SUSE

Understanding SELinux Basics

WHAT?

This article provides basic information about Security-Enhanced Linux.

WHY?

You want to understand SELinux and how to configure it on SUSE Linux Enterprise Micro.

EFFORT

It takes approximately 40 minutes to read this article.

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Contents

1 About SELinux

SELinux was developed as an additional Linux security solution that uses the security framework in the Linux kernel. The purpose was to allow for a more granular security policy that goes beyond the standard Discretionary Access Controls (DAC), the traditional file permissions of owner/group/world, and read/write/execute.

SELinux uses labels attached to objects (for example, files and network sockets) to make access control decisions.

The default action of SELinux is to deny any access. SELinux allows only actions that were specifically allowed in the SELinux policy. Another feature of SELinux that increases security is that SELinux allows strict confinement of processes up to the point where the processes cannot access files of other processes on the same system.

SELinux was designed to enhance existing security solutions, not to replace them. For example, discretionary access control (DAC) is still applied, even if the system is using SELinux. If DAC denies access first, SELinux is then not used as the access was already blocked by another mechanism.

2 Getting SELinux

SELinux is installed by default when installing SLE Micro by YaST or is part of the pre-built images.

If SELinux is not set up on your system, run the following command:

```
# transactional-update setup-selinux
```

Reboot your system after the command has finished. The command installs the SELinux policy if it is not installed, sets the `enforcing` SELinux mode and rebuilds `initrd`.

3 SELinux modes

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

Using the `disabled` mode means that no rules from the SELinux policy are applied and your system is not protected. Therefore, we do not recommend using the `disabled` mode.

In the `permissive` mode, SELinux is active, the security policy is loaded, the file system is labeled and access denial entries are logged. However, the policy is not enforced and thus no access is actually denied.

In the `enforced` mode, the security policy is applied. Each access that is not explicitly allowed by the policy is denied.

For information about switching between SELinux modes, refer to *Section 3.1, "Changing the SELinux mode"*.

3.1 Changing the SELinux mode

You can switch the SELinux mode temporarily or permanently.

3.1.1 Changing the SELinux mode temporarily

To set SELinux to the `permissive` or `enforcing` mode temporarily, use the command **`setenforce`**.

The **`setenforce`** command has the following syntax:

```
# setenforce MODE_ID
```

where *`MODE_ID`* is *`0`* for the `permissive` mode or *`1`* for the `enforced` mode.

Remember that you cannot disable SELinux using the **`setenforce`** command.

3.1.2 Changing the SELinux mode permanently

To perform changes to the SELinux mode that persists rebooting of the system, edit the `/etc/selinux/config` configuration file. In this file, you can also disable SELinux on your system. However, this action is not recommended. If SELinux is possibly causing issues to your system, switch to the `permissive` mode instead and debug your system.

In the file `/etc/selinux/config`, change the value of `SELINUX` to `disabled`, or `permissive`, or `enforced` as follows:

```
SELINUX=disabled
```

The changes in the file are applied after the next reboot.

Note: Relabeling your system after switching from the `disabled` mode

If you disable SELinux on your system and then enable it later, make sure that you relabel your system. When SELinux is disabled and you perform changes to your file system, the changes are not reflected in the context anymore (for example, new files do not have any context). Therefore, you need to relabel your system by using the **`restorecon`** command, using the `autorelabel` boot parameter, or by creating a file that will trigger relabeling on the next boot. To create the file, run the following command:

```
# touch /etc/selinux/.autorelabel
```

After reboot, the file `/etc/selinux/.autorelabel` is replaced with another flag file, `/etc/selinux/.relabelled`, to prevent relabeling on subsequent reboots.

3.1.3 Verifying the active SELinux mode

To verify the mode, run the following command:

```
# getenforce
```

The command should return `permissive` or `enforced`, depending on the provided *`MODE_ID`*.

3.2 Verifying that SELinux is functional

If you are performing configuration changes, it may be useful to switch to permissive mode. During this time, users might label files incorrectly, and thus cause problems when switching back to enforcing mode.

