**) with the target context (**tcontext**). Should the process (**scontext**) be accessing such an object (**tcontext**)? For example, the Apache HTTP Server (**httpd\_t**) should only be accessing types specified in the `httpd_selinux(8)` manual page, such as **httpd\_sys\_content\_t**, **public\_content\_t**, and so on, unless configured otherwise.

### 11.3.7. sealert Messages

Denials are assigned IDs, as seen in `/var/log/messages`. The following is an example AVC denial (logged to **messages**) that occurred when the Apache HTTP Server (running in the **httpd\_t** domain) attempted to access the `/var/www/html/file1` file (labeled with the **samba\_share\_t** type):

```
hostname setroubleshoot: SELinux is preventing httpd (httpd_t) "getattr" to /var/www/html/file1
(samba_share_t). For complete SELinux messages. run sealert -l 32eee32b-21ca-4846-a22f-
0ba050206786
```

As suggested, run the **sealert -l 32eee32b-21ca-4846-a22f-0ba050206786** command to view the complete message. This command only works on the local machine, and presents the same information as the **sealert** GUI:

```
~]$ sealert -l 32eee32b-21ca-4846-a22f-0ba050206786
SELinux is preventing httpd from getattr access on the file /var/www/html/file1.

**** Plugin restorecon (92.2 confidence) suggests ****

If you want to fix the label.
/var/www/html/file1 default label should be httpd_sys_content_t.
Then you can run restorecon.
Do
# /sbin/restorecon -v /var/www/html/file1

**** Plugin public_content (7.83 confidence) suggests ****

If you want to treat file1 as public content
Then you need to change the label on file1 to public_content_t or public_content_rw_t.
```

```
Do
# semanage fcontext -a -t public_content_t '/var/www/html/file1'
# restorecon -v '/var/www/html/file1'

***** Plugin catchall (1.41 confidence) suggests *****
```

If you believe that httpd should be allowed getattr access on the file1 file by default.  
Then you should report this as a bug.

You can generate a local policy module to allow this access.

```
Do
allow this access for now by executing:
# ausearch -c 'httpd' --raw | audit2allow -M my-httpd
# semodule -i my-httpd.pp
```

#### Additional Information:

```
Source Context      system_u:system_r:httpd_t:s0
Target Context      unconfined_u:object_r:samba_share_t:s0
Target Objects      /var/www/html/file1 [ file ]
Source              httpd
Source Path          httpd
Port                <Unknown>
Host                hostname.redhat.com
Source RPM Packages
Target RPM Packages
Policy RPM           selinux-policy-3.13.1-166.el7.noarch
Selinux Enabled      True
Policy Type          targeted
Enforcing Mode       Enforcing
Host Name            hostname.redhat.com
Platform             Linux hostname.redhat.com
                    3.10.0-693.el7.x86_64 #1 SMP Thu Jul 6 19:56:57
                    EDT 2017 x86_64 x86_64
Alert Count          2
First Seen           2017-07-20 02:52:11 EDT
Last Seen            2017-07-20 02:52:11 EDT
Local ID             32eee32b-21ca-4846-a22f-0ba050206786
```

#### Raw Audit Messages

```
type=AVC msg=audit(1500533531.140:295): avc: denied { getattr } for pid=24934 comm="httpd"
path="/var/www/html/file1" dev="vda1" ino=31457414 scontext=system_u:system_r:httpd_t:s0
tcontext=unconfined_u:object_r:samba_share_t:s0 tclass=file
```

```
Hash: httpd,httpd_t,samba_share_t,file,getattr
```

## Summary

A brief summary of the denied action. This is the same as the denial in **/var/log/messages**. In this example, the **httpd** process was denied access to a file ( **file1**), which is labeled with the **samba\_share\_t** type.

## Detailed Description

A more verbose description. In this example, **file1** is labeled with the **samba\_share\_t** type. This type is used for files and directories that you want to export using Samba. The description suggests changing the type to a type that can be accessed by the Apache HTTP Server and Samba, if such

access is required.

### Allowing Access

A suggestion for how to allow access. This may be relabeling files, enabling a Boolean, or making a local policy module. In this case, the suggestion is to label the file with a type accessible to both the Apache HTTP Server and Samba.

### Fix Command

A suggested command to allow access and resolve the denial. In this example, it gives the command to change the **file1** type to **public\_content\_t**, which is accessible to the Apache HTTP Server and Samba.

### Additional Information

Information that is useful in bug reports, such as the policy package name and version (**selinux-policy-3.13.1-166.el7.noarch**), but may not help towards solving why the denial occurred.

### Raw Audit Messages

The raw audit messages from **/var/log/audit/audit.log** that are associated with the denial. See [Section 11.3.6, "Raw Audit Messages"](#) for information about each item in the AVC denial.

## 11.3.8. Allowing Access: audit2allow



### WARNING

Do not use the example in this section in production. It is used only to demonstrate the use of the **audit2allow** utility.

The **audit2allow** utility gathers information from logs of denied operations and then generates SELinux policy allow rules.<sup>[13]</sup> After analyzing denial messages as per [Section 11.3.7, "sealert Messages"](#), and if no label changes or Booleans allowed access, use **audit2allow** to create a local policy module. When access is denied by SELinux, running **audit2allow** generates Type Enforcement rules that allow the previously denied access.

You should not use **audit2allow** to generate a local policy module as your first option when you see an SELinux denial. Troubleshooting should start with a check if there is a labeling problem. The second most often case is that you have changed a process configuration, and you forgot to tell SELinux about it. For more information, see the [Four Key Causes of SELinux Errors](#) white paper.

The following example demonstrates using **audit2allow** to create a policy module:

1. A denial message and the associated system call are logged to the **/var/log/audit/audit.log** file:

```
type=AVC msg=audit(1226270358.848:238): avc: denied { write } for pid=13349
comm="certwatch" name="cache" dev=dm-0 ino=218171
scontext=system_u:system_r:certwatch_t:s0 tcontext=system_u:object_r:var_t:s0 tclass=dir
```

```
type=SYSCALL msg=audit(1226270358.848:238): arch=400000003 syscall=39 success=no
exit=-13 a0=39a2bf a1=3ff a2=3a0354 a3=94703c8 items=0 ppid=13344 pid=13349
auid=4294967295 uid=0 gid=0 euid=0 suid=0 fsuid=0 egid=0 sgid=0 fsgid=0 tty=(none)
ses=4294967295 comm="certwatch" exe="/usr/bin/certwatch"
subj=system_u:system_r:certwatch_t:s0 key=(null)
```

In this example, **certwatch** was denied the write access to a directory labeled with the **var\_t** type. Analyze the denial message as per [Section 11.3.7, “sealert Messages”](#). If no label changes or Booleans allowed access, use **audit2allow** to create a local policy module.

2. Enter the following command to produce a human-readable description of why the access was denied. The **audit2allow** utility reads **/var/log/audit/audit.log**, and as such, must be run as the root user:

```
~]# audit2allow -w -a
type=AVC msg=audit(1226270358.848:238): avc: denied { write } for pid=13349
comm="certwatch" name="cache" dev=dm-0 ino=218171
scontext=system_u:system_r:certwatch_t:s0 tcontext=system_u:object_r:var_t:s0 tclass=dir
Was caused by:
Missing type enforcement (TE) allow rule.
```

You can use **audit2allow** to generate a loadable module to allow this access.

The **-a** command-line option causes all audit logs to be read. The **-w** option produces the human-readable description. As shown, access was denied due to a missing Type Enforcement rule.

3. Enter the following command to view the Type Enforcement rule that allows the denied access:

```
~]# audit2allow -a

#===== certwatch_t =====
allow certwatch_t var_t:dir write;
```



## IMPORTANT

Missing Type Enforcement rules are usually caused by bugs in the SELinux policy, and should be reported in [Red Hat Bugzilla](#). For Red Hat Enterprise Linux, create bugs against the **Red Hat Enterprise Linux** product, and select the **selinux-policy** component. Include the output of the **audit2allow -w -a** and **audit2allow -a** commands in such bug reports.

4. To use the rule displayed by **audit2allow -a**, enter the following command as root to create a custom module. The **-M** option creates a Type Enforcement file ( **.te** ) with the name specified with **-M**, in your current working directory:

```
~]# audit2allow -a -M mycertwatch
***** IMPORTANT *****

To make this policy package active, execute:

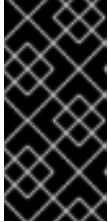
semodule -i mycertwatch.pp
```

5. Also, **audit2allow** compiles the Type Enforcement rule into a policy package ( **.pp** ):

```
~]# ls  
mycertwatch.pp mycertwatch.te
```

To install the module, enter the following command as the root:

```
~]# semodule -i mycertwatch.pp
```



## IMPORTANT

Modules created with **audit2allow** may allow more access than required. It is recommended that policy created with **audit2allow** be posted to the upstream SELinux list for review. If you believe there is a bug in the policy, create a bug in [Red Hat Bugzilla](#).

If you have multiple denial messages from multiple processes, but only want to create a custom policy for a single process, use the **grep** utility to narrow down the input for **audit2allow**. The following example demonstrates using **grep** to only send denial messages related to **certwatch** through **audit2allow**:

```
~]# grep certwatch /var/log/audit/audit.log | audit2allow -R -M mycertwatch2
```

```
***** IMPORTANT *****
```

To make this policy package active, execute:

```
semodule -i mycertwatch2.pp
```

---

[8] Files in **/etc/selinux/targeted/contexts/files/** define contexts for files and directories. Files in this directory are read by the **restorecon** and **setfiles** utilities to restore files and directories to their default contexts.

[9] The **semanage port -a** command adds an entry to the **/etc/selinux/targeted/modules/active/ports.local** file. Note that by default, this file can only be viewed by root.

[10] See the **ausearch(8)** manual page for further information about **ausearch**.

[11] See the **aureport(8)** manual page for further information about **aureport**.

[12] See the **sealert(8)** manual page for further information about **sealert**.

[13] See the **audit2allow(1)** manual page for more information about **audit2allow**.

## CHAPTER 12. FURTHER INFORMATION

### 12.1. CONTRIBUTORS

- [Dominick Grift](#) – Technical Editor
- [Murray McAllister](#) – Red Hat Product Security
- [James Morris](#) – Technical Editor
- [Eric Paris](#) – Technical Editor
- [Scott Radvan](#) – Red Hat Customer Content Services
- [Daniel Walsh](#) – Red Hat Security Engineering

### 12.2. OTHER RESOURCES

#### Fedora

- Main page: <http://fedoraproject.org/wiki/SELinux>.
- Troubleshooting: <http://fedoraproject.org/wiki/SELinux/Troubleshooting>.
- Fedora SELinux FAQ: [https://fedoraproject.org/wiki/SELinux\\_FAQ](https://fedoraproject.org/wiki/SELinux_FAQ).

#### The National Security Agency (NSA)

NSA was the original developer of SELinux. Researchers in NSA's National Information Assurance Research Laboratory (NIARL) designed and implemented flexible mandatory access controls in the major subsystems of the Linux kernel and implemented the new operating system components provided by the Flask architecture, namely the security server and the access vector cache.

- Main SELinux website: <https://www.nsa.gov/what-we-do/research/selinux/>.
- SELinux Mailing List: <https://www.nsa.gov/what-we-do/research/selinux/mailling-list.shtml>.
- SELinux documentation: <https://www.nsa.gov/what-we-do/research/selinux/documentation/index.shtml>.
- SELinux background: <https://www.nsa.gov/what-we-do/research/selinux/related-work/>.

#### Tresys Technology

[Tresys Technology](#) are the upstream for:

- [SELinux User Space Libraries and Tools](#) .
- [SELinux Reference Policy](#) .

#### The SELinux GitHub repositories

- SELinux Project: <https://github.com/SELinuxProject>
- Tresys Technology: <https://github.com/TresysTechnology/>

#### SELinux Project Wiki

- Main page: [http://selinuxproject.org/page/Main\\_Page](http://selinuxproject.org/page/Main_Page).
- User resources, including links to documentation, mailing lists, websites, and tools: [http://selinuxproject.org/page/User\\_Resources](http://selinuxproject.org/page/User_Resources).

### **The SELinux Notebook - The Foundations - 4th Edition**

[http://freecomputerbooks.com/books/The\\_SELinux\\_Notebook-4th\\_Edition.pdf](http://freecomputerbooks.com/books/The_SELinux_Notebook-4th_Edition.pdf)

### **DigitalOcean: An Introduction to SELinux on CentOS 7**

[https://www.digitalocean.com/community/tutorial\\_series/an-introduction-to-selinux-on-centos-7](https://www.digitalocean.com/community/tutorial_series/an-introduction-to-selinux-on-centos-7)

### **IRC**

On [Freenode](#):

- `#selinux`
- `#fedora-selinux`

## PART II. MANAGING CONFINED SERVICES

## CHAPTER 13. INTRODUCTION

This part of the book focuses more on practical tasks and provides information how to set up and configure various services. For each service, there are listed the most common types and Booleans with the specifications. Also included are real-world examples of configuring those services and demonstrations of how SELinux complements their operation.

When SELinux is in enforcing mode, the default policy used in Red Hat Enterprise Linux, is the targeted policy. Processes that are targeted run in a confined domain, and processes that are not targeted run in an unconfined domain. See [Chapter 3, Targeted Policy](#) for more information about targeted policy and confined and unconfined processes.

## CHAPTER 14. THE APACHE HTTP SERVER

The Apache HTTP Server provides an open-source HTTP server with the current HTTP standards.<sup>[14]</sup>

In Red Hat Enterprise Linux, the `httpd` package provides the Apache HTTP Server. Enter the following command to see if the `httpd` package is installed:

```
~]$ rpm -q httpd
package httpd is not installed
```

If it is not installed and you want to use the Apache HTTP Server, use the **yum** utility as the root user to install it:

```
~]# yum install httpd
```

### 14.1. THE APACHE HTTP SERVER AND SELINUX

When SELinux is enabled, the Apache HTTP Server (**httpd**) runs confined by default. Confined processes run in their own domains, and are separated from other confined processes. If a confined process is compromised by an attacker, depending on SELinux policy configuration, an attacker's access to resources and the possible damage they can do is limited. The following example demonstrates the **httpd** processes running in their own domain. This example assumes the `httpd`, `setroubleshoot`, `setroubleshoot-server` and `policycoreutils-python` packages are installed:

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Enter the following command as root to start **httpd**:

```
~]# systemctl start httpd.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]# systemctl status httpd.service
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: active (running) since Mon 2013-08-05 14:00:55 CEST; 8s ago
```

3. To view the **httpd** processes, execute the following command:

```
~]$ ps -eZ | grep httpd
system_u:system_r:httpd_t:s0 19780 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 19781 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 19782 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 19783 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 19784 ? 00:00:00 httpd
system_u:system_r:httpd_t:s0 19785 ? 00:00:00 httpd
```

The SELinux context associated with the **httpd** processes is **system\_u:system\_r:httpd\_t:s0**. The second last part of the context, **httpd\_t**, is the type. A type defines a domain for processes and a type for files. In this case, the **httpd** processes are running in the **httpd\_t** domain.

SELinux policy defines how processes running in confined domains (such as **httpd\_t**) interact with files, other processes, and the system in general. Files must be labeled correctly to allow **httpd** access to them. For example, **httpd** can read files labeled with the **httpd\_sys\_content\_t** type, but cannot write to them, even if Linux (DAC) permissions allow write access. Booleans must be enabled to allow certain behavior, such as allowing scripts network access, allowing **httpd** access to NFS and CIFS volumes, and **httpd** being allowed to execute Common Gateway Interface (CGI) scripts.