To return the system back to its secured state, perform the following steps:

1. Reset the security context:

   ```
   > sudo restorecon -R /
   ```

2. Switch to enforcing mode by setting `SELINUX=enforcing` in the `/etc/selinux/config`.

3. Reboot the system and log in again.

4. Run the `sestatus -v` command. It should give you an output similar to the following one:

```
> sudo sestatus -v
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
Memory protection checking:     requested(insecure)
Max kernel policy version:      33

Process contexts:
Current context:                unconfined_u:unconfined_r:unconfined_t:s0-
s0:c0.c1023
Init context:                   system_u:system_r:init_t:s0
/usr/sbin/sshd                  system_u:system_r:sshd_t:s0-s0:c0.c1023

File contexts:
Controlling terminal:           unconfined_u:object_r:user_tty_device_t:s0
/etc/passwd                     system_u:object_r:passwd_file_t:s0
/etc/shadow                     system_u:object_r:shadow_t:s0
/bin/bash                       system_u:object_r:shell_exec_t:s0 \
                                -> system_u:object_r:shell_exec_t:s0
/bin/login                      system_u:object_r:login_exec_t:s0
/bin/sh                         system_u:object_r:bin_t:s0 \
                                -> system_u:object_r:shell_exec_t:s0
/sbin/agetty                    system_u:object_r:bin_t:s0 \
                                -> system_u:object_r:getty_exec_t:s0
/sbin/init                      system_u:object_r:bin_t:s0 -> \
                                system_u:object_r:init_exec_t:s0
/usr/sbin/sshd                  system_u:object_r:sshd_exec_t:s0
```

5. If the system is not working properly, check the log files in `/var/log/audit/audit.log`. For more details, refer to SELinux troubleshooting (https://documentation.suse.com/sle-micro/6.0/html/Micro-setroubleshoot/setroubleshoot.html).

4 SELinux security context

The security context is a set of information assigned to a file or a process. It consists of SELinux user, role, type, level and category. This information is used to make access control decisions.

SELinux user

An identity defined in the policy that is authorized for a specific set of roles and for a specific *level* range. Each Linux user is mapped to only one SELinux user. However, one SELinux user can have several roles.

SELinux does not use the list of user accounts maintained by Linux in `/etc/passwd`, but uses its own database and mapping. By convention, the identity name is suffixed with `_u`, for example, `user_u`.

When a new Linux account is created and the SELinux user is not assigned to the account, the default SELinux user is used. Usually, the default value is `unconfined_u`. For a procedure on how to change the default value, refer to *Section 7.5.2, "The* **`semanage login`** *command"*.

role

Defines a set of permissions that a user can be granted. A role defines which *types* a user assigned to this role can access. By convention, the role name is suffixed with `_r`, for example, `system_r`.

type

The type conveys information on how particular files and processes can interact. A process consists of files with a concrete SELinux type, and it cannot access files outside of this type. By convention, the type name is suffixed with `_t`, for example, `var_t`.

level

An optional attribute that specifies the range of levels of clearance in the multilevel security.

category

An optional attribute that allows you to add categories to processes, files and users. A user can then access files that have the same category.

Here is an example of an SELinux context:

```
allow user_t bin_t:file {read execute gettattr};
```

This example rule states that the user who has the context type `user_t` (this user is called the source object) is allowed to access objects of the class *file* with the context type `bin_t` (the target), using the permissions `read`, `execute` and `getattr`.

5 SELinux policy overview

The policy is the key component in SELinux. Your SELinux policy defines rules that specify which objects can access which files, directories, ports and processes on a system. To do this, a security context is defined for all of these.

An SELinux policy contains a huge number of rules. To make it more manageable, policies are often split into modules. This allows the administrator to switch protection on or off for different parts of the system.

When compiling the policy for your system, you will have a choice to either work with a modular policy, or a monolithic policy, where one huge policy is used to protect everything on your system. We strongly recommend using a modular policy and not a monolithic policy. Modular policies are much easier to manage.

SLE Micro is shipped with the `targeted` SELinux policy.

5.1 Working with SELinux modules

As an administrator, you can switch modules on or off. This can be useful if you want to disable only a part of the SELinux policy and you do not want to run a specific service without SELinux protection.

To view all SELinux policy modules in use, run the command:

```
semodule -l
```

After you get the name of the module you want to switch off, run the command:

```
> sudo semodule -d MODULENAME
```

To switch on the policy module, run the command:

```
> sudo semodule -e MODULENAME
```

5.2 Creating policies for containers

SLE Micro is delivered with a policy that, by default, does not allow containers to access files outside the container data. On the other hand, all network access is allowed. Typically, containers are created with bind mounts and should be able to access other directories, like `/home` or `/var`. You may want a possibility to allow access to these directories or, on the contrary,

restrict some ports to the container even if SELinux is used on your system. In this case, you need to create new policy rules that enable or disable the access. SLE Micro provides the Udica tool for this purpose.

The following procedure describes how to create a custom policy for your containers:

1. Make sure that SELinux is in the enforcing mode. For details, refer to *Section 3.1, "Changing the SELinux mode"*.
2. Start a container using the following parameters:

   ```
   # podman run -v /home:/home:rw -v /var/:/var/:rw -p 21:21 -it sle15 bash
   ```

   The container runs with the default policy that does not allow access to the mount points but does not restrict other ports.
3. You can exit the container.
4. Obtain the container ID:

   ```
   # podman ps -a

   CONTAINER ID  IMAGE
                COMMAND     CREATED        STATUS            PORTS               NAMES
   e59f9d0f86f2  registry.opensuse.org/devel/bci/tumbleweed/containerfile/opensuse/
   bci/ruby:latest  /bin/bash   8 minutes ago  Up 8 seconds ago  0.0.0.0:21->21/tcp
    zen_ramanujan
   ```
5. Create a JSON file that Udica will use to create a custom policy for the container:

   ```
   # podman inspect e59f9d0f86f2 > OUTPUT_JSON_FILE
   ```

   For example, substitute *`OUTPUT_JSON_FILE`* with `container.json`.
6. Run Udica to generate a policy according to the container parameters:

   ```
   # udica -j OUTPUT_JSON_FILE  CUSTOM_CONTAINER_POLICY
   ```

   For example:

   ```
   # udica -j container.json custom_policy
   ```
7. According to the provided instructions, load the policy modules by running:

   ```
   # semodule -i custom_policy.cil /usr/share/udica/templates/
   {base_container.cil,net_container.cil,home_container.cil}
   ```

8. Run a container with the new policy module by using the `--security-opt` option as follows:

```
# podman run --security-opt label=type:custom_policy.process -v /home:/home:rw -v /
var/:/var/:rw -p 21:21 -it sle15 bash
```

6 SELinux Booleans

SELinux Booleans support a flexible policy management approach. For example, Booleans enable you to disable a particular policy on one server, while keeping the same policy active on another one. In other words, a Boolean can be understood as a switch for a policy rule. Instead of changing a particular policy, you can switch it off. In the policy code, Booleans are called a *tunable*. Because Booleans are included in the policy, they are available as soon as a policy is loaded.

The changes to the Booleans value may be persistent or temporary, lasting until the end of the session.

SELinux offers tools that enable you to list and view details or change the state of Booleans. See the following sections for details.

6.1 Working with Booleans

6.1.1 Listing Booleans

You can use the **`getsebool`** or **`semanage`** command to list currently defined Booleans. To list all currently defined Booleans, along with their state, run the following command:

```
# getsebool -a

abrt_anon_write --> off
abrt_handle_event --> off
abrt_upload_watch_anon_write --> on
...
```

To get more details about particular Booleans, you can use the **`semanage`** command as follows:

```
# semanage boolean -l
```

```
SELinux boolean                State   Default     Description

abrt_anon_write                (off  ,  off)       Allow abrt to anon write
abrt_handle_event              (off  ,  off)       Allow abrt to handle event
abrt_upload_watch_anon_write   (on   ,   on)       Allow abrt to upload watch anon write
```