When the **/etc/httpd/conf/httpd.conf** file is configured so **httpd** listens on a port other than TCP ports 80, 443, 488, 8008, 8009, or 8443, the **semanage port** command must be used to add the new port number to SELinux policy configuration. The following example demonstrates configuring **httpd** to listen on a port that is not already defined in SELinux policy configuration for **httpd**, and, as a consequence, **httpd** failing to start. This example also demonstrates how to then configure the SELinux system to allow **httpd** to successfully listen on a non-standard port that is not already defined in the policy. This example assumes the **httpd** package is installed. Run each command in the example as the root user:

1. Enter the following command to confirm **httpd** is not running:

```
~]# systemctl status httpd.service
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: inactive (dead)
```

If the output differs, stop the process:

```
~]# systemctl stop httpd.service
```

2. Use the **semanage** utility to view the ports SELinux allows **httpd** to listen on:

```
~]# semanage port -l | grep -w http_port_t
http_port_t            tcp      80, 443, 488, 8008, 8009, 8443
```

3. Edit the **/etc/httpd/conf/httpd.conf** file as root. Configure the **Listen** option so it lists a port that is not configured in SELinux policy configuration for **httpd**. In this example, **httpd** is configured to listen on port 12345:

```
# Change this to Listen on specific IP addresses as shown below to
# prevent Apache from glomming onto all bound IP addresses (0.0.0.0)
#
#Listen 12.34.56.78:80
Listen 127.0.0.1:12345
```

4. Enter the following command to start **httpd**:

```
~]# systemctl start httpd.service
Job for httpd.service failed. See 'systemctl status httpd.service' and 'journalctl -xn' for details.
```

An SELinux denial message similar to the following is logged:

```
setroubleshoot: SELinux is preventing the httpd (httpd_t) from binding to port 12345. For
complete SELinux messages. run sealert -l f18bca99-db64-4c16-9719-1db89f0d8c77
```

- For SELinux to allow **httpd** to listen on port 12345, as used in this example, the following command is required:

```
~]# semanage port -a -t http_port_t -p tcp 12345
```

- Start **httpd** again and have it listen on the new port:

```
~]# systemctl start httpd.service
```

- Now that SELinux has been configured to allow **httpd** to listen on a non-standard port (TCP 12345 in this example), **httpd** starts successfully on this port.
- To prove that **httpd** is listening and communicating on TCP port 12345, open a telnet connection to the specified port and issue a HTTP GET command, as follows:

```
~]# telnet localhost 12345
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
GET / HTTP/1.0

HTTP/1.1 200 OK
Date: Wed, 02 Dec 2009 14:36:34 GMT
Server: Apache/2.2.13 (Red Hat)
Accept-Ranges: bytes
Content-Length: 3985
Content-Type: text/html; charset=UTF-8
[...continues...]
```

## 14.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following example creates a new file in the **/var/www/html/** directory, and shows the file inheriting the **httpd\_sys\_content\_t** type from its parent directory (**/var/www/html/**):

- Enter the following command to view the SELinux context of **/var/www/html/**:

```
~]$ ls -dZ /var/www/html
drwxr-xr-x root root system_u:object_r:httpd_sys_content_t:s0 /var/www/html
```

This shows **/var/www/html/** is labeled with the **httpd\_sys\_content\_t** type.

- Create a new file by using the **touch** utility as root:

```
~]# touch /var/www/html/file1
```

3. Enter the following command to view the SELinux context:

```
~]$ ls -Z /var/www/html/file1
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 /var/www/html/file1
```

The **ls -Z** command shows **file1** labeled with the **httpd\_sys\_content\_t** type. SELinux allows **httpd** to read files labeled with this type, but not write to them, even if Linux permissions allow write access. SELinux policy defines what types a process running in the **httpd\_t** domain (where **httpd** runs) can read and write to. This helps prevent processes from accessing files intended for use by another process.

For example, **httpd** can access files labeled with the **httpd\_sys\_content\_t** type (intended for the Apache HTTP Server), but by default, cannot access files labeled with the **samba\_share\_t** type (intended for Samba). Also, files in user home directories are labeled with the **user\_home\_t** type: by default, this prevents **httpd** from reading or writing to files in user home directories.

The following lists some of the types used with **httpd**. Different types allow you to configure flexible access:

#### **httpd\_sys\_content\_t**

Use this type for static web content, such as **.html** files used by a static website. Files labeled with this type are accessible (read only) to **httpd** and scripts executed by **httpd**. By default, files and directories labeled with this type cannot be written to or modified by **httpd** or other processes. Note that by default, files created in or copied into the **/var/www/html/** directory are labeled with the **httpd\_sys\_content\_t** type.

#### **httpd\_sys\_script\_exec\_t**

Use this type for scripts you want **httpd** to execute. This type is commonly used for Common Gateway Interface (CGI) scripts in the **/var/www/cgi-bin/** directory. By default, SELinux policy prevents **httpd** from executing CGI scripts. To allow this, label the scripts with the **httpd\_sys\_script\_exec\_t** type and enable the **httpd\_enable\_cgi** Boolean. Scripts labeled with **httpd\_sys\_script\_exec\_t** run in the **httpd\_sys\_script\_t** domain when executed by **httpd**. The **httpd\_sys\_script\_t** domain has access to other system domains, such as **postgresql\_t** and **mysqld\_t**.

#### **httpd\_sys\_rw\_content\_t**

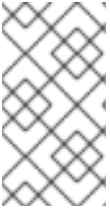
Files labeled with this type can be written to by scripts labeled with the **httpd\_sys\_script\_exec\_t** type, but cannot be modified by scripts labeled with any other type. You must use the **httpd\_sys\_rw\_content\_t** type to label files that will be read from and written to by scripts labeled with the **httpd\_sys\_script\_exec\_t** type.

#### **httpd\_sys\_ra\_content\_t**

Files labeled with this type can be appended to by scripts labeled with the **httpd\_sys\_script\_exec\_t** type, but cannot be modified by scripts labeled with any other type. You must use the **httpd\_sys\_ra\_content\_t** type to label files that will be read from and appended to by scripts labeled with the **httpd\_sys\_script\_exec\_t** type.

#### **httpd\_unconfined\_script\_exec\_t**

Scripts labeled with this type run without SELinux protection. Only use this type for complex scripts, after exhausting all other options. It is better to use this type instead of disabling SELinux protection for **httpd**, or for the entire system.



## NOTE

To see more of the available types for `httpd`, enter the following command:

```
~]$ grep httpd /etc/selinux/targeted/contexts/files/file_contexts
```

### Procedure 14.1. Changing the SELinux Context

The type for files and directories can be changed with the **chcon** command. Changes made with **chcon** do not survive a file system relabel or the **restorecon** command. SELinux policy controls whether users are able to modify the SELinux context for any given file. The following example demonstrates creating a new directory and an **index.html** file for use by **httpd**, and labeling that file and directory to allow **httpd** access to them:

1. Use the **mkdir** utility as root to create a top-level directory structure to store files to be used by **httpd**:

```
~]# mkdir -p /my/website
```

2. Files and directories that do not match a pattern in file-context configuration may be labeled with the **default\_t** type. This type is inaccessible to confined services:

```
~]$ ls -dZ /my
drwxr-xr-x root root unconfined_u:object_r:default_t:s0 /my
```

3. Enter the following command as root to change the type of the **my/** directory and subdirectories, to a type accessible to **httpd**. Now, files created under **/my/website/** inherit the **httpd\_sys\_content\_t** type, rather than the **default\_t** type, and are therefore accessible to **httpd**:

```
~]# chcon -R -t httpd_sys_content_t /my/
~]# touch /my/website/index.html
~]# ls -Z /my/website/index.html
-rw-r--r-- root root unconfined_u:object_r:httpd_sys_content_t:s0 /my/website/index.html
```

See [Section 4.7.1, "Temporary Changes: chcon"](#) for further information about **chcon**.

Use the **semanage fcontext** command (**semanage** is provided by the `polycoreutils-python` package) to make label changes that survive a relabel and the **restorecon** command. This command adds changes to file-context configuration. Then, run **restorecon**, which reads file-context configuration, to apply the label change. The following example demonstrates creating a new directory and an **index.html** file for use by **httpd**, and persistently changing the label of that directory and file to allow **httpd** access to them:

1. Use the **mkdir** utility as root to create a top-level directory structure to store files to be used by **httpd**:

```
~]# mkdir -p /my/website
```

2. Enter the following command as root to add the label change to file-context configuration:

```
~]# semanage fcontext -a -t httpd_sys_content_t "/my(/.*)?"
```

The **"my/(.\*)?"** expression means the label change applies to the **my/** directory and all files and directories under it.

3. Use the **touch** utility as root to create a new file:

```
~]# touch /my/website/index.html
```

4. Enter the following command as root to apply the label changes (**restorecon** reads file-context configuration, which was modified by the **semanage** command in step 2):

```
~]# restorecon -R -v /my/
restorecon reset /my context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
restorecon reset /my/website context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
restorecon reset /my/website/index.html context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
```

See [Section 4.7.2, "Persistent Changes: semanage fcontext"](#) for further information on **semanage**.

## 14.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. This can be achieved using Booleans that allow parts of SELinux policy to be changed at runtime, without any knowledge of SELinux policy writing. This allows changes, such as allowing services access to NFS volumes, without reloading or recompiling SELinux policy.

To modify the state of a Boolean, use the **setsebool** command. For example, to enable the **httpd\_anon\_write** Boolean, enter the following command as the root user:

```
~]# setsebool -P httpd_anon_write on
```

To disable a Boolean, using the same example, simply change **on** to **off** in the command, as shown below:

```
~]# setsebool -P httpd_anon_write off
```



### NOTE

Do not use the **-P** option if you do not want **setsebool** changes to persist across reboots.

Below is a description of common Booleans available that cater for the way **httpd** is running:

#### **httpd\_anon\_write**

When disabled, this Boolean allows **httpd** to only have read access to files labeled with the **public\_content\_rw\_t** type. Enabling this Boolean allows **httpd** to write to files labeled with the **public\_content\_rw\_t** type, such as a public directory containing files for a public file transfer service.

#### **httpd\_mod\_auth\_ntlm\_winbind**

Enabling this Boolean allows access to NTLM and Winbind authentication mechanisms using the **mod\_auth\_ntlm\_winbind** module in **httpd**.

**httpd\_mod\_auth\_pam**

Enabling this Boolean allows access to PAM authentication mechanisms using the **mod\_auth\_pam** module in **httpd**.

**httpd\_sys\_script\_anon\_write**

This Boolean defines whether or not HTTP scripts are allowed write access to files labeled with the **public\_content\_rw\_t** type, as used in a public file transfer service.

**httpd\_builtin\_scripting**

This Boolean defines access to **httpd** scripting. Having this Boolean enabled is often required for PHP content.

**httpd\_can\_network\_connect**

When disabled, this Boolean prevents HTTP scripts and modules from initiating a connection to a network or remote port. Enable this Boolean to allow this access.

**httpd\_can\_network\_connect\_db**

When disabled, this Boolean prevents HTTP scripts and modules from initiating a connection to database servers. Enable this Boolean to allow this access.

**httpd\_can\_network\_relay**

Enable this Boolean when **httpd** is being used as a forward or reverse proxy.

**httpd\_can\_sendmail**

When disabled, this Boolean prevents HTTP modules from sending mail. This can prevent spam attacks should a vulnerability be found in **httpd**. Enable this Boolean to allow HTTP modules to send mail.

**httpd\_dbus\_avahi**

When disabled, this Boolean denies **httpd** access to the **avahi** service through **D-Bus**. Enable this Boolean to allow this access.

**httpd\_enable\_cgi**

When disabled, this Boolean prevents **httpd** from executing CGI scripts. Enable this Boolean to allow **httpd** to execute CGI scripts (CGI scripts must be labeled with the **httpd\_sys\_script\_exec\_t** type).

**httpd\_enable\_ftp\_server**

Enabling this Boolean allows **httpd** to listen on the FTP port and act as an FTP server.

**httpd\_enable\_homedirs**

When disabled, this Boolean prevents **httpd** from accessing user home directories. Enable this Boolean to allow **httpd** access to user home directories; for example, content in **/home/\*/**.

**httpd\_execmem**

When enabled, this Boolean allows **httpd** to execute programs that require memory addresses that are both executable and writable. Enabling this Boolean is not recommended from a security standpoint as it reduces protection against buffer overflows, however certain modules and applications (such as Java and Mono applications) require this privilege.

### **httpd\_ssi\_exec**

This Boolean defines whether or not server side include (SSI) elements in a web page can be executed.

### **httpd\_tty\_comm**

This Boolean defines whether or not **httpd** is allowed access to the controlling terminal. Usually this access is not required, however in cases such as configuring an SSL certificate file, terminal access is required to display and process a password prompt.

### **httpd\_unified**

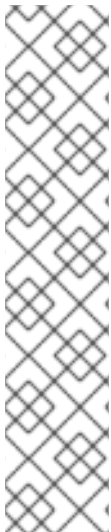
When enabled, this Boolean allows **httpd\_t** complete access to all of the **httpd** types (that is to execute, read, or write **sys\_content\_t**). When disabled, there is separation in place between web content that is read-only, writable, or executable. Disabling this Boolean ensures an extra level of security but adds the administrative overhead of having to individually label scripts and other web content based on the file access that each should have.

### **httpd\_use\_cifs**

Enable this Boolean to allow **httpd** access to files on CIFS volumes that are labeled with the **cifs\_t** type, such as file systems mounted using Samba.

### **httpd\_use\_nfs**

Enable this Boolean to allow **httpd** access to files on NFS volumes that are labeled with the **nfs\_t** type, such as file systems mounted using NFS.



#### **NOTE**

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sestatus booleans -b boolean_name
```

Note that the additional **policycoreutils-devel** package providing the **sepolicy** utility is required for this command to work.

## **14.4. CONFIGURATION EXAMPLES**

The following examples provide real-world demonstrations of how SELinux complements the Apache HTTP Server and how full function of the Apache HTTP Server can be maintained.

### **14.4.1. Running a static site**

To create a static website, label the **.html** files for that website with the **httpd\_sys\_content\_t** type. By default, the Apache HTTP Server cannot write to files that are labeled with the **httpd\_sys\_content\_t** type. The following example creates a new directory to store files for a read-only website:

1. Use the **mkdir** utility as root to create a top-level directory:

```
~]# mkdir /mywebsite
```

2. As root, create a **/mywebsite/index.html** file. Copy and paste the following content into **/mywebsite/index.html**:

```
<html>
<h2>index.html from /mywebsite/</h2>
</html>
```

3. To allow the Apache HTTP Server read only access to **/mywebsite/**, as well as files and subdirectories under it, label the directory with the **httpd\_sys\_content\_t** type. Enter the following command as root to add the label change to file-context configuration:

```
~]# semanage fcontext -a -t httpd_sys_content_t "/mywebsite(/.*)?"
```

4. Use the **restorecon** utility as root to make the label changes:

```
~]# restorecon -R -v /mywebsite
restorecon reset /mywebsite context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
restorecon reset /mywebsite/index.html context unconfined_u:object_r:default_t:s0-
>system_u:object_r:httpd_sys_content_t:s0
```

5. For this example, edit the **/etc/httpd/conf/httpd.conf** file as root. Comment out the existing **DocumentRoot** option. Add a **DocumentRoot "/mywebsite"** option. After editing, these options should look as follows:

```
#DocumentRoot "/var/www/html"
DocumentRoot "/mywebsite"
```

6. Enter the following command as root to see the status of the Apache HTTP Server. If the server is stopped, start it:

```
~]# systemctl status httpd.service
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: inactive (dead)
```

```
~]# systemctl start httpd.service
```

If the server is running, restart the service by executing the following command as root (this also applies any changes made to **httpd.conf**):

```
~]# systemctl status httpd.service
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: active (running) since Wed 2014-02-05 13:16:46 CET; 2s ago
```

```
~]# systemctl restart httpd.service
```

7. Use a web browser to navigate to **http://localhost/index.html**. The following is displayed:

```
index.html from /mywebsite/
```

### 14.4.2. Sharing NFS and CIFS volumes

By default, NFS mounts on the client side are labeled with a default context defined by policy for NFS volumes. In common policies, this default context uses the **nfs\_t** type. Also, by default, Samba shares mounted on the client side are labeled with a default context defined by policy. In common policies, this default context uses the **cifs\_t** type.

Depending on policy configuration, services may not be able to read files labeled with the **nfs\_t** or **cifs\_t** types. This may prevent file systems labeled with these types from being mounted and then read or exported by other services. Booleans can be enabled or disabled to control which services are allowed to access the **nfs\_t** and **cifs\_t** types.

Enable the **httpd\_use\_nfs** Boolean to allow **httpd** to access and share NFS volumes (labeled with the **nfs\_t** type):

```
~]# setsebool -P httpd_use_nfs on
```

Enable the **httpd\_use\_cifs** Boolean to allow **httpd** to access and share CIFS volumes (labeled with the **cifs\_t** type):