To get the status of an individual Boolean, you can use the following command:

```
# getsebool BOOLEAN_NAME
```

Alternatively, you can just use the **`grep`** command on the **`semanage boolean`** output:

```
# semanage boolean -l | grep BOOLEAN_NAME
```

6.1.2 Toggling Booleans

The commands **`setsebool`** and **`semanage`** can be used to toggle the value of Booleans. You can change the Boolean status persistently or just temporarily until the session ends. To change a Boolean value temporarily, run the following command:

```
# setsebool BOOLEAN_NAME BOOLEAN_VALUE
```

where *`BOOLEAN_VALUE`* is either `on` or `off`.

To change a Boolean value persistently, run one of the following two commands:

```
# setsebool -P BOOLEAN_NAME BOOLEAN_VALUE
```

Alternatively, using the **`semanage`** command:

```
# semanage boolean -m --BOOLEAN_VALUE  BOOLEAN_NAME
```

where *`BOOLEAN_VALUE`* is either `on` or `off`.

A single Boolean can enable or disable several policy rules. To see which policy rules are enabled or disabled by specific Booleans, use the **`sedispol`** tool to analyze the policy file:

```
# sedispol /etc/selinux/targeted/policy/policy.32
```

As the policy rules are usually huge, we recommend setting an output file by selecting the `f` and specifying a file name. After specifying the file name, press `6`. Then you can inspect the file.

7 Tools for managing SELinux

SLE Micro provides you with tools to manage SELinux on your system. If the below described tools are not installed on your system, install the tools by running:

```
# transactional-update pkg install policycoreutils-python-utils
```

After successful installation, reboot the system.

7.1 Using the Z option

Where SELinux is installed and configured, you can use the `-Z` to regular commands like **`ls`**, **`id`** or **`ps`**. Using this option, you can display the security context of files or processes. For example, with the **`ls`** command:

```
> ls -Z /etc/shadow

        system_u:object_r:shadow_t:s0 /etc/shadow
```

7.2 The **chcon** command

The command name **`chcon`** stands for change context. The command can change the full security context of a file to the value provided on the CLI, or it can change parts of the context. Alternatively, you can provide a file that serves as a reference.

To change the full security context of a file, the command syntax looks as follows:

```
# chcon SECURITY_CONTEXT FILENAME
```

where:

- *`SECURITY_CONTEXT`* is in the format: *`SELinux_USER`*:*`ROLE`*:*`TYPE`*:*`LEVEL`*:*`CATEGORY`*. For example, the context could be: *system_u:object_r:httpd_config_t:s0*.
- *`FILENAME`* is a path to the file whose context should be changed.

To set a security context according to a provided file that serves as a reference, run **`chcon`** as follows:

```
# chcon --reference=REFERENCE_FILE FILENAME
```

where:

- *REFERENCE_FILE* is a path to a file that should be used as a reference.
- *FILENAME* is a path to the file whose context should be changed.

Alternatively, you can change only one part of the security context. The general syntax of the **chcon** command is as follows:

```
# chcon CONTEXT_OPTION CONTEXT_PART FILENAME
```

The options and arguments have the following meaning:

- depending on the context part, *CONTEXT_OPTION* can be any of the following:

  `-u` resp `--user`
  : denotes that an SELinux user context will be changed on the provided file:

    ```
    # chcon -u system_u logind.conf
    ```

  `-r` resp `--role`
  : only the role part will be changed in the context of the provided file:

    ```
    # chcon -r object_r logind.conf
    ```

  `-t` resp `--type`
  : only the type part will be changed in the context of the provided file:

    ```
    # chcon -t etc_t logind.conf
    ```

  `-l` resp `--range`
  : only the range part of the security context will be changed:

    ```
    # chcon -l s0 logind.conf
    ```

- *CONTEXT_PART* is the particular value of the security context to be set.
- *FILENAME* is a path to the file whose context will be changed.

Note: Using **chcon** on symbolic links

By default, when you change the security context on a symbolic link, the context of the link target is changed and the symbolic link context is **not** changed. To force `chcon` to change the context of the symbolic link and not the link target, use the `--no-dereference` option as shown below:

```
# chcon --no-dereference -u system_u -t etc_t network.conf
```

You can change the context of all files in a directory by using the recursive option:

```
# chcon --recursive  system_u:object_r:httpd_config_t:s0 conf.d
```

7.3 `getenforce` and `setenforce` commands

The `getenforce` command returns the current SELinux mode: `Enforcing`, `Permissive` or `Disabled`.

```
# getenforce

Permissive
```

The `setenforce` command temporarily changes the SELinux mode to enforcing or permissive. You cannot use this command to disable SELinux. Remember that the change persists only until the next reboot. To change the state permanently, follow the description in *Section 3.1, "Changing the SELinux mode"*.

```
# setenforce MODE_ID
```

where *`MODE_ID`* is *`0`* for the `permissive` mode or *`1`* for the `enforced` mode.

7.4 The `fixfiles` script

The script enables you to perform the following tasks with the security context:

- check if the context is correct
- change any incorrect file context labels
- relabel your system if you added a new policy

The script syntax is as follows:

```
# fixfiles [OPTIONS] ARGUMENT
```

where:

- *`OPTIONS`* can be the following:

  `-l` *`LOGFILE`*
  : saves the output to the provided file

  `-o` *`OUTPUT_FILE`*
  : saves to the provided output file the names of all files whose file context differs from the default

  `-F`
  : forces a reset of context

- *`ARGUMENT`* can be one of the following:

  `check`
  : shows previous and current file context for an incorrect label without performing any changes

  `relabel`
  : relabels incorrect file contexts according to the currently loaded policy

  `restore`
  : restores incorrect file contexts to the default values

  `verify`
  : lists all files with incorrect file context labels without performing any changes

7.5 The **`semanage`** command

The **`semanage`** command can be used to configure parts of the policy without the need to re-compile the policy from sources. The command enables you to perform the following tasks:

- manage Booleans by using the `boolean` argument. For details about Booleans, refer to *Section 6.1, "Working with Booleans"*.
- adjust the context of files by using the `fcontext` argument

- manage user mappings using the `login` argument
- manage SELinux users using the `user` argument
- manage SELinux policy modules using the `module` argument

The general command syntax looks as follows:

```
# semanage ARGUMENT OPTIONS [OBJECT_NAME]
```

where:

- *`ARGUMENT`* is one of the following: **`login`**, **`user`**, **`fcontext`**, **`boolean`**, **`module`**.
- *`OPTIONS`* depends on the provided *`ARGUMENT`*. Common options are described in *Common options*.
- *`OBJECT_NAME`*, depending on the provided *`ARGUMENT`*, can be a login name, module name, file name or SELinux user.

COMMON OPTIONS

`-a`, `--add`
: adds a provided object

`-h`, `--help`
: prints the command help

--extract
: displays commands that were used to change the system (Booleans, file context, and so on)

`-l`, `--list`
: lists all objects

`-m`, `--modify`
: modifies the provided object

`-n`, `--noheading`
: modifies the output of the listing operation by omitting headings

`-s`, `--seuser`
: specifies the SELinux user

Other options are specific to particular **`semanage`** commands and are described in corresponding sections.

7.5.1 The `semanage fcontext` command

Using the `semanage fcontext` command, you can perform the following tasks:

- query file context definitions
- add contexts on files
- add your own rules

Changes performed to the file context using the `semanage fcontext` command do not require modifications or recompilation of the policy.