```
~]# setsebool -P httpd_use_cifs on
```



#### NOTE

Do not use the **-P** option if you do not want **setsebool** changes to persist across reboots.

### 14.4.3. Sharing files between services

Type Enforcement helps prevent processes from accessing files intended for use by another process. For example, by default, Samba cannot read files labeled with the **httpd\_sys\_content\_t** type, which are intended for use by the Apache HTTP Server. Files can be shared between the Apache HTTP Server, FTP, rsync, and Samba, if the required files are labeled with the **public\_content\_t** or **public\_content\_rw\_t** type.

The following example creates a directory and files, and allows that directory and files to be shared (read only) through the Apache HTTP Server, FTP, rsync, and Samba:

1. Use the **mkdir** utility as root to create a new top-level directory to share files between multiple services:

```
~]# mkdir /shares
```

2. Files and directories that do not match a pattern in file-context configuration may be labeled with the **default\_t** type. This type is inaccessible to confined services:

```
~]$ ls -dZ /shares
drwxr-xr-x root root unconfined_u:object_r:default_t:s0 /shares
```

3. As root, create a **/shares/index.html** file. Copy and paste the following content into **/shares/index.html**:

```
<html>
<body>
<p>Hello</p>
</body>
</html>
```

4. Labeling **/shares/** with the **public\_content\_t** type allows read-only access by the Apache HTTP Server, FTP, rsync, and Samba. Enter the following command as root to add the label change to file-context configuration:

```
~]# semanage fcontext -a -t public_content_t "/shares(/.*)"?"
```

5. Use the **restorecon** utility as root to apply the label changes:

```
~]# restorecon -R -v /shares/
restorecon reset /shares context unconfined_u:object_r:default_t:s0-
>system_u:object_r:public_content_t:s0
restorecon reset /shares/index.html context unconfined_u:object_r:default_t:s0-
>system_u:object_r:public_content_t:s0
```

To share **/shares/** through Samba:

1. Confirm the **samba**, **samba-common**, and **samba-client** packages are installed (version numbers may differ):

```
~]$ rpm -q samba samba-common samba-client
samba-3.4.0-0.41.el6.3.i686
samba-common-3.4.0-0.41.el6.3.i686
samba-client-3.4.0-0.41.el6.3.i686
```

If any of these packages are not installed, install them by running the following command as root:

```
~]# yum install package-name
```

2. Edit the **/etc/samba/smb.conf** file as root. Add the following entry to the bottom of this file to share the **/shares/** directory through Samba:

```
[shares]
comment = Documents for Apache HTTP Server, FTP, rsync, and Samba
path = /shares
public = yes
writable = no
```

3. A Samba account is required to mount a Samba file system. Enter the following command as root to create a Samba account, where *username* is an existing Linux user. For example, **smbpasswd -a testuser** creates a Samba account for the Linux **testuser** user:

```
~]# smbpasswd -a testuser
New SMB password: Enter a password
```

```
Retype new SMB password: Enter the same password again
Added user testuser.
```

If you run the above command, specifying a user name of an account that does not exist on the system, it causes a **Cannot locate Unix account for 'username'!** error.

4. Start the Samba service:

```
~]# systemctl start smb.service
```

5. Enter the following command to list the available shares, where *username* is the Samba account added in step 3. When prompted for a password, enter the password assigned to the Samba account in step 3 (version numbers may differ):

```
~]$ smbclient -U username -L localhost
Enter username's password:
Domain=[HOSTNAME] OS=[Unix] Server=[Samba 3.4.0-0.41.el6]

Sharename      Type      Comment
-----
shares         Disk      Documents for Apache HTTP Server, FTP, rsync, and Samba
IPC$           IPC       IPC Service (Samba Server Version 3.4.0-0.41.el6)
username      Disk      Home Directories
Domain=[HOSTNAME] OS=[Unix] Server=[Samba 3.4.0-0.41.el6]

Server          Comment
-----
Workgroup        Master
```

6. Use the **mkdir** utility to create a new directory. This directory will be used to mount the **shares** Samba share:

```
~]# mkdir /test/
```

7. Enter the following command as root to mount the **shares** Samba share to **/test/**, replacing *username* with the user name from step 3:

```
~]# mount //localhost/shares /test/ -o user=username
```

Enter the password for *username*, which was configured in step 3.

8. View the content of the file, which is being shared through Samba:

```
~]$ cat /test/index.html
<html>
<body>
<p>Hello</p>
</body>
</html>
```

To share **/shares/** through the Apache HTTP Server:

1. Confirm the `httpd` package is installed (version number may differ):

```
~]$ rpm -q httpd
httpd-2.2.11-6.i386
```

If this package is not installed, use the **yum** utility as root to install it:

```
~]# yum install httpd
```

2. Change into the `/var/www/html/` directory. Enter the following command as root to create a link (named **shares**) to the `/shares/` directory:

```
html]# ln -s /shares/ shares
```

3. Start the Apache HTTP Server:

```
~]# systemctl start httpd.service
```

4. Use a web browser to navigate to **`http://localhost/shares`**. The `/shares/index.html` file is displayed.

By default, the Apache HTTP Server reads an **`index.html`** file if it exists. If `/shares/` did not have **`index.html`**, and instead had **`file1`**, **`file2`**, and **`file3`**, a directory listing would occur when accessing **`http://localhost/shares`**:

1. Remove the **`index.html`** file:

```
~]# rm -i /shares/index.html
```

2. Use the **`touch`** utility as root to create three files in `/shares/`:

```
~]# touch /shares/file{1,2,3}
~]# ls -Z /shares/
-rw-r--r-- root root system_u:object_r:public_content_t:s0 file1
-rw-r--r-- root root unconfined_u:object_r:public_content_t:s0 file2
-rw-r--r-- root root unconfined_u:object_r:public_content_t:s0 file3
```

3. Enter the following command as root to see the status of the Apache HTTP Server:





```
~]# systemctl status httpd.service
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: inactive (dead)
```

If the server is stopped, start it:

```
~]# systemctl start httpd.service
```

4. Use a web browser to navigate to **`http://localhost/shares`**. A directory listing is displayed:

# Index of /shares

<a href="#">Name</a>	<a href="#">Last modified</a>	<a href="#">Size</a>	<a href="#">Description</a>
 <a href="#">Parent Directory</a>		-	
 <a href="#">file1</a>	25-Feb-2009 10:11	0	
 <a href="#">file2</a>	25-Feb-2009 10:11	0	
 <a href="#">file3</a>	25-Feb-2009 10:11	0	

## 14.4.4. Changing port numbers

Depending on policy configuration, services may only be allowed to run on certain port numbers. Attempting to change the port a service runs on without changing policy may result in the service failing to start. Use the **semanage** utility as the root user to list the ports SELinux allows **httpd** to listen on:

```
~]# semanage port -l | grep -w http_port_t
http_port_t      tcp      80, 443, 488, 8008, 8009, 8443
```

By default, SELinux allows **httpd** to listen on TCP ports 80, 443, 488, 8008, 8009, or 8443. If **/etc/httpd/conf/httpd.conf** is configured so that **httpd** listens on any port not listed for **http\_port\_t**, **httpd** fails to start.

To configure **httpd** to run on a port other than TCP ports 80, 443, 488, 8008, 8009, or 8443:

1. Edit the **/etc/httpd/conf/httpd.conf** file as root so the **Listen** option lists a port that is not configured in SELinux policy for **httpd**. The following example configures **httpd** to listen on the 10.0.0.1 IP address, and on TCP port 12345:

```
# Change this to Listen on specific IP addresses as shown below to
# prevent Apache from glomming onto all bound IP addresses (0.0.0.0)
#
#Listen 12.34.56.78:80
Listen 10.0.0.1:12345
```

2. Enter the following command as the root user to add the port to SELinux policy configuration:

```
~]# semanage port -a -t http_port_t -p tcp 12345
```

3. Confirm that the port is added:

```
~]# semanage port -l | grep -w http_port_t
http_port_t      tcp      12345, 80, 443, 488, 8008, 8009, 8443
```

If you no longer run **httpd** on port 12345, use the **semanage** utility as root to remove the port from policy configuration:

```
~]# semanage port -d -t http_port_t -p tcp 12345
```

---

[14] For more information, see the section named *The Apache HTTP Server* in the [System Administrator's Guide](#).

## CHAPTER 15. SAMBA

Samba is an open-source implementation of the Server Message Block (SMB) and Common Internet File System (CIFS) protocols that provides file and print services between clients across various operating systems.<sup>[15]</sup>

In Red Hat Enterprise Linux, the `samba` package provides the Samba server. Enter the following command to see if the `samba` package is installed:

```
~]$ rpm -q samba
package samba is not installed
```

If it is not installed and you want to use Samba, use the **yum** utility as the root user to install it:

```
~]# yum install samba
```

### 15.1. SAMBA AND SELINUX

When SELinux is enabled, the Samba server (**smbd**) runs confined by default. Confined services run in their own domains, and are separated from other confined services. The following example demonstrates the **smbd** process running in its own domain. This example assumes the `samba` package is installed:

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Enter the following command as root to start **smbd**:

```
~]# systemctl start smb.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]# systemctl status smb.service
smb.service - Samba SMB Daemon
  Loaded: loaded (/usr/lib/systemd/system/smb.service; disabled)
  Active: active (running) since Mon 2013-08-05 12:17:26 CEST; 2h 22min ago
```

3. To view the **smbd** processes, execute the following command:

```
~]$ ps -eZ | grep smb
system_u:system_r:smbd_t:s0    9653 ?        00:00:00 smbd
system_u:system_r:smbd_t:s0    9654 ?        00:00:00 smbd
```

The SELinux context associated with the **smbd** processes is **system\_u:system\_r:smbd\_t:s0**. The second last part of the context, **smbd\_t**, is the type. A type defines a domain for processes and a type for files. In this case, the **smbd** processes are running in the **smbd\_t** domain.

Files must be labeled correctly to allow **smbd** to access and share them. For example, **smbd** can read and write to files labeled with the **samba\_share\_t** type, but by default, cannot access files labeled with the **httpd\_sys\_content\_t** type, which is intended for use by the Apache HTTP Server. Booleans must be enabled to allow certain behavior, such as allowing home directories and NFS volumes to be exported through Samba, as well as to allow Samba to act as a domain controller.

## 15.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

Label files with the **samba\_share\_t** type to allow Samba to share them. Only label files you have created, and do not relabel system files with the **samba\_share\_t** type: Booleans can be enabled to share such files and directories. SELinux allows Samba to write to files labeled with the **samba\_share\_t** type, as long as the **/etc/samba/smb.conf** file and Linux permissions are set accordingly.

The **samba\_etc\_t** type is used on certain files in the **/etc/samba/** directory, such as **smb.conf**. Do not manually label files with the **samba\_etc\_t** type. If files in this directory are not labeled correctly, enter the **restorecon -R -v /etc/samba** command as the root user to restore such files to their default contexts. If **/etc/samba/smb.conf** is not labeled with the **samba\_etc\_t** type, starting the Samba service may fail and an SELinux denial message may be logged. The following is an example denial message when **/etc/samba/smb.conf** was labeled with the **httpd\_sys\_content\_t** type:

setroubleshoot: SELinux is preventing smbd (smbd\_t) "read" to ./smb.conf (httpd\_sys\_content\_t). For complete SELinux messages. run **sealert -l deb33473-1069-482b-bb50-e4cd05ab18af**

## 15.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **smbd\_anon\_write**

Having this Boolean enabled allows **smbd** to write to a public directory, such as an area reserved for common files that otherwise has no special access restrictions.

### **samba\_create\_home\_dirs**

Having this Boolean enabled allows Samba to create new home directories independently. This is often done by mechanisms such as PAM.

### **samba\_domain\_controller**

When enabled, this Boolean allows Samba to act as a domain controller, as well as giving it permission to execute related commands such as **useradd**, **groupadd**, and **passwd**.

### **samba\_enable\_home\_dirs**

Enabling this Boolean allows Samba to share users' home directories.

### **samba\_export\_all\_ro**

Export any file or directory, allowing read-only permissions. This allows files and directories that are

not labeled with the **samba\_share\_t** type to be shared through Samba. When the **samba\_export\_all\_ro** Boolean is enabled, but the **samba\_export\_all\_rw** Boolean is disabled, write access to Samba shares is denied, even if write access is configured in **/etc/samba/smb.conf**, as well as Linux permissions allowing write access.

### **samba\_export\_all\_rw**

Export any file or directory, allowing read and write permissions. This allows files and directories that are not labeled with the **samba\_share\_t** type to be exported through Samba. Permissions in **/etc/samba/smb.conf** and Linux permissions must be configured to allow write access.

### **samba\_run\_unconfined**

Having this Boolean enabled allows Samba to run unconfined scripts in the **/var/lib/samba/scripts/** directory.

### **samba\_share\_fusefs**

This Boolean must be enabled for Samba to share fusefs file systems.

### **samba\_share\_nfs**

Disabling this Boolean prevents **smbd** from having full access to NFS shares through Samba. Enabling this Boolean will allow Samba to share NFS volumes.

### **use\_samba\_home\_dirs**

Enable this Boolean to use a remote server for Samba home directories.

### **virt\_use\_samba**

Allow virtual machine access to CIFS files.



#### **NOTE**

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional **policycoreutils-devel** package providing the **sepolicy** utility is required for this command to work.

## **15.4. CONFIGURATION EXAMPLES**

The following examples provide real-world demonstrations of how SELinux complements the Samba server and how full function of the Samba server can be maintained.

### **15.4.1. Sharing directories you create**

The following example creates a new directory, and shares that directory through Samba:

1. Confirm that the **samba**, **samba-common**, and **samba-client** packages are installed:

```
~]$ rpm -q samba samba-common samba-client
package samba is not installed
package samba-common is not installed
package samba-client is not installed
```

If any of these packages are not installed, install them by using the **yum** utility as root:

```
~]# yum install package-name
```

2. Use the **mkdir** utility as root to create a new top-level directory to share files through Samba:

```
~]# mkdir /myshare
```

3. Use the **touch** utility root to create an empty file. This file is used later to verify the Samba share mounted correctly:

```
~]# touch /myshare/file1
```

4. SELinux allows Samba to read and write to files labeled with the **samba\_share\_t** type, as long as the **/etc/samba/smb.conf** file and Linux permissions are set accordingly. Enter the following command as root to add the label change to file-context configuration:

```
~]# semanage fcontext -a -t samba_share_t "/myshare(/.*)?"
```

5. Use the **restorecon** utility as root to apply the label changes:

```
~]# restorecon -R -v /myshare
restorecon reset /myshare context unconfined_u:object_r:default_t:s0-
>system_u:object_r:samba_share_t:s0
restorecon reset /myshare/file1 context unconfined_u:object_r:default_t:s0-
>system_u:object_r:samba_share_t:s0
```

6. Edit **/etc/samba/smb.conf** as root. Add the following to the bottom of this file to share the **/myshare/** directory through Samba:

```
[myshare]
comment = My share
path = /myshare
public = yes
writable = no
```

7. A Samba account is required to mount a Samba file system. Enter the following command as root to create a Samba account, where *username* is an existing Linux user. For example, **smbpasswd -a testuser** creates a Samba account for the Linux **testuser** user:

```
~]# smbpasswd -a testuser
New SMB password: Enter a password
Retype new SMB password: Enter the same password again
```

```
Added user testuser.
```

If you enter the above command, specifying a user name of an account that does not exist on the system, it causes a **Cannot locate Unix account for 'username'!** error.

8. Start the Samba service:

```
~]# systemctl start smb.service
```

9. Enter the following command to list the available shares, where *username* is the Samba account added in step 7. When prompted for a password, enter the password assigned to the Samba account in step 7 (version numbers may differ):

```
~]$ smbclient -U username -L localhost
Enter username's password:
Domain=[HOSTNAME] OS=[Unix] Server=[Samba 3.4.0-0.41.el6]

Sharename      Type      Comment
-----
myshare        Disk      My share
IPC$           IPC       IPC Service (Samba Server Version 3.4.0-0.41.el6)
username       Disk      Home Directories
Domain=[HOSTNAME] OS=[Unix] Server=[Samba 3.4.0-0.41.el6]

Server          Comment
-----
Workgroup       Master
```

10. Use the **mkdir** utility as root to create a new directory. This directory will be used to mount the **myshare** Samba share:

```
~]# mkdir /test/
```

11. Enter the following command as root to mount the **myshare** Samba share to **/test/**, replacing *username* with the user name from step 7:

```
~]# mount //localhost/myshare /test/ -o user=username
```

Enter the password for *username*, which was configured in step 7.

12. Enter the following command to view the **file1** file created in step 3:

```
~]$ ls /test/
file1
```

### 15.4.2. Sharing a website

It may not be possible to label files with the **samba\_share\_t** type, for example, when wanting to share a website in the **/var/www/html/** directory. For these cases, use the **samba\_export\_all\_ro** Boolean to share any file or directory (regardless of the current label), allowing read only permissions, or the

**samba\_export\_all\_rw** Boolean to share any file or directory (regardless of the current label), allowing read and write permissions.

The following example creates a file for a website in **/var/www/html/**, and then shares that file through Samba, allowing read and write permissions. This example assumes the `httpd`, `samba`, `samba-common`, `samba-client`, and `wget` packages are installed:

1. As the root user, create a **/var/www/html/file1.html** file. Copy and paste the following content into this file:

```
<html>
<h2>File being shared through the Apache HTTP Server and Samba.</h2>
</html>
```

2. Enter the following command to view the SELinux context of **file1.html**:

```
~]$ ls -Z /var/www/html/file1.html
-rw-r--r--. root root unconfined_u:object_r:httpd_sys_content_t:s0 /var/www/html/file1.html
```

The file is labeled with the **httpd\_sys\_content\_t**. By default, the Apache HTTP Server can access this type, but Samba cannot.

3. Start the Apache HTTP Server:

```
~]# systemctl start httpd.service
```

4. Change into a directory your user has write access to, and enter the following command. Unless there are changes to the default configuration, this command succeeds:

```
~]$ wget http://localhost/file1.html
Resolving localhost... 127.0.0.1
Connecting to localhost|127.0.0.1|:80... connected.
HTTP request sent, awaiting response... 200 OK
Length: 84 [text/html]
Saving to: `file1.html.1'

100%[=====>] 84      --.-K/s  in 0s

`file1.html.1' saved [84/84]
```

5. Edit **/etc/samba/smb.conf** as root. Add the following to the bottom of this file to share the **/var/www/html/** directory through Samba:

```
[website]
comment = Sharing a website
path = /var/www/html/
public = no
writable = no
```

6. The **/var/www/html/** directory is labeled with the **httpd\_sys\_content\_t** type. By default, Samba cannot access files and directories labeled with the this type, even if Linux permissions allow it. To allow Samba access, enable the **samba\_export\_all\_ro** Boolean:

```
~]# setsebool -P samba_export_all_ro on
```

Do not use the **-P** option if you do not want the change to persist across reboots. Note that enabling the **samba\_export\_all\_ro** Boolean allows Samba to access any type.

7. Start the Samba service:

```
~]# systemctl start smb.service
```

---

[15] For more information, see the *Samba* section in the [System Administrator's Guide](#).

## CHAPTER 16. FILE TRANSFER PROTOCOL

File Transfer Protocol (FTP) is one of the oldest and most commonly used protocols found on the Internet today. Its purpose is to reliably transfer files between computer hosts on a network without requiring the user to log directly into the remote host or have knowledge of how to use the remote system. It allows users to access files on remote systems using a standard set of simple commands.

The Very Secure FTP Daemon (**vsftpd**) is designed from the ground up to be fast, stable, and, most importantly, secure. Its ability to handle large numbers of connections efficiently and securely is why **vsftpd** is the only stand-alone FTP distributed with Red Hat Enterprise Linux.

In Red Hat Enterprise Linux, the **vsftpd** package provides the Very Secure FTP daemon. Enter the following command to see if **vsftpd** is installed:

```
~]$ rpm -q vsftpd
package vsftpd is not installed
```

If you want an FTP server and the **vsftpd** package is not installed, use the **yum** utility as the root user to install it:

```
~]# yum install vsftpd
```

### 16.1. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

By default, anonymous users have read access to files in the **/var/ftp/** directory when they log in using FTP. This directory is labeled with the **public\_content\_t** type, allowing only read access, even if write access is configured in **/etc/vsftpd/vsftpd.conf**. The **public\_content\_t** type is accessible to other services, such as Apache HTTP Server, Samba, and NFS.

Use one of the following types to share files through FTP:

#### **public\_content\_t**

Label files and directories you have created with the **public\_content\_t** type to share them read-only through **vsftpd**. Other services, such as Apache HTTP Server, Samba, and NFS, also have access to files labeled with this type. Files labeled with the **public\_content\_t** type cannot be written to, even if Linux permissions allow write access. If you require write access, use the **public\_content\_rw\_t** type.

#### **public\_content\_rw\_t**

Label files and directories you have created with the **public\_content\_rw\_t** type to share them with read and write permissions through **vsftpd**. Other services, such as Apache HTTP Server, Samba, and NFS, also have access to files labeled with this type. Remember that Booleans for each service must be enabled before they can write to files labeled with this type.

### 16.2. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **ftpd\_anon\_write**

When disabled, this Boolean prevents **vsftpd** from writing to files and directories labeled with the **public\_content\_rw\_t** type. Enable this Boolean to allow users to upload files using FTP. The directory where files are uploaded to must be labeled with the **public\_content\_rw\_t** type and Linux permissions must be set accordingly.

### **ftpd\_full\_access**

When this Boolean is enabled, only Linux (DAC) permissions are used to control access, and authenticated users can read and write to files that are not labeled with the **public\_content\_t** or **public\_content\_rw\_t** types.

### **ftpd\_use\_cifs**

Having this Boolean enabled allows **vsftpd** to access files and directories labeled with the **cifs\_t** type; therefore, having this Boolean enabled allows you to share file systems mounted using Samba through **vsftpd**.

### **ftpd\_use\_nfs**

Having this Boolean enabled allows **vsftpd** to access files and directories labeled with the **nfs\_t** type; therefore, this Boolean allows you to share file systems mounted using NFS through **vsftpd**.

### **ftpd\_connect\_db**

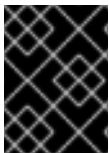
Allow FTP daemons to initiate a connection to a database.

### **httpd\_enable\_ftp\_server**

Allow the **httpd** daemon to listen on the FTP port and act as a FTP server.

### **tftp\_anon\_write**

Having this Boolean enabled allows TFTP access to a public directory, such as an area reserved for common files that otherwise has no special access restrictions.



## **IMPORTANT**

Red Hat Enterprise Linux 7.7 does not provide the **ftp\_home\_dir** Boolean. See the [Red Hat Enterprise Linux 7.3 Release Notes](#) document for more information.



## NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## CHAPTER 17. NETWORK FILE SYSTEM

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 system administrators to consolidate resources onto centralized servers on the network.<sup>[16]</sup>

In Red Hat Enterprise Linux, the `nfs-utils` package is required for full NFS support. Enter the following command to see if the `nfs-utils` is installed:

```
~]$ rpm -q nfs-utils
package nfs-utils is not installed
```

If it is not installed and you want to use NFS, use the **yum** utility as root to install it:

```
~]# yum install nfs-utils
```

### 17.1. NFS AND SELINUX

When running SELinux, the NFS daemons are confined by default except the **nfstd** process, which is labeled with the unconfined **kernel\_t** domain type. The SELinux policy allows NFS to share files by default. Also, passing SELinux labels between a client and the server is supported, which provides better security control of confined domains accessing NFS volumes. For example, when a home directory is set up on an NFS volume, it is possible to specify confined domains that are able to access only the home directory and not other directories on the volume. Similarly, applications, such as Secure Virtualization, can set the label of an image file on an NFS volume, thus increasing the level of separation of virtual machines.

The support for labeled NFS is disabled by default. To enable it, see [Section 17.4.1, “Enabling SELinux Labeled NFS Support”](#).

### 17.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

By default, mounted NFS volumes on the client side are labeled with a default context defined by policy for NFS. In common policies, this default context uses the **nfs\_t** type. The root user is able to override the default type using the **mount -context** option. The following types are used with NFS. Different types allow you to configure flexible access:

#### **var\_lib\_nfs\_t**

This type is used for existing and new files copied to or created in the **/var/lib/nfs/** directory. This type should not need to be changed in normal operation. To restore changes to the default settings, run the **restorecon -R -v /var/lib/nfs** command as the root user.

#### **nfstd\_exec\_t**

The **/usr/sbin/rpc.nfstd** file is labeled with the **nfstd\_exec\_t**, as are other system executables and libraries related to NFS. Users should not label any files with this type. **nfstd\_exec\_t** will transition to **nfstd\_t**.

## 17.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **ftpd\_use\_nfs**

When enabled, this Boolean allows the **ftpd** daemon to access NFS volumes.

### **cobbler\_use\_nfs**

When enabled, this Boolean allows the **cobblerd** daemon to access NFS volumes.

### **git\_system\_use\_nfs**

When enabled, this Boolean allows the Git system daemon to read system shared repositories on NFS volumes.

### **httpd\_use\_nfs**

When enabled, this Boolean allows the **httpd** daemon to access files stored on NFS volumes.

### **samba\_share\_nfs**

When enabled, this Boolean allows the **smbd** daemon to share NFS volumes. When disabled, this Boolean prevents **smbd** from having full access to NFS shares using Samba.

### **sanlock\_use\_nfs**

When enabled, this Boolean allows the **sanlock** daemon to manage NFS volumes.

### **sge\_use\_nfs**

When enabled, this Boolean allows the **sge** scheduler to access NFS volumes.

### **use\_nfs\_home\_dirs**

When enabled, this Boolean adds support for NFS home directories.

### **virt\_use\_nfs**

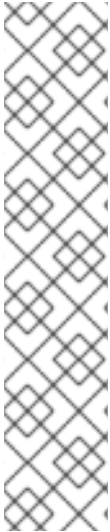
When enabled, this Boolean allows confident virtual guests to manage files on NFS volumes.

### **xen\_use\_nfs**

When enabled, this Boolean allows **Xen** to manage files on NFS volumes.

### **git\_cgi\_use\_nfs**

When enabled, this Boolean allows the Git Common Gateway Interface (CGI) to access NFS volumes.

**NOTE**

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## 17.4. CONFIGURATION EXAMPLES

### 17.4.1. Enabling SELinux Labeled NFS Support

The following example demonstrates how to enable SELinux labeled NFS support. This example assumes that the `nfs-utils` package is installed, that the SELinux targeted policy is used, and that SELinux is running in enforcing mode.

**NOTE**

Steps 1-3 are supposed to be performed on the NFS server, **nfs-srv**.

1. If the NFS server is running, stop it:

```
[nfs-srv]# systemctl stop nfs
```

Confirm that the server is stopped:

```
[nfs-srv]# systemctl status nfs
nfs-server.service - NFS Server
Loaded: loaded (/usr/lib/systemd/system/nfs-server.service; disabled)
Active: inactive (dead)
```

2. Edit the `/etc/sysconfig/nfs` file to set the **RPCNFSDARGS** flag to **"-V 4.2"**:

```
# Optional arguments passed to rpc.nfsd. See rpc.nfsd(8)
RPCNFSDARGS="-V 4.2"
```

3. Start the server again and confirm that it is running. The output will contain information below, only the time stamp will differ:

```
[nfs-srv]# systemctl start nfs
```

```
[nfs-srv]# systemctl status nfs
nfs-server.service - NFS Server
Loaded: loaded (/usr/lib/systemd/system/nfs-server.service; disabled)
```

Active: active (exited) since Wed 2013-08-28 14:07:11 CEST; 4s ago

4. On the client side, mount the NFS server:

```
[nfs-client]# mount -o v4.2 server:mntpoint localmountpoint
```

5. All SELinux labels are now successfully passed from the server to the client:

```
[nfs-srv]$ ls -Z file
-rw-rw-r--. user user unconfined_u:object_r:svirt_image_t:s0 file
[nfs-client]$ ls -Z file
-rw-rw-r--. user user unconfined_u:object_r:svirt_image_t:s0 file
```



## NOTE

If you enable labeled NFS support for home directories or other content, the content will be labeled the same as it was on an EXT file system. Also note that mounting systems with different versions of NFS or an attempt to mount a server that does not support labeled NFS could cause errors to be returned.

---

[16] See the *Network File System (NFS)* chapter in the [Storage Administration Guide](#) for more information.

## CHAPTER 18. BERKELEY INTERNET NAME DOMAIN

BIND performs name resolution services using the **named** daemon. BIND lets users locate computer resources and services by name instead of numerical addresses.

In Red Hat Enterprise Linux, the **bind** package provides a DNS server. Enter the following command to see if the **bind** package is installed:

```
~]$ rpm -q bind
package bind is not installed
```

If it is not installed, use the **yum** utility as the root user to install it:

```
~]# yum install bind
```

### 18.1. BIND AND SELINUX

The default permissions on the **/var/named/slaves/**, **/var/named/dynamic/** and **/var/named/data/** directories allow zone files to be updated using zone transfers and dynamic DNS updates. Files in **/var/named/** are labeled with the **named\_zone\_t** type, which is used for master zone files.

For a slave server, configure the **/etc/named.conf** file to place slave zones in **/var/named/slaves/**. The following is an example of a domain entry in **/etc/named.conf** for a slave DNS server that stores the zone file for **testdomain.com** in **/var/named/slaves/**:

```
zone "testdomain.com" {
    type slave;
    masters { IP-address; };
    file "/var/named/slaves/db.testdomain.com";
};
```

If a zone file is labeled **named\_zone\_t**, the **named\_write\_master\_zones** Boolean must be enabled to allow zone transfers and dynamic DNS to update the zone file. Also, the mode of the parent directory has to be changed to allow the **named** user or group read, write and execute access.

If zone files in **/var/named/** are labeled with the **named\_cache\_t** type, a file system relabel or running **restorecon -R /var/** will change their type to **named\_zone\_t**.

### 18.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with BIND. Different types allow you to configure flexible access:

#### **named\_zone\_t**

Used for master zone files. Other services cannot modify files of this type. The **named** daemon can only modify files of this type if the **named\_write\_master\_zones** Boolean is enabled.

#### **named\_cache\_t**

By default, **named** can write to files labeled with this type, without additional Booleans being set. Files copied or created in the **/var/named/slaves/**, **/var/named/dynamic/** and **/var/named/data/** directories are automatically labeled with the **named\_cache\_t** type.

#### **named\_var\_run\_t**

Files copied or created in the **/var/run/bind/**, **/var/run/named/**, and **/var/run/unbound/** directories are automatically labeled with the **named\_var\_run\_t** type.

#### **named\_conf\_t**

BIND-related configuration files, usually stored in the **/etc** directory, are automatically labeled with the **named\_conf\_t** type.

#### **named\_exec\_t**

BIND-related executable files, usually stored in the **/usr/sbin/** directory, are automatically labeled with the **named\_exec\_t** type.

#### **named\_log\_t**

BIND-related log files, usually stored in the **/var/log/** directory, are automatically labeled with the **named\_log\_t** type.

#### **named\_unit\_file\_t**

Executable BIND-related files in the **/usr/lib/systemd/system/** directory are automatically labeled with the **named\_unit\_file\_t** type.

## 18.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

#### **named\_write\_master\_zones**

When disabled, this Boolean prevents **named** from writing to zone files or directories labeled with the **named\_zone\_t** type. The daemon does not usually need to write to zone files; but in the case that it needs to, or if a secondary server needs to write to zone files, enable this Boolean to allow this action.

#### **named\_tcp\_bind\_http\_port**

When enabled, this Boolean allows BIND to bind an Apache port.



## NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## 18.4. CONFIGURATION EXAMPLES

### 18.4.1. Dynamic DNS

BIND allows hosts to update their records in DNS and zone files dynamically. This is used when a host computer's IP address changes frequently and the DNS record requires real-time modification.

Use the `/var/named/dynamic/` directory for zone files you want updated by dynamic DNS. Files created in or copied into this directory inherit Linux permissions that allow **named** to write to them. As such files are labeled with the **named\_cache\_t** type, SELinux allows **named** to write to them.

If a zone file in `/var/named/dynamic/` is labeled with the **named\_zone\_t** type, dynamic DNS updates may not be successful for a certain period of time as the update needs to be written to a journal first before being merged. If the zone file is labeled with the **named\_zone\_t** type when the journal attempts to be merged, an error such as the following is logged:

```
named[PID]: dumping master file: rename: /var/named/dynamic/zone-name: permission denied
```

Also, the following SELinux denial message is logged:

```
setroubleshoot: SELinux is preventing named (named_t) "unlink" to zone-name (named_zone_t)
```

To resolve this labeling issue, use the **restorecon** utility as root:

```
~]# restorecon -R -v /var/named/dynamic
```

## CHAPTER 19. CONCURRENT VERSIONING SYSTEM

The Concurrent Versioning System (CVS) is a free revision-control system. It is used to monitor and keep track of modifications to a central set of files which are usually accessed by several different users. It is commonly used by programmers to manage a source code repository and is widely used by open source developers.

In Red Hat Enterprise Linux, the `cvs` package provides CVS. Enter the following command to see if the `cvs` package is installed:

```
~]$ rpm -q cvs  
package cvs is not installed
```

If it is not installed and you want to use CVS, use the **yum** utility as root to install it:

```
~]# yum install cvs
```

### 19.1. CVS AND SELINUX

The **cvs** daemon runs labeled with the **cvs\_t** type. By default in Red Hat Enterprise Linux, CVS is only allowed to read and write certain directories. The label **cvs\_data\_t** defines which areas **cvs** has read and write access to. When using CVS with SELinux, assigning the correct label is essential for clients to have full access to the area reserved for CVS data.

### 19.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with CVS. Different types allow you to configure flexible access:

#### **cvs\_data\_t**

This type is used for data in a CVS repository. CVS can only gain full access to data if it has this type.

#### **cvs\_exec\_t**

This type is used for the **/usr/bin/cvs** binary.

### 19.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

#### **cvs\_read\_shadow**

This Boolean allows the **cvs** daemon to access the **/etc/shadow** file for user authentication.

**NOTE**

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sestatus booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sestatus** utility is required for this command to work.

## 19.4. CONFIGURATION EXAMPLES

### 19.4.1. Setting up CVS

This example describes a simple CVS setup and an SELinux configuration which allows remote access. Two hosts are used in this example; a CVS server with a host name of **cvb-srv** with an IP address of **192.168.1.1** and a client with a host name of **cvb-client** and an IP address of **192.168.1.100**. Both hosts are on the same subnet (192.168.1.0/24). This is an example only and assumes that the cvs and xinetd packages are installed, that the SELinux targeted policy is used, and that SELinux is running in enforced mode.

This example will show that even with full DAC permissions, SELinux can still enforce policy rules based on file labels and only allow access to certain areas that have been specifically labeled for access by CVS.

**NOTE**

Steps 1-9 are supposed be performed on the CVS server, **cvb-srv**.

1. This example requires the cvs and xinetd packages. Confirm that the packages are installed:

```
[cvb-srv]$ rpm -q cvs xinetd
package cvs is not installed
package xinetd is not installed
```

If they are not installed, use the **yum** utility as root to install it:

```
[cvb-srv]# yum install cvs xinetd
```

2. Enter the following command as root to create a group named **CVS**:

```
[cvb-srv]# groupadd CVS
```

This can by also done by using the **system-config-users** utility.

3. Create a user with a user name of **cvbuser** and make this user a member of the CVS group. This can be done using **system-config-users**.

4. Edit the **/etc/services** file and make sure that the CVS server has uncommented entries looking similar to the following:

```
cvspserver 2401/tcp  # CVS client/server operations
cvspserver 2401/udp  # CVS client/server operations
```

5. Create the CVS repository in the root area of the file system. When using SELinux, it is best to have the repository in the root file system so that recursive labels can be given to it without affecting any other subdirectories. For example, as root, create a **/cvs/** directory to house the repository:

```
[root@cvs-srv]# mkdir /cvs
```

6. Give full permissions to the **/cvs/** directory to all users:

```
[root@cvs-srv]# chmod -R 777 /cvs
```



### WARNING

This is an example only and these permissions should not be used in a production system.

7. Edit the **/etc/xinetd.d/cvs** file and make sure that the CVS section is uncommented and configured to use the **/cvs/** directory. The file should look similar to:

```
service cvspserver
{
    disable = no
    port    = 2401
    socket_type = stream
    protocol = tcp
    wait     = no
    user     = root
    passenv  = PATH
    server   = /usr/bin/cvs
    env      = HOME=/cvs
    server_args = -f --allow-root=/cvs pserver
    # bind    = 127.0.0.1
```

8. Start the **xinetd** daemon:

```
[cvs-srv]# systemctl start xinetd.service
```

9. Add a rule which allows inbound connections through TCP on port 2401 by using the **system-config-firewall** utility.
10. On the client side, enter the following command as the **cvsuser** user:

■

```
[cvsuser@cvs-client]$ cvs -d /cvs init
```

11. At this point, CVS has been configured but SELinux will still deny logins and file access. To demonstrate this, set the **\$CVSROOT** variable on **cvs-client** and try to log in remotely. The following step is supposed to be performed on **cvs-client**:

```
[cvsuser@cvs-client]$ export CVSROOT=:pserver:cvsuser@192.168.1.1:/cvs
[cvsuser@cvs-client]$
[cvsuser@cvs-client]$ cvs login
Logging in to :pserver:cvsuser@192.168.1.1:2401/cvs
CVS password: *****
cvs [login aborted]: unrecognized auth response from 192.168.100.1: cvs pserver: cannot
open /cvs/CVSROOT/config: Permission denied
```

SELinux has blocked access. In order to get SELinux to allow this access, the following step is supposed to be performed on **cvs-srv**:

12. Change the context of the **/cvs/** directory as root in order to recursively label any existing and new data in the **/cvs/** directory, giving it the **cvs\_data\_t** type:

```
[root@cvs-srv]# semanage fcontext -a -t cvs_data_t '/cvs(/.*)?'
[root@cvs-srv]# restorecon -R -v /cvs
```

13. The client, **cvs-client** should now be able to log in and access all CVS resources in this repository:

```
[cvsuser@cvs-client]$ export CVSROOT=:pserver:cvsuser@192.168.1.1:/cvs
[cvsuser@cvs-client]$
[cvsuser@cvs-client]$ cvs login
Logging in to :pserver:cvsuser@192.168.1.1:2401/cvs
CVS password: *****
[cvsuser@cvs-client]$
```

## CHAPTER 20. SQUID CACHING PROXY

Squid is a high-performance proxy caching server for web clients, supporting FTP, Gopher, and HTTP data objects. It reduces bandwidth and improves response times by caching and reusing frequently-requested web pages.<sup>[17]</sup>

In Red Hat Enterprise Linux, the squid package provides the Squid Caching Proxy. Enter the following command to see if the squid package is installed:

```
~]$ rpm -q squid
package squid is not installed
```

If it is not installed and you want to use squid, use the **yum** utility as root to install it:

```
~]# yum install squid
```

### 20.1. SQUID CACHING PROXY AND SELINUX

When SELinux is enabled, Squid runs confined by default. Confined processes run in their own domains, and are separated from other confined processes. If a confined process is compromised by an attacker, depending on SELinux policy configuration, an attacker's access to resources and the possible damage they can do is limited. The following example demonstrates the Squid processes running in their own domain. This example assumes the squid package is installed:

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Enter the following command as the root user to start the **squid** daemon:

```
~]# systemctl start squid.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]# systemctl status squid.service
squid.service - Squid caching proxy
Loaded: loaded (/usr/lib/systemd/system/squid.service; disabled)
Active: active (running) since Mon 2013-08-05 14:45:53 CEST; 2s ago
```

3. Enter the following command to view the **squid** processes:

```
~]$ ps -eZ | grep squid
system_u:system_r:squid_t:s0 27018 ? 00:00:00 squid
system_u:system_r:squid_t:s0 27020 ? 00:00:00 log_file_daemon
```

The SELinux context associated with the **squid** processes is **system\_u:system\_r:squid\_t:s0**. The second last part of the context, **squid\_t**, is the type. A type defines a domain for processes and a type for files. In this case, the Squid processes are running in the **squid\_t** domain.

SELinux policy defines how processes running in confined domains, such as **squid\_t**, interact with files, other processes, and the system in general. Files must be labeled correctly to allow squid access to them.

When the **/etc/squid/squid.conf** file is configured so **squid** listens on a port other than the default TCP ports 3128, 3401 or 4827, the **semanage port** command must be used to add the required port number to the SELinux policy configuration. The following example demonstrates configuring **squid** to listen on a port that is not initially defined in SELinux policy configuration for it, and, as a consequence, the server failing to start. This example also demonstrates how to then configure the SELinux system to allow the daemon to successfully listen on a non-standard port that is not already defined in the policy. This example assumes the squid package is installed. Run each command in the example as the root user:

1. Confirm the **squid** daemon is not running:

```
~]# systemctl status squid.service
squid.service - Squid caching proxy
   Loaded: loaded (/usr/lib/systemd/system/squid.service; disabled)
   Active: inactive (dead)
```

If the output differs, stop the process:

```
~]# systemctl stop squid.service
```

2. Enter the following command to view the ports SELinux allows **squid** to listen on:

```
~]# semanage port -l | grep -w -i squid_port_t
squid_port_t      tcp      3401, 4827
squid_port_t      udp      3401, 4827
```

3. Edit **/etc/squid/squid.conf** as root. Configure the **http\_port** option so it lists a port that is not configured in SELinux policy configuration for **squid**. In this example, the daemon is configured to listen on port 10000:

```
# Squid normally listens to port 3128
http_port 10000
```

4. Run the **setsebool** command to make sure the **squid\_connect\_any** Boolean is set to off. This ensures **squid** is only permitted to operate on specific ports:

```
~]# setsebool -P squid_connect_any 0
```

5. Start the **squid** daemon:

```
~]# systemctl start squid.service
Job for squid.service failed. See 'systemctl status squid.service' and 'journalctl -xn' for details.
```

An SELinux denial message similar to the following is logged:

```
localhost setroubleshoot: SELinux is preventing the squid (squid_t) from binding to port
10000. For complete SELinux messages. run sealert -l 97136444-4497-4fff-a7a7-
c4d8442db982
```

- For SELinux to allow **squid** to listen on port 10000, as used in this example, the following command is required:

```
~]# semanage port -a -t squid_port_t -p tcp 10000
```

- Start **squid** again and have it listen on the new port:

```
~]# systemctl start squid.service
```

- Now that SELinux has been configured to allow Squid to listen on a non-standard port (TCP 10000 in this example), it starts successfully on this port.

## 20.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with Squid. Different types allow you to configure flexible access:

### **httpd\_squid\_script\_exec\_t**

This type is used for utilities such as **cachemgr.cgi**, which provides a variety of statistics about Squid and its configuration.

### **squid\_cache\_t**

Use this type for data that is cached by Squid, as defined by the **cache\_dir** directive in **/etc/squid/squid.conf**. By default, files created in or copied into the **/var/cache/squid/** and **/var/spool/squid/** directories are labeled with the **squid\_cache\_t** type. Files for the [squidGuard](#) URL redirector plug-in for **squid** created in or copied to the **/var/squidGuard/** directory are also labeled with the **squid\_cache\_t** type. Squid is only able to use files and directories that are labeled with this type for its cached data.

### **squid\_conf\_t**

This type is used for the directories and files that Squid uses for its configuration. Existing files, or those created in or copied to the **/etc/squid/** and **/usr/share/squid/** directories are labeled with this type, including error messages and icons.

### **squid\_exec\_t**

This type is used for the **squid** binary, **/usr/sbin/squid**.

### **squid\_log\_t**

This type is used for logs. Existing files, or those created in or copied to **/var/log/squid/** or **/var/log/squidGuard/** must be labeled with this type.

### **squid\_initrc\_exec\_t**

This type is used for the initialization file required to start **squid** which is located at **/etc/rc.d/init.d/squid**.

### **squid\_var\_run\_t**

This type is used by files in the **/var/run/** directory, especially the process id (PID) named **/var/run/squid.pid** which is created by Squid when it runs.

## 20.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **squid\_connect\_any**

When enabled, this Boolean permits Squid to initiate a connection to a remote host on any port.

### **squid\_use\_tproxy**

When enabled, this Boolean allows Squid to run as a transparent proxy.



#### NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## 20.4. CONFIGURATION EXAMPLES

### 20.4.1. Squid Connecting to Non-Standard Ports

The following example provides a real-world demonstration of how SELinux complements Squid by enforcing the above Boolean and by default only allowing access to certain ports. This example will then demonstrate how to change the Boolean and show that access is then allowed.

Note that this is an example only and demonstrates how SELinux can affect a simple configuration of Squid. Comprehensive documentation of Squid is beyond the scope of this document. See the official [Squid documentation](#) for further details. This example assumes that the Squid host has two network interfaces, Internet access, and that any firewall has been configured to allow access on the internal interface using the default TCP port on which Squid listens (TCP 3128).

1. Confirm that the squid is installed:

```
~]$ rpm -q squid
package squid is not installed
```

If the package is not installed, use the **yum** utility as root to install it:

```
~]# yum install squid
```

2. Edit the main configuration file, **/etc/squid/squid.conf**, and confirm that the **cache\_dir** directive is uncommented and looks similar to the following:

```
cache_dir ufs /var/spool/squid 100 16 256
```

This line specifies the default settings for the **cache\_dir** directive to be used in this example; it consists of the Squid storage format (**ufs**), the directory on the system where the cache resides (**/var/spool/squid**), the amount of disk space in megabytes to be used for the cache ( **100**), and finally the number of first-level and second-level cache directories to be created (**16** and **256** respectively).

3. In the same configuration file, make sure the **http\_access allow localnet** directive is uncommented. This allows traffic from the **localnet** ACL which is automatically configured in a default installation of Squid on Red Hat Enterprise Linux. It will allow client machines on any existing RFC1918 network to have access through the proxy, which is sufficient for this simple example.
4. In the same configuration file, make sure the **visible\_hostname** directive is uncommented and is configured to the host name of the machine. The value should be the fully qualified domain name (FQDN) of the host:

```
visible_hostname squid.example.com
```

5. As root, enter the following command to start the **squid** daemon. As this is the first time **squid** has started, this command will initialise the cache directories as specified above in the **cache\_dir** directive and will then start the daemon:

```
~]# systemctl start squid.service
```

Ensure that **squid** starts successfully. The output will include the information below, only the time stamp will differ:

```
~]# systemctl status squid.service
squid.service - Squid caching proxy
   Loaded: loaded (/usr/lib/systemd/system/squid.service; disabled)
   Active: active (running) since Thu 2014-02-06 15:00:24 CET; 6s ago
```

6. Confirm that the **squid** process ID (PID) has started as a confined service, as seen here by the **squid\_var\_run\_t** value:

```
~]# ls -lZ /var/run/squid.pid
-rw-r--r--. root squid unconfined_u:object_r:squid_var_run_t:s0 /var/run/squid.pid
```

7. At this point, a client machine connected to the **localnet** ACL configured earlier is successfully able to use the internal interface of this host as its proxy. This can be configured in the settings for all common web browsers, or system-wide. Squid is now listening on the default port of the target machine (TCP 3128), but the target machine will only allow outgoing connections to other services on the Internet through common ports. This is a policy defined by SELinux itself. SELinux will deny access to non-standard ports, as shown in the next step:

8. When a client makes a request using a non-standard port through the Squid proxy such as a website listening on TCP port 10000, a denial similar to the following is logged:

```
SELinux is preventing the squid daemon from connecting to network port 10000
```

9. To allow this access, the **squid\_connect\_any** Boolean must be modified, as it is disabled by default:

```
~]# setsebool -P squid_connect_any on
```



#### NOTE

Do not use the **-P** option if you do not want **setsebool** changes to persist across reboots.

10. The client will now be able to access non-standard ports on the Internet as Squid is now permitted to initiate connections to any port, on behalf of its clients.

---

[17] See the [Squid Caching Proxy](#) project page for more information.

## CHAPTER 21. MARIADB (A REPLACEMENT FOR MYSQL)

The MariaDB database is a multi-user, multi-threaded SQL database server that consists of the MariaDB server daemon (**mysqld**) and many client programs and libraries. <sup>[18]</sup>

In Red Hat Enterprise Linux, the mariadb-server package provides MariaDB. Enter the following command to see if the mariadb-server package is installed:

```
~]$ rpm -q mariadb-server
package mariadb-server is not installed
```

If it is not installed, use the **yum** utility as root to install it:

```
~]# yum install mariadb-server
```

### 21.1. MARIADB AND SELINUX

When MariaDB is enabled, it runs confined by default. Confined processes run in their own domains, and are separated from other confined processes. If a confined process is compromised by an attacker, depending on SELinux policy configuration, an attacker's access to resources and the possible damage they can do is limited. The following example demonstrates the MariaDB processes running in their own domain. This example assumes the mariadb-server package is installed:

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Enter the following command as the root user to start **mariadb**:

```
~]# systemctl start mariadb.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]# systemctl status mariadb.service
mariadb.service - MariaDB database server
  Loaded: loaded (/usr/lib/systemd/system/mariadb.service; disabled)
  Active: active (running) since Mon 2013-08-05 11:20:11 CEST; 3h 28min ago
```

3. Enter the following command to view the **mysqld** processes:

```
~]$ ps -eZ | grep mysqld
system_u:system_r:mysqld_safe_t:s0 12831 ?    00:00:00 mysqld_safe
system_u:system_r:mysqld_t:s0 13014 ?    00:00:00 mysqld
```

The SELinux context associated with the **mysqld** processes is

**system\_u:system\_r:mysqld\_t:s0**. The second last part of the context, **mysqld\_t**, is the type. A type defines a domain for processes and a type for files. In this case, the **mysqld** processes are running in the **mysqld\_t** domain.

## 21.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with **mysqld**. Different types allow you to configure flexible access:

### **mysqld\_db\_t**

This type is used for the location of the MariaDB database. In Red Hat Enterprise Linux, the default location for the database is the **/var/lib/mysql/** directory, however this can be changed. If the location for the MariaDB database is changed, the new location must be labeled with this type. See the example in [Section 21.4.1, “MariaDB Changing Database Location”](#) for instructions on how to change the default database location and how to label the new section appropriately.

### **mysqld\_etc\_t**

This type is used for the MariaDB main configuration file **/etc/my.cnf** and any other configuration files in the **/etc/mysql/** directory.

### **mysqld\_exec\_t**

This type is used for the **mysqld** binary located at **/usr/libexec/mysqld**, which is the default location for the MariaDB binary on Red Hat Enterprise Linux. Other systems may locate this binary at **/usr/sbin/mysqld** which should also be labeled with this type.

### **mysqld\_unit\_file\_t**

This type is used for executable MariaDB-related files located in the **/usr/lib/systemd/system/** directory by default in Red Hat Enterprise Linux.

### **mysqld\_log\_t**

Logs for MariaDB need to be labeled with this type for proper operation. All log files in the **/var/log/** directory matching the **mysql.\*** wildcard must be labeled with this type.

### **mysqld\_var\_run\_t**

This type is used by files in the **/var/run/mariadb/** directory, specifically the process id (PID) named **/var/run/mariadb/mariadb.pid** which is created by the **mysqld** daemon when it runs. This type is also used for related socket files such as **/var/lib/mysql/mysql.sock**. Files such as these must be labeled correctly for proper operation as a confined service.

## 21.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **selinuxuser\_mysql\_connect\_enabled**

When enabled, this Boolean allows users to connect to the local MariaDB server.

### **exim\_can\_connect\_db**

When enabled, this Boolean allows the **exim** mailer to initiate connections to a database server.

### ftpd\_connect\_db

When enabled, this Boolean allows **ftp** daemons to initiate connections to a database server.

### httpd\_can\_network\_connect\_db

Enabling this Boolean is required for a web server to communicate with a database server.



#### NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sestatus booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## 21.4. CONFIGURATION EXAMPLES

### 21.4.1. MariaDB Changing Database Location

When using Red Hat Enterprise Linux, the default location for MariaDB to store its database is `/var/lib/mysql/`. This is where SELinux expects it to be by default, and hence this area is already labeled appropriately for you, using the **mysqld\_db\_t** type.

The location where the database is stored can be changed depending on individual environment requirements or preferences, however it is important that SELinux is aware of this new location; that it is labeled accordingly. This example explains how to change the location of a MariaDB database and then how to label the new location so that SELinux can still provide its protection mechanisms to the new area based on its contents.

Note that this is an example only and demonstrates how SELinux can affect MariaDB. Comprehensive documentation of MariaDB is beyond the scope of this document. See the official [MariaDB documentation](#) for further details. This example assumes that the `mariadb-server` and `setroubleshoot-server` packages are installed, that the **auditd** service is running, and that there is a valid database in the default location of `/var/lib/mysql/`.

1. View the SELinux context of the default database location for **mysql**:

```
~]# ls -lZ /var/lib/mysql
drwx-----. mysql mysql system_u:object_r:mysqld_db_t:s0 mysql
```

This shows **mysqld\_db\_t** which is the default context element for the location of database files. This context will have to be manually applied to the new database location that will be used in this example in order for it to function properly.

2. Enter the following command and enter the **mysql** root password to show the available databases:

```
~]# mysqlshow -u root -p
Enter password: *****
+-----+
| Databases |
+-----+
| information_schema |
| mysql            |
| test             |
| wikidb           |
+-----+
```

3. Stop the **mysqld** daemon:

```
~]# systemctl stop mariadb.service
```

4. Create a new directory for the new location of the database(s). In this example, **/mysql/** is used:

```
~]# mkdir -p /mysql
```

5. Copy the database files from the old location to the new location:

```
~]# cp -R /var/lib/mysql/* /mysql/
```

6. Change the ownership of this location to allow access by the mysql user and group. This sets the traditional Unix permissions which SELinux will still observe:

```
~]# chown -R mysql:mysql /mysql
```

7. Enter the following command to see the initial context of the new directory:

```
~]# ls -lZ /mysql
drwxr-xr-x. mysql mysql unconfined_u:object_r:usr_ts0 mysql
```

The context **usr\_t** of this newly created directory is not currently suitable to SELinux as a location for MariaDB database files. Once the context has been changed, MariaDB will be able to function properly in this area.

8. Open the main MariaDB configuration file **/etc/my.cnf** with a text editor and modify the **datadir** option so that it refers to the new location. In this example the value that should be entered is **/mysql**:

```
[mysqld]
datadir=/mysql
```

Save this file and exit.

9. Start **mysqld**. The service should fail to start, and a denial message will be logged to the **/var/log/messages** file:

```
~]# systemctl start mariadb.service
Job for mariadb.service failed. See 'systemctl status postgresql.service' and 'journalctl -xn'
for details.
```

However, if the **audit** daemon is running alongside the **setroubleshoot** service, the denial will be logged to the **/var/log/audit/audit.log** file instead:

```
SELinux is preventing /usr/libexec/mysqld "write" access on /mysql. For complete SELinux
messages. run sealert -l b3f01aff-7fa6-4ebe-ad46-abaef6f8ad71
```

The reason for this denial is that **/mysql/** is not labeled correctly for MariaDB data files. SELinux is stopping MariaDB from having access to the content labeled as **usr\_t**. Perform the following steps to resolve this problem:

10. Enter the following command to add a context mapping for **/mysql/**. Note that the **semanage** utility is not installed by default. If it is missing on your system, install the **policycoreutils-python** package.

```
~]# semanage fcontext -a -t mysqld_db_t "/mysql(/.*)?"
```

11. This mapping is written to the **/etc/selinux/targeted/contexts/files/file\_contexts.local** file:

```
~]# grep -i mysql /etc/selinux/targeted/contexts/files/file_contexts.local

/mysql(/.*)?  system_u:object_r:mysqld_db_t:s0
```

12. Now use the **restorecon** utility to apply this context mapping to the running system:

```
~]# restorecon -R -v /mysql
```

13. Now that the **/mysql/** location has been labeled with the correct context for MariaDB, **mysqld** starts:

```
~]# systemctl start mariadb.service
```

14. Confirm the context has changed for **/mysql/**:

```
~]$ ls -lZ /mysql
drwxr-xr-x. mysql mysql system_u:object_r:mysqld_db_t:s0 mysql
```

15. The location has been changed and labeled, and **mysqld** has started successfully. At this point all running services should be tested to confirm normal operation.

---

[18] See the [MariaDB](#) project page for more information.

## CHAPTER 22. POSTGRESQL

PostgreSQL is an Object-Relational database management system (DBMS).<sup>[19]</sup>

In Red Hat Enterprise Linux, the `postgresql-server` package provides PostgreSQL. Enter the following command to see if the `postgresql-server` package is installed:

```
~]# rpm -q postgresql-server
```

If it is not installed, use the **yum** utility as root to install it:

```
~]# yum install postgresql-server
```

### 22.1. POSTGRESQL AND SELINUX

When PostgreSQL is enabled, it runs confined by default. Confined processes run in their own domains, and are separated from other confined processes. If a confined process is compromised by an attacker, depending on SELinux policy configuration, an attacker's access to resources and the possible damage they can do is limited. The following example demonstrates the PostgreSQL processes running in their own domain. This example assumes the `postgresql-server` package is installed:

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Enter the following command as the root user to start **postgresql**:

```
~]# systemctl start postgresql.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]# systemctl start postgresql.service
postgresql.service - PostgreSQL database server
   Loaded: loaded (/usr/lib/systemd/system/postgresql.service; disabled)
   Active: active (running) since Mon 2013-08-05 14:57:49 CEST; 12s
```

3. Enter the following command to view the **postgresql** processes:

```
~]$ ps -eZ | grep postgres
system_u:system_r:postgresql_t:s0 395 ?    00:00:00 postmaster
system_u:system_r:postgresql_t:s0 397 ?    00:00:00 postmaster
system_u:system_r:postgresql_t:s0 399 ?    00:00:00 postmaster
system_u:system_r:postgresql_t:s0 400 ?    00:00:00 postmaster
system_u:system_r:postgresql_t:s0 401 ?    00:00:00 postmaster
system_u:system_r:postgresql_t:s0 402 ?    00:00:00 postmaster
```

The SELinux context associated with the **postgresql** processes is **system\_u:system\_r:postgresql\_t:s0**. The second last part of the context, **postgresql\_t**, is the

type. A type defines a domain for processes and a type for files. In this case, the **postgresql** processes are running in the **postgresql\_t** domain.

## 22.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with **postgresql**. Different types allow you to configure flexible access. Note that in the list below are used several regular expression to match the whole possible locations:

### **postgresql\_db\_t**

This type is used for several locations. The locations labeled with this type are used for data files for PostgreSQL:

- **/usr/lib/pgsql/test/regres**
- **/usr/share/jonas/pgsql**
- **/var/lib/pgsql/data**
- **/var/lib/postgres(ql)?**

### **postgresql\_etc\_t**

This type is used for configuration files in the **/etc/postgresql/** directory.

### **postgresql\_exec\_t**

This type is used for several locations. The locations labeled with this type are used for binaries for PostgreSQL:

- **/usr/bin/initdb(.sepgsql)?**
- **/usr/bin/(se)?postgres**
- **/usr/lib(64)?/postgresql/bin/\***
- **/usr/lib(64)?/pgsql/test/regress/pg\_regress**

### **systemd\_unit\_file\_t**

This type is used for the executable PostgreSQL-related files located in the **/usr/lib/systemd/system/** directory.

### **postgresql\_log\_t**

This type is used for several locations. The locations labeled with this type are used for log files:

- **/var/lib/pgsql/logfile**
- **/var/lib/pgsql/pgstartup.log**
- **/var/lib/sepgsql/pgstartup.log**

- `/var/log/postgresql`
- `/var/log/postgres.log.*`
- `/var/log/rhdb/rhdb`
- `/var/log/sepostgresql.log.*`

### **postgresql\_var\_run\_t**

This type is used for run-time files for PostgreSQL, such as the process id (PID) in the `/var/run/postgresql/` directory.

## **22.3. BOOLEANS**

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **selinuxuser\_postgresql\_connect\_enabled**

Having this Boolean enabled allows any user domain (as defined by PostgreSQL) to make connections to the database server.



#### **NOTE**

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional `polycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## **22.4. CONFIGURATION EXAMPLES**

### **22.4.1. PostgreSQL Changing Database Location**

When using Red Hat Enterprise Linux, the default location for PostgreSQL to store its database is `/var/lib/pgsql/data/`. This is where SELinux expects it to be by default, and hence this area is already labeled appropriately for you, using the **postgresql\_db\_t** type.

The area where the database is located can be changed depending on individual environment requirements or preferences, however it is important that SELinux is aware of this new location; that it is labeled accordingly. This example explains how to change the location of a PostgreSQL database and then how to label the new location so that SELinux can still provide its protection mechanisms to the new area based on its contents.

Note that this is an example only and demonstrates how SELinux can affect PostgreSQL. Comprehensive documentation of PostgreSQL is beyond the scope of this document. See the official [PostgreSQL documentation](#) for further details. This example assumes that the `postgresql-server` package is installed.

1. View the SELinux context of the default database location for **postgresql**:

```
~]# ls -lZ /var/lib/pgsql
drwx-----. postgres postgres system_u:object_r:postgresql_db_t:s0 data
```

This shows **postgresql\_db\_t** which is the default context element for the location of database files. This context will have to be manually applied to the new database location that will be used in this example in order for it to function properly.

2. Create a new directory for the new location of the database(s). In this example, **/opt/postgresql/data/** is used. If you use a different location, replace the text in the following steps with your location:

```
~]# mkdir -p /opt/postgresql/data
```

3. Perform a directory listing of the new location. Note that the initial context of the new directory is **usr\_t**. This context is not sufficient for SELinux to offer its protection mechanisms to PostgreSQL. Once the context has been changed, it will be able to function properly in the new area.

```
~]# ls -lZ /opt/postgresql/
drwxr-xr-x. root root unconfined_u:object_r:usr_t:s0 data
```

4. Change the ownership of the new location to allow access by the `postgres` user and group. This sets the traditional Unix permissions which SELinux will still observe.

```
~]# chown -R postgres:postgres /opt/postgresql
```

5. Open the **/etc/systemd/system/postgresql.service** file with a text editor and modify the **PGDATA** and **PGLOG** variables to point to the new location:

```
~]# vi /etc/systemd/system/postgresql.service
PGDATA=/opt/postgresql/data
PGLOG=/opt/postgresql/data/pgstartup.log
```

Save this file and exit the text editor.

If the **/etc/systemd/system/postgresql.service** file does not exist, create it and insert the following content:

```
.include /lib/systemd/system/postgresql.service
[Service]

# Location of database directory
Environment=PGDATA=/opt/postgresql/data
Environment=PGLOG=/opt/postgresql/data/pgstartup.log
```

6. Initialize the database in the new location:

```
~]$ su - postgres -c "initdb -D /opt/postgresql/data"
```

7. Having changed the database location, starting the service will fail at this point:

```
~]# systemctl start postgresql.service
Job for postgresql.service failed. See 'systemctl status postgresql.service' and 'journalctl -xn'
for details.
```

SELinux has caused the service to not start. This is because the new location is not properly labeled. The following steps explain how to label the new location (**/opt/postgresql/**) and start the postgresql service properly:

8. Use the **semanage** utility to add a context mapping for **/opt/postgresql/** and any other directories/files within it:

```
~]# semanage fcontext -a -t postgresql_db_t "/opt/postgresql(/.*)?"
```

9. This mapping is written to the **/etc/selinux/targeted/contexts/files/file\_contexts.local** file:

```
~]# grep -i postgresql /etc/selinux/targeted/contexts/files/file_contexts.local

/opt/postgresql(/.*)?  system_u:object_r:postgresql_db_t:s0
```

10. Now use the **restorecon** utility to apply this context mapping to the running system:

```
~]# restorecon -R -v /opt/postgresql
```

11. Now that the **/opt/postgresql/** location has been labeled with the correct context for PostgreSQL, the **postgresql** service will start successfully:

```
~]# systemctl start postgresql.service
```

12. Confirm the context is correct for **/opt/postgresql/**:

```
~]$ ls -lZ /opt
drwxr-xr-x. root root system_u:object_r:postgresql_db_t:s0 postgresql
```

13. Check with the **ps** command that the **postgresql** process displays the new location:

```
~]# ps aux | grep -i postmaster

postgres 21564 0.3 0.3 42308 4032 ?        S   10:13   0:00 /usr/bin/postmaster -p 5432 -D
/opt/postgresql/data/
```

14. The location has been changed and labeled, and **postgresql** has started successfully. At this point all running services should be tested to confirm normal operation.

---

[19] See the [PostgreSQL](#) project page for more information.

## CHAPTER 23. RSYNC

The **rsync** utility performs fast file transfer and it is used for synchronizing data between systems. [20]

When using Red Hat Enterprise Linux, the **rsync** package provides **rsync**. Enter the following command to see if the **rsync** package is installed:

```
~]$ rpm -q rsync
package rsync is not installed
```

If it is not installed, use the **yum** utility as root to install it:

```
~)# yum install rsync
```

### 23.1. RSYNC AND SELINUX

SELinux requires files to have an extended attribute to define the file type. Policy governs the access daemons have to these files. If you want to share files using the **rsync** daemon, you must label the files and directories with the **public\_content\_t** type. Like most services, correct labeling is required for SELinux to perform its protection mechanisms over **rsync**.<sup>[21]</sup>

### 23.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with **rsync**. Different types allow you to configure flexible access:

#### **public\_content\_t**

This is a generic type used for the location of files (and the actual files) to be shared using **rsync**. If a special directory is created to house files to be shared with **rsync**, the directory and its contents need to have this label applied to them.

#### **rsync\_exec\_t**

This type is used for the **/usr/bin/rsync** system binary.

#### **rsync\_log\_t**

This type is used for the **rsync** log file, located at **/var/log/rsync.log** by default. To change the location of the file **rsync** logs to, use the **--log-file=FILE** option to the **rsync** command at run-time.

#### **rsync\_var\_run\_t**

This type is used for the **rsyncd** lock file, located at **/var/run/rsyncd.lock**. This lock file is used by the **rsync** server to manage connection limits.

#### **rsync\_data\_t**

This type is used for files and directories which you want to use as **rsync** domains and isolate them from the access scope of other services. Also, the **public\_content\_t** is a general SELinux context

type, which can be used when a file or a directory interacts with multiple services (for example, FTP and NFS directory as an **rsync** domain).

### **rsync\_etc\_t**

This type is used for **rsync**-related files in the **/etc** directory.

## 23.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **rsync\_anon\_write**

Having this Boolean enabled allows **rsync** in the **rsync\_t** domain to manage files, links and directories that have a type of **public\_content\_rw\_t**. Often these are public files used for public file transfer services. Files and directories must be labeled this type.

### **rsync\_client**

Having this Boolean enabled allows **rsync** to initiate connections to ports defined as **rsync\_port\_t**, as well as allowing the daemon to manage files, links, and directories that have a type of **rsync\_data\_t**. Note that **rsync** must be in the **rsync\_t** domain in order for SELinux to enact its control over it. The configuration example in this chapter demonstrates **rsync** running in the **rsync\_t** domain.

### **rsync\_export\_all\_ro**

Having this Boolean enabled allows **rsync** in the **rsync\_t** domain to export NFS and CIFS volumes with read-only access to clients.



#### NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional **polycoreutils-devel** package providing the **sepolicy** utility is required for this command to work.

## 23.4. CONFIGURATION EXAMPLES

### 23.4.1. Rsync as a daemon

When using Red Hat Enterprise Linux, **rsync** can be used as a daemon so that multiple clients can directly communicate with it as a central server, in order to house centralized files and keep them synchronized. The following example will demonstrate running **rsync** as a daemon over a network socket

in the correct domain, and how SELinux expects this daemon to be running on a pre-defined (in SELinux policy) TCP port. This example will then show how to modify SELinux policy to allow the **rsync** daemon to run normally on a non-standard port.

This example will be performed on a single system to demonstrate SELinux policy and its control over local daemons and processes. Note that this is an example only and demonstrates how SELinux can affect rsync. Comprehensive documentation of rsync is beyond the scope of this document. See the official [rsync documentation](#) for further details. This example assumes that the `rsync`, `setroubleshoot-server` and `audit` packages are installed, that the SELinux targeted policy is used and that SELinux is running in enforcing mode.

### Procedure 23.1. Getting rsync to launch as `rsync_t`

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Run the **which** command to confirm that the `rsync` binary is in the system path:

```
~]$ which rsync
/usr/bin/rsync
```

3. When running `rsync` as a daemon, a configuration file should be used and saved as **/etc/rsyncd.conf**. Note that the following configuration file used in this example is very simple and is not indicative of all the possible options that are available, rather it is just enough to demonstrate the **rsync** daemon:

```
log file = /var/log/rsyncd.log
pid file = /var/run/rsyncd.pid
lock file = /var/run/rsyncd.lock
[files]
path = /srv/rsync
  comment = file area
  read only = false
  timeout = 300
```

4. Now that a simple configuration file exists for `rsync` to operate in daemon mode, you can start it by running the following command:

```
~]# systemctl start rsyncd.service
```

Ensure that **rsyncd** was successfully started (the output is supposed to look similar to the one below, only the time stamp will differ):

```
~]# systemctl status rsyncd.service
rsyncd.service - fast remote file copy program daemon
  Loaded: loaded (/usr/lib/systemd/system/rsyncd.service; disabled)
  Active: active (running) since Thu 2014-02-27 09:46:24 CET; 2s ago
  Main PID: 3220 (rsync)
  CGroup: /system.slice/rsyncd.service
          └─3220 /usr/bin/rsync --daemon --no-detach
```

-

SELinux can now enforce its protection mechanisms over the **rsync** daemon as it is now running in the **rsync\_t** domain:

```
~]$ ps -eZ | grep rsync
system_u:system_r:rsync_t:s0 3220 ? 00:00:00 rsync
```

This example demonstrated how to get **rsyncd** running in the **rsync\_t** domain. Rsync can also be run as a socket-activated service. In that case, the **rsyncd** is not executed until a client tries to connect to the service. To enable **rsyncd** to run as a socket-activated service, follow the steps above. To start **rsyncd** as a socket-activated service, enter the following command as root:

```
~]# systemctl start rsyncd.socket
```

The next example shows how to get this daemon successfully running on a non-default port. TCP port 10000 is used in the next example.

### Procedure 23.2. Running the rsync daemon on a non-default port

1. Modify the **/etc/rsyncd.conf** file and add the **port = 10000** line at the top of the file in the global configuration area (that is, before any file areas are defined). The new configuration file will look like:

```
log file = /var/log/rsyncd.log
pid file = /var/run/rsyncd.pid
lock file = /var/run/rsync.lock
port = 10000
[files]
    path = /srv/rsync
    comment = file area
    read only = false
    timeout = 300
```

2. After launching the **rsync** daemon with this new setting, a denial message similar to the following is logged by SELinux:

```
Jul 22 10:46:59 localhost setroubleshoot: SELinux is preventing the rsync (rsync_t) from
binding to port 10000. For complete SELinux messages, run sealert -l c371ab34-639e-45ae-
9e42-18855b5c2de8
```

3. Use the **semanage** utility to add TCP port 10000 to the SELinux policy in **rsync\_port\_t**:

```
~]# semanage port -a -t rsync_port_t -p tcp 10000
```

4. Now that TCP port 10000 has been added to the SELinux policy for **rsync\_port\_t**, **rsyncd** will start and operate normally on this port:

```
~]# systemctl start rsyncd.service
```

```
~]# netstat -lnp | grep 10000
tcp    0  0 0.0.0.0:10000 0.0.0.0:*  LISTEN  9910/rsync
```

SELinux has had its policy modified and is now permitting **rsyncd** to operate on TCP port 10000.

---

[20] See the [Rsync](#) project page for more information.

[21] See the `rsync_selinux(8)` manual page for more information about rsync and SELinux.

## CHAPTER 24. POSTFIX

Postfix is an open-source Mail Transport Agent (MTA), which supports protocols like LDAP, SMTP AUTH (SASL), and TLS.<sup>[22]</sup>

In Red Hat Enterprise Linux, the postfix package provides Postfix. Enter the following command to see if the postfix package is installed:

```
~]$ rpm -q postfix
package postfix is not installed
```

If it is not installed, use the **yum** utility root to install it:

```
~]# yum install postfix
```

### 24.1. POSTFIX AND SELINUX

When Postfix is enabled, it runs confined by default. Confined processes run in their own domains, and are separated from other confined processes. If a confined process is compromised by an attacker, depending on SELinux policy configuration, an attacker's access to resources and the possible damage they can do is limited. The following example demonstrates the Postfix and related processes running in their own domain. This example assumes the postfix package is installed and that the Postfix service has been started:

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Enter the following command as the root user to start **postfix**:

```
~]# systemctl start postfix.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]# systemctl status postfix.service
postfix.service - Postfix Mail Transport Agent
  Loaded: loaded (/usr/lib/systemd/system/postfix.service; disabled)
  Active: active (running) since Mon 2013-08-05 11:38:48 CEST; 3h 25min ago
```

3. Run following command to view the **postfix** processes:

```
~]$ ps -eZ | grep postfix
system_u:system_r:postfix_master_t:s0 1651 ? 00:00:00 master
system_u:system_r:postfix_pickup_t:s0 1662 ? 00:00:00 pickup
system_u:system_r:postfix_qmgr_t:s0 1663 ? 00:00:00 qmgr
```

In the output above, the SELinux context associated with the Postfix **master** process is **system\_u:system\_r:postfix\_master\_t:s0**. The second last part of the context,

**postfix\_master\_t**, is the type for this process. A type defines a domain for processes and a type for files. In this case, the **master** process is running in the **postfix\_master\_t** domain.

## 24.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with Postfix. Different types allow you to configure flexible access:

### **postfix\_etc\_t**

This type is used for configuration files for Postfix in the **/etc/postfix/** directory.

### **postfix\_data\_t**

This type is used for Postfix data files in the **/var/lib/postfix/** directory.

### **postfix\_var\_run\_t**

This type is used for Postfix files stored in the **/run/** directory.

### **postfix\_initrc\_exec\_t**

The Postfix executable files are labeled with the **postfix\_initrc\_exec\_t** type. When executed, they transition to the **postfix\_initrc\_t** domain.

### **postfix\_spool\_t**

This type is used for Postfix files stored in the **/var/spool/** directory.



#### NOTE

To see the full list of files and their types for Postfix, enter the following command:

```
~]$ grep postfix /etc/selinux/targeted/contexts/files/file_contexts
```

## 24.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **postfix\_local\_write\_mail\_spool**

Having this Boolean enabled allows Postfix to write to the local mail spool on the system. Postfix requires this Boolean to be enabled for normal operation when local spools are used.



## NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sestatus booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## 24.4. CONFIGURATION EXAMPLES

### 24.4.1. SpamAssassin and Postfix

SpamAssassin is an open-source mail filter that provides a way to filter unsolicited email (spam messages) from incoming email.<sup>[23]</sup>

When using Red Hat Enterprise Linux, the `spamassassin` package provides SpamAssassin. Enter the following command to see if the `spamassassin` package is installed:

```
~]$ rpm -q spamassassin
package spamassassin is not installed
```

If it is not installed, use the **yum** utility as root to install it:

```
~]# yum install spamassassin
```

SpamAssassin operates in tandem with a mailer such as Postfix to provide spam-filtering capabilities. In order for SpamAssassin to effectively intercept, analyze and filter mail, it must listen on a network interface. The default port for SpamAssassin is TCP/783, however this can be changed. The following example provides a real-world demonstration of how SELinux complements SpamAssassin by only allowing it access to a certain port by default. This example will then demonstrate how to change the port and have SpamAssassin operate on a non-default port.

Note that this is an example only and demonstrates how SELinux can affect a simple configuration of SpamAssassin. Comprehensive documentation of SpamAssassin is beyond the scope of this document. See the official [SpamAssassin documentation](#) for further details. This example assumes the `spamassassin` is installed, that any firewall has been configured to allow access on the ports in use, that the SELinux targeted policy is used, and that SELinux is running in enforcing mode:

#### Procedure 24.1. Running SpamAssassin on a non-default port

1. Use the **semanage** utility as root to show the port that SELinux allows the **spamd** daemon to listen on by default:

```
~]# semanage port -l | grep spamd
spamd_port_t tcp 783
```

This output shows that TCP/783 is defined in **spamd\_port\_t** as the port for SpamAssassin to operate on.

2. Edit the **/etc/sysconfig/spamassassin** configuration file and modify it so that it will start SpamAssassin on the example port TCP/10000:

```
# Options to spamd
SPAMDOPTIONS="-d -p 10000 -c m5 -H"
```

This line now specifies that SpamAssassin will operate on port 10000. The rest of this example will show how to modify the SELinux policy to allow this socket to be opened.

3. Start SpamAssassin and an error message similar to the following will appear:

```
~]# systemctl start spamassassin.service
Job for spamassassin.service failed. See 'systemctl status spamassassin.service' and
'journalctl -xn' for details.
```

This output means that SELinux has blocked access to this port.

4. A denial message similar to the following will be logged by SELinux:

```
SELinux is preventing the spamd (spamd_t) from binding to port 10000.
```

5. As root, run **semanage** to modify the SELinux policy in order to allow SpamAssassin to operate on the example port (TCP/10000):

```
~]# semanage port -a -t spamd_port_t -p tcp 10000
```

6. Confirm that SpamAssassin will now start and is operating on TCP port 10000:

```
~]# systemctl start spamassassin.service

~]# netstat -lnp | grep 10000
tcp 0 0 127.0.0.1:10000 0.0.0.0:* LISTEN 2224/spamd.pid
```

7. At this point, **spamd** is properly operating on TCP port 10000 as it has been allowed access to that port by the SELinux policy.

---

[22] For more information, see the *Postfix* section in the [System Administrator's Guide](#).

[23] For more information, see the *Spam Filters* section in the [System Administrator's Guide](#).

## CHAPTER 25. DHCP

The **dhcpcd** daemon is used in Red Hat Enterprise Linux to dynamically deliver and configure Layer 3 TCP/IP details for clients.

The `dhcp` package provides the DHCP server and the **dhcpcd** daemon. Enter the following command to see if the `dhcp` package is installed:

```
~]# rpm -q dhcp
package dhcp is not installed
```

If it is not installed, use the **yum** utility as root to install it:

```
~]# yum install dhcp
```

### 25.1. DHCP AND SELINUX

When **dhcpcd** is enabled, it runs confined by default. Confined processes run in their own domains, and are separated from other confined processes. If a confined process is compromised by an attacker, depending on SELinux policy configuration, an attacker's access to resources and the possible damage they can do is limited. The following example demonstrates **dhcpcd** and related processes running in their own domain. This example assumes the `dhcp` package is installed and that the **dhcpcd** service has been started:

1. Run the **getenforce** command to confirm SELinux is running in enforcing mode:

```
~]$ getenforce
Enforcing
```

The command returns **Enforcing** when SELinux is running in enforcing mode.

2. Enter the following command as the root user to start **dhcpcd**:

```
~]# systemctl start dhcpcd.service
```

Confirm that the service is running. The output should include the information below (only the time stamp will differ):

```
~]# systemctl status dhcpcd.service
dhcpcd.service - DHCPv4 Server Daemon
  Loaded: loaded (/usr/lib/systemd/system/dhcpcd.service; disabled)
  Active: active (running) since Mon 2013-08-05 11:49:07 CEST; 3h 20min ago
```

3. Run following command to view the **dhcpcd** processes:

```
~]$ ps -eZ | grep dhcpcd
system_u:system_r:dhcpcd_t:s0 5483 ?        00:00:00 dhcpcd
```

The SELinux context associated with the `dhcpcd` process is **system\_u:system\_r:dhcpcd\_t:s0**.

### 25.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with DHCP:

#### **dhcp\_etc\_t**

This type is mainly used for files in the **/etc** directory, including configuration files.

#### **dhcpd\_var\_run\_t**

This type is used for the PID file for **dhcpd**, in the **/var/run/** directory.

#### **dhcpd\_exec\_t**

This type is used for transition of DHCP executable files to the **dhcpd\_t** domain.

#### **dhcpd\_initrc\_exec\_t**

This type is used for transition of DHCP executable files to the **dhcpd\_initrc\_t** domain.



#### **NOTE**

To see the full list of files and their types for **dhcpd**, enter the following command:

```
~]$ grep dhcp /etc/selinux/targeted/contexts/files/file_contexts
```

## CHAPTER 26. OPENSIFT BY RED HAT

OpenShift by Red Hat is a Platform as a Service (PaaS) that enables developers to build and deploy web applications. OpenShift provides a wide selection of programming languages and frameworks including Java, Ruby, and PHP. It also provides integrated developer tools to support the application life cycle, including Eclipse integration, JBoss Developer Studio, and Jenkins. OpenShift uses an open source ecosystem to provide a platform for mobile applications, database services, and more. [24]

In Red Hat Enterprise Linux, the `rhc` package provides the OpenShift client tools. Enter the following command to see if it is installed:

```
~]$ rpm -q rhc
package rhc is not installed
```

If `rhc` is not installed, see the [OpenShift Enterprise Client Tools Installation Guide](#) and [OpenShift Online Client Tools Installation Guide](#) for detailed information on the OpenShift client tools installation process.

### 26.1. OPENSIFT AND SELINUX

SELinux provides better security control over applications that use OpenShift because all processes are labeled according to the SELinux policy. Therefore, SELinux protects OpenShift from possible malicious attacks within different gears running on the same node.

See the [Dan Walsh's presentation](#) for more information about SELinux and OpenShift.

### 26.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with OpenShift. Different types allow you to configure flexible access:

#### Process types

##### **openshift\_t**

The OpenShift process is associated with the **openshift\_t** SELinux type.

#### Types on executables

##### **openshift\_cgroup\_read\_exec\_t**

SELinux allows files with this type to transition an executable to the **openshift\_cgroup\_read\_t** domain.

##### **openshift\_cron\_exec\_t**

SELinux allows files with this type to transition an executable to the **openshift\_cron\_t** domain.

##### **openshift\_initrc\_exec\_t**

SELinux allows files with this type to transition an executable to the **openshift\_initrc\_t** domain.

## Writable types

### **openshift\_cgroup\_read\_tmp\_t**

This type allows OpenShift control groups (cgroup) read and access temporary files in the **/tmp** directory.

### **openshift\_cron\_tmp\_t**

This type allows storing temporary files of the OpenShift cron jobs in **/tmp**.

### **openshift\_initrc\_tmp\_t**

This type allows storing the OpenShift **initrc** temporary files in **/tmp**.

### **openshift\_log\_t**

Files with this type are treated as OpenShift log data, usually stored under the **/var/log/** directory.

### **openshift\_rw\_file\_t**

OpenShift have permission to read and to write to files labeled with this type.

### **openshift\_tmp\_t**

This type is used for storing the OpenShift temporary files in **/tmp**.

### **openshift\_tmpfs\_t**

This type allows storing the OpenShift data on a tmpfs file system.

### **openshift\_var\_lib\_t**

This type allows storing the OpenShift files in the **/var/lib/** directory.

### **openshift\_var\_run\_t**

This type allows storing the OpenShift files in the **/run/** or **/var/run/** directory.

## 26.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **openshift\_use\_nfs**

Having this Boolean enabled allows installing OpenShift on an NFS share.



## NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## 26.4. CONFIGURATION EXAMPLES

### 26.4.1. Changing the Default OpenShift Directory

By default, OpenShift stores its data in the `/var/lib/openshift/` directory, which is labeled with the **openshift\_var\_lib\_t** SELinux type. To allow OpenShift to store data in a different directory, label the new directory with the proper SELinux context.

The following procedure shows how to change the default OpenShift directory for storing data to `/srv/openshift/`:

#### Procedure 26.1. Changing the Default OpenShift Directory for Storing Data

1. As root, create a new **openshift/** directory within the `/srv` directory. The new directory is labeled with the **var\_t** type:

```
~]# mkdir /srv/openshift
```

```
~]$ ls -Zd /srv/openshift
drwxr-xr-x. root root unconfined_u:object_r:var_t:s0 openshift/
```

2. As root, use the **semanage** utility to map `/srv/openshift/` to the proper SELinux context:

```
~]# semanage fcontext -a -e /var/lib/openshift /srv/openshift
```

3. Then, use the **restorecon** utility as root to apply the changes:

```
~]# restorecon -R -v /srv/openshift
```

4. The `/srv/openshift/` directory is now labeled with the correct **openshift\_var\_lib\_t** type:

```
~]$ ls -Zd /srv/openshift
drwxr-xr-x. root root unconfined_u:object_r:openshift_var_lib_t:s0 openshift/
```

[24] To learn more about OpenShift, see [Product Documentation for OpenShift Container Platform](#) and [Product Documentation for OpenShift Online](#).

## CHAPTER 27. IDENTITY MANAGEMENT

Identity Management (IdM) provides a unifying environment for standards-defined, common network services, including PAM, LDAP, Kerberos, DNS, NTP, and certificate services. IdM allows Red Hat Enterprise Linux systems to serve as domain controllers.<sup>[25]</sup>

In Red Hat Enterprise Linux, the `ipa-server` package provides the IdM server. Enter the following command to see if the `ipa-server` package is installed:

```
~]$ rpm -q ipa-server
package ipa-server is not installed
```

If it is not installed, enter the following command as the root user to install it:

```
~]# yum install ipa-server
```

### 27.1. IDENTITY MANAGEMENT AND SELINUX

Identity Management can map IdM users to configured SELinux roles per host so that it is possible to specify SELinux context for IdM access rights. During the user login process, the System Security Services Daemon (**SSSD**) queries the access rights defined for a particular IdM user. Then the **pam\_selinux** module sends a request to the kernel to launch the user process with the proper SELinux context according to the IdM access rights, for example **guest\_u:guest\_r:guest\_t:s0**.

For more information about Identity Management and SELinux, see the [Linux Domain, Identity, Authentication, and Policy Guide](#) for Red Hat Enterprise Linux 7.

#### 27.1.1. Trust to Active Directory Domains

In previous versions of Red Hat Enterprise Linux, Identity Management used the **WinSync** utility to allow users from Active Directory (AD) domains to access data stored on IdM domains. To do that, **WinSync** had to replicate the user and group data from the AD server to the local server and kept the data synchronized.

In Red Hat Enterprise Linux 7, the **SSSD** daemon has been enhanced to work with AD and users are able to create a trusted relationship between IdM and AD domains. The user and group data are read directly from the AD server. Additionally, Kerberos cross-realm trust allowing single sign-on (SSO) authentication between the AD and IdM domains is provided. If SSO is set, users from the AD domains can access data protected by Kerberos that is stored on the IdM domains without requiring a password.

This feature is not installed by default. To use it, install the additional `ipa-server-trust-ad` package.

### 27.2. CONFIGURATION EXAMPLES

#### 27.2.1. Mapping SELinux users to IdM users

The following procedure shows how to create a new SELinux mapping and how to add a new IdM user to this mapping.

##### Procedure 27.1. How to Add a User to an SELinux Mapping

1. To create a new SELinux mapping, enter the following command where **SELinux\_mapping** is the name of the new SELinux mapping and the **--selinuxuser** option specifies a particular SELinux user:

```
~]$ ipa selinuxusermap-add SELinux_mapping --selinuxuser=staff_u:s0-s0:c0.c1023
```

2. Enter the following command to add an IdM user with the **tuser** user name to the SELinux mapping:

```
~]$ ipa selinuxusermap-add-user --users=tuser SELinux_mapping
```

3. To add a new host named **ipaclient.example.com** to the SELinux mapping, enter the following command:

```
~]$ ipa selinuxusermap-add-host --hosts=ipaclient.example.com SELinux_mapping
```

4. The **tuser** user gets the **staff\_u:s0-s0:c0.c1023** label when logged in to the *ipaclient.example.com* host:

```
[tuser@ipa-client]$ id -Z  
staff_u:staff_r:staff_t:s0-s0:c0.c1023
```

---

[25] For more information about Identity Management, see the [Linux Domain, Identity, Authentication, and Policy Guide](#) for Red Hat Enterprise Linux 7.

## CHAPTER 28. RED HAT GLUSTER STORAGE

*Red Hat Gluster Storage* provides flexible and affordable unstructured data storage for the enterprise. *GlusterFS*, a key building block of Gluster, is based on a stackable user-space design and aggregates various storage servers over a network and interconnects them into one large parallel network file system. The POSIX-compatible GlusterFS servers, which use the XFS file system format to store data on disks, can be accessed using industry standard access protocols including NFS and CIFS.

See the [Product Documentation for Red Hat Gluster Storage](#) collection of guides for more information.

The `glusterfs-server` package provides Red Hat Gluster Storage. For detailed information about its installation process, see the [Installation Guide](#) for Red Hat Gluster Storage.

### 28.1. RED HAT GLUSTER STORAGE AND SELINUX

When enabled, SELinux serves as an additional security layer by providing flexible mandatory access control for the **glusterd** (GlusterFS Management Service) and **glusterfsd** (NFS server) processes as a part of Red Hat Gluster Storage. These processes have advanced process isolation unbounded with the **glusterd\_t** SELinux type.

### 28.2. TYPES

The main permission control method used in SELinux targeted policy to provide advanced process isolation is Type Enforcement. All files and processes are labeled with a type: types define a SELinux domain for processes and a SELinux type for files. SELinux policy rules define how types access each other, whether it be a domain accessing a type, or a domain accessing another domain. Access is only allowed if a specific SELinux policy rule exists that allows it.

The following types are used with Red Hat Gluster Storage. Different types allow you to configure flexible access:

#### Process types

##### **glusterd\_t**

The Gluster processes are associated with the **glusterd\_t** SELinux type.

#### Types on executables

##### **glusterd\_initrc\_exec\_t**

The SELinux-specific script type context for the Gluster init script files.

##### **glusterd\_exec\_t**

The SELinux-specific executable type context for the Gluster executable files.

#### Port Types

##### **gluster\_port\_t**

This type is defined for **glusterd**. By default, **glusterd** uses 204007-24027, and 38465-38469 TCP ports.

## File Contexts

### **glusterd\_brick\_t**

This type is used for files treated as **glusterd** brick data.

### **glusterd\_conf\_t**

This type is associated with the **glusterd** configuration data, usually stored in the **/etc** directory.

### **glusterd\_log\_t**

Files with this type are treated as **glusterd** log data, usually stored under the **/var/log/** directory.

### **glusterd\_tmp\_t**

This type is used for storing the **glusterd** temporary files in the **/tmp** directory.

### **glusterd\_var\_lib\_t**

This type allows storing the **glusterd** files in the **/var/lib/** directory.

### **glusterd\_var\_run\_t**

This type allows storing the **glusterd** files in the **/run/** or **/var/run/** directory.

## 28.3. BOOLEANS

SELinux is based on the least level of access required for a service to run. Services can be run in a variety of ways; therefore, you need to specify how you run your services. Use the following Booleans to set up SELinux:

### **gluster\_export\_all\_ro**

Having this Boolean enabled allows **glusterfsd** to share files and directory as read-only. This Boolean is disabled by default.

### **gluster\_export\_all\_rw**

Having this Boolean enabled allows **glusterfsd** to share files and directories with read and write access. This Boolean is enabled by default.

### **gluster\_anon\_write**

Having this Boolean enabled allows **glusterfsd** to modify public files labeled with the **public\_content\_rw\_t** SELinux type.



## NOTE

Due to the continuous development of the SELinux policy, the list above might not contain all Booleans related to the service at all times. To list them, enter the following command:

```
~]$ getsebool -a | grep service_name
```

Enter the following command to view description of a particular Boolean:

```
~]$ sepolicy booleans -b boolean_name
```

Note that the additional `policycoreutils-devel` package providing the **sepolicy** utility is required for this command to work.

## 28.4. CONFIGURATION EXAMPLES

### 28.4.1. Labeling Gluster Bricks

A Gluster brick is an export directory on a server in the trusted storage pool. In case that the brick is not labeled with the correct SELinux context, **glusterd\_brick\_t**, SELinux denies certain file access operations and generates various AVC messages.

The following procedure shows how to label Gluster bricks with the correct SELinux context. The procedure assumes that you previously created and formatted a logical volume, for example **/dev/rhgs/gluster**, to be used as the Gluster brick.

For detailed information about Gluster bricks, see the [Red Hat Gluster Storage Volumes](#) chapter in the [Administration Guide](#) for Red Hat Gluster Storage.

#### Procedure 28.1. How to Label a Gluster Brick

1. Create a directory to mount the previously formatted logical volume. For example:

```
~]# mkdir /mnt/brick1
```

2. Mount the logical volume, in this case **/dev/vg-group/gluster**, to the **/mnt/brick1/** directory created in the previous step.

```
~]# mount /dev/vg-group/gluster /mnt/brick1/
```

Note that the **mount** command mounts devices only temporarily. To mount the device permanently, add an entry similar as the following one to the **/etc/fstab** file:

```
/dev/vg-group/gluster /mnt/brick1 xfs rw,inode64,noatime,nouuid 1 2
```

For more information, see the `fstab(5)` manual page.

3. Check the SELinux context of **/mnt/brick1/**:

```
~]$ ls -lZd /mnt/brick1/
drwxr-xr-x. root root system_u:object_r:unlabeled_t:s0 /mnt/brick1/
```

The directory is labeled with the **unlabeled\_t** SELinux type.

4. Change the SELinux type of **/mnt/brick1/** to the **glusterd\_brick\_t** SELinux type:

```
~]# semanage fcontext -a -t glusterd_brick_t "/mnt/brick1(/.*)?"
```

5. Use the **restorecon** utility to apply the changes:

```
~]# restorecon -Rv /mnt/brick1
```

6. Finally, verify that the context has been successfully changed:

```
~]$ ls -lZd /mnt/brick1
drwxr-xr-x. root root system_u:object_r:glusterd_brick_t:s0 /mnt/brick1/
```

## CHAPTER 29. REFERENCES

The following references are pointers to additional information that is relevant to SELinux but beyond the scope of this guide. Note that due to the rapid development of SELinux, some of this material may only apply to specific releases of Red Hat Enterprise Linux.

### Books

#### SELinux by Example

Mayer, MacMillan, and Caplan

Prentice Hall, 2007

#### SELinux: NSA's Open Source Security Enhanced Linux

Bill McCarty

O'Reilly Media Inc., 2004

### Tutorials and Help

#### Tutorials and talks from Russell Coker

<http://www.coker.com.au/selinux/talks/ibmtu-2004/>

#### Dan Walsh's Journal

<http://danwalsh.livejournal.com/>

#### Red Hat Knowledgebase

<https://access.redhat.com/site/>

### General Information

#### NSA SELinux main website

<https://www.nsa.gov/What-We-Do/Research/SELinux/>

#### NSA SELinux FAQ

<https://www.nsa.gov/What-We-Do/Research/SELinux/FAQs/>

### Mailing Lists

#### NSA SELinux mailing list

<https://www.nsa.gov/What-We-Do/Research/SELinux/Mailing-List/>

#### Fedora SELinux mailing list

<http://www.redhat.com/mailman/listinfo/fedora-selinux-list>

### Community

**SELinux Project Wiki**

[http://selinuxproject.org/page/Main\\_Page](http://selinuxproject.org/page/Main_Page)

**SELinux community page**

<http://selinux.sourceforge.net/>

**IRC**

irc.freenode.net, #selinux

## APPENDIX A. REVISION HISTORY

<b>Revision 0.3-06</b> Version for 7.7 GA publication.	<b>Fri Aug 9 2019</b>	<b>Mirek Jahoda</b>
<b>Revision 0.3-05</b> Version for 7.6 GA publication.	<b>Sat Oct 20 2018</b>	<b>Mirek Jahoda</b>
<b>Revision 0.3-03</b> Version for 7.5 GA publication.	<b>Tue Apr 3 2018</b>	<b>Mirek Jahoda</b>
<b>Revision 0.3-01</b> Version for 7.4 GA publication.	<b>Thu Jul 13 2017</b>	<b>Mirek Jahoda</b>
<b>Revision 0.2-18</b> Version for 7.3 GA publication.	<b>Wed Nov 2 2016</b>	<b>Mirek Jahoda</b>
<b>Revision 0.2-11</b> Async release with fixes.	<b>Sun Jun 26 2016</b>	<b>Mirek Jahoda</b>
<b>Revision 0.2-10</b> Async release with fixes.	<b>Sun Feb 14 2016</b>	<b>Robert Krátký</b>
<b>Revision 0.2-9</b> Added the Red Hat Gluster Storage chapter.	<b>Thu Dec 10 2015</b>	<b>Barbora Ančincová</b>
<b>Revision 0.2-8</b> Red Hat Enterprise Linux 7.2 GA release of the book.	<b>Thu Nov 11 2015</b>	<b>Barbora Ančincová</b>
<b>Revision 0.2-7</b> Red Hat Enterprise Linux 7.2 Beta release of the book.	<b>Thu Aug 13 2015</b>	<b>Barbora Ančincová</b>
<b>Revision 0.2-6</b> Red Hat Enterprise Linux 7.1 GA release of the book.	<b>Wed Feb 18 2015</b>	<b>Barbora Ančincová</b>
<b>Revision 0.2-5</b> Update to sort order on the Red Hat Customer Portal.	<b>Fri Dec 05 2014</b>	<b>Barbora Ančincová</b>
<b>Revision 0.2-4</b> Red Hat Enterprise Linux 7.1 Beta release of the book.	<b>Thu Dec 04 2014</b>	<b>Barbora Ančincová</b>
<b>Revision 0.1-41</b> Rebuild for style changes.	<b>Tue May 20 2014</b>	<b>Tomáš Čapek</b>
<b>Revision 0.1-1</b> Initial creation of the book for Red Hat Enterprise Linux 7	<b>Tue Jan 17 2013</b>	<b>Tomáš Čapek</b>