On top of the common options described in *Common options*, the `semanage fcontext` command takes the following options:

`-e`, `--equal`
: The option enables you to use the context of the provided path context to label files in a different directory (the provided target path). For example, you want to assign the same context as `/home` has to an alternative home directory `/export/home`. If you use this option, you need to provide the source path and the target path:

```
# semanage fcontext -a -e /home /export/home
```

`-f`, `--ftype`
: To specify a file type. Use one of the following values:

  - `a` - all files, which is also the default value
  - `b` - a block device
  - `c` - a character device
  - `d` - a directory
  - `f` - regular files
  - `l` - a symbolic link
  - `p` - a named pipe
  - `s` - a socket

7.5.2 The `semanage login` command

The `semanage login` enables you the perform the following tasks:

- Mapping of Linux users on a particular SELinux user. For example, to map the Linux user *tux* on `sysadm_u`, run the command:

```
# semanage login -a -s sysadm_u tux
```

- Mapping of a group of Linux users on a particular SELinux user. For example, to map users of the *writers* group on `user_u`, run the command:

```
# semanage login -a -s user_u %writers
```

  The group is then listed in the output of `semanage login -l`, prefixed with the % character.
  Keep in mind that the user group should be primary because mapping SELinux users on supplementary groups may result in incompatible mappings.

```
# semanage login -m -s staff_u %writers
```

- Mapping of Linux users on a particular SELinux MLS/MCS security range.
- Modifying of the already created mapping. For this purpose, just replace the `-a` option with `-m` in the previous commands.
- Setting the default SELinux user for new Linux users. The usual default SELinux user is `unconfined_u`. To change the value to `staff_u`, run the command:

```
# semanage login -m -s staff_u __default__
```

7.5.3 The `semanage boolean` command

The `semanage boolean` command is used to control Booleans in the SELinux policy.

The command synopsis looks as follows:

```
semanage boolean [-h] [-n]  [ --extract |
       --deleteall | --list [-C] | --modify ( --on | --off | -1 | -0 ) boolean ]
```

On top of the common options, you can use the following ones specific to the **`semanage boolean`** command:

--list -C
: To display a list of local modifications to Booleans.

-m --on | -1
: To switch the provided Boolean on.

-m --off | -0
: To switch the provided Boolean off.

-D, --deleteall
: To delete all local modifications to Booleans.

The most common usage of the command is to switch on or off a particular Boolean. For example, to switch on the `authlogin_yubikey` Boolean, run:

```
# semanage boolean -m on authlogin_yubikey
```

7.5.4 The `semanage user` command

The **`semanage user`** command controls the mapping between the SELinux user and the roles and MLS/MCS levels.

On top of the common options described in *Common options*, the **`semanage use`** command takes the following options:

-R [ROLES], --roles [ROLES]
: A list of SELinux roles. You can enclose multiple roles within double quotes and separate them by spaces, or you can use the `-R` several times.

Using this command, you can perform the following tasks:

- Listing the mapping of SELinux users on roles by running:

  ```
  # semanage user -l
  ```

- Changing the roles assigned to the `user_u` SELinux user:

  ```
  # semanage user -m -R "system_r unconfined_r user_r"
  ```

- Assigning to `admin_u` the role `staff_r` and a category `s0`:

```
# semanage user -a -R "staff_r -r s0 admin_u
```

- Creating a new SELinux user, for example, `admin_u` with the `staff_r` role. You also need to define the labeling prefix for this user by using the `-P`:

```
# semanage user -a -R "staff_r" -P admin admin_u
```

7.5.5 The `semanage module` command

The **`semanage module`** command can install, remove, disable or enable SELinux policy modules.

On top of the common options described in *Common options*, the **`semanage fcontext`** command takes the following options:

`-d`, `--disable`
: To disable the provided SELinux policy module:

```
# semanage module --disable MODULE_NAME
```

`-e`, `--enable`
: To enable the provided SELinux policy module:

```
# semanage module --enable MODULE_NAME
```

7.6 The `sestatus` command

The **`sestatus`** gets the status of a system where SELinux is running.

The generic syntax of the command looks as follows:

```
sestatus [OPTION]
```

When run without any options and arguments, the command outputs the following information:

```
# 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
Memory protection checking:     requested (insecure)
Max kernel policy version:      33
```

The command can take the following options:

-b

Displays the status of Booleans on the system.

-v

Displays the security context of files and processes listed in the `/etc/sestatus.conf` file.

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