Authentication with PAM

Pluggable Authentication Modules (PAM) mediate access between users and applications in SUSE Linux Enterprise Server. By centralizing authentication mechanisms through modular shared libraries, PAM allows administrators to adapt or introduce new authentication schemes without modifying individual applications. This framework significantly simplifies security management, reduces configuration errors and enhances system flexibility by enabling features like Universal 2nd Factor (U2F) hardware key authentication for local logins.

Prerequisites

- YubiKey or compatible Security Key hardware devices (for U2F configuration)

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1 Introduction to PAM

System administrators and programmers often want to restrict access to certain parts of the system or to limit the use of certain functions of an application. Without PAM, applications must be adapted every time a new authentication mechanism, such as LDAP, Samba, or Kerberos, is introduced. However, this process is time-consuming and error-prone. One way to avoid these drawbacks is to separate applications from the authentication mechanism and delegate authentication to centrally managed modules. Whenever a newly required authentication scheme is needed, it is sufficient to adapt or write a suitable *PAM module* for use by the program in question.

The PAM concept consists of:

- *PAM modules*, which are a set of shared libraries for a specific authentication mechanism.
- A *module stack* with one or more PAM modules.
- A PAM-aware *service* which needs authentication by using a module stack or PAM modules. Usually a service is a familiar name of the corresponding application, like **`login`** or **`su`**. The service name `other` is a reserved word for default rules.
- *Module arguments*, with which the execution of a single PAM module can be influenced.
- A mechanism evaluating each *result* of a single PAM module execution. A positive value executes the next PAM module. The way a negative value is dealt with depends on the configuration: “no influence, proceed” up to “terminate immediately” and anything in between are valid options.

2 Structure of PAM configuration

PAM on SUSE Linux Enterprise Server comes with a so-called directory-based configuration. The set of configuration files is stored in `/etc/pam.d`. Every service (or program) that relies on the PAM mechanism has its own configuration file in this directory. For example, the service for `sshd` can be found in the `/etc/pam.d/sshd` file.

The default configuration files provided by SUSE are stored in `/usr/lib/pam.d`. Do not modify these files, as they get overwritten during system updates. For custom changes to the configuration, use the directory `/etc/pam.d`. Either create configuration files there or use the directory to store **`pam-config`** generated configurations. If a particular configuration file exists in `/etc/pam.d/`, for example, `/etc/pam.d/sshd`, such a configuration file takes precedence over `/usr/lib/pam.d/sshd`.



Note: File-based configuration (`/etc/pam.conf`) not used on SUSE Linux Enterprise Server

The configuration of each service can also be stored in `/etc/pam.conf`. However, for maintenance and usability reasons, this configuration scheme is not used in SUSE Linux Enterprise Server.

The files under `/etc/pam.d/` define the PAM modules used for authentication. Each file consists of lines, which define a service, and each line consists of a maximum of four components:

```
TYPE  CONTROL
 MODULE_PATH  MODULE_ARGS
```

The components have the following meaning:

TYPE

Declares the type of the service. PAM modules are processed as stacks. Different types of modules have different purposes. For example, one module checks the password, another verifies the location from which the system is accessed, and yet another reads user-specific settings. PAM knows about four different types of modules:

`auth`

Check the user's authenticity, traditionally by querying a password. However, this can also be achieved with a chip card or through biometrics (for example, fingerprints or iris scan).

`account`

Modules of this type check if the user has general permission to use the requested service. As an example, such a check should be performed to ensure that no one can log in with the user name of an expired account.

`password`

The purpose of this type of module is to enable the change of an authentication token. Usually this is a password.

`session`

Modules of this type are responsible for managing and configuring user sessions. They are started before and after authentication to log login attempts and configure the user's specific environment.

CONTROL

Indicates the behavior of a PAM module. Each module can have the following control flags:

`required`

A module with this flag must be successfully processed before the authentication may proceed. After the failure of a module with the `required` flag, all other modules with the same flag are processed before the user receives a message about the failure of the authentication attempt.

`requisite`

Modules having this flag must also be processed successfully, in much the same way as a module with the `required` flag. However, in case of failure a module with this flag gives immediate feedback to the user and no further modules are processed. In case of success, other modules are subsequently processed, like any modules with the `required` flag. The `requisite` flag can be used as a basic filter checking for the existence of certain conditions that are essential for a correct authentication.

`sufficient`

After a module with this flag has been successfully processed, the requesting application receives an immediate message about the success and no further modules are processed, provided there was no preceding failure of a module with the `required` flag. The failure of a module with the `sufficient` flag has no direct consequences, in the sense that any subsequent modules are processed in their respective order.

`optional`

The failure or success of a module with this flag does not have any direct consequences. This can be useful for modules that are only intended to display a message (for example, to tell the user that mail has arrived) without taking any further action.

`include`

If this flag is given, the file specified as argument is inserted at this place.

MODULE_PATH

Contains a full file name of a PAM module. It does not need to be specified explicitly, if the module is located in the default directory `/lib/security` (for all 64-bit platforms supported by SUSE Linux Enterprise Server, the directory is `/lib64/security`).

MODULE_ARGS

Contains a space-separated list of options to influence the behavior of a PAM module, such as `debug` (enables debugging) or `nullok` (allows the use of empty passwords).

In addition, there are global configuration files for PAM modules under `/etc/security`, which define the exact behavior of these modules (examples include `pam_env.conf` and `time.conf`). Every application that uses a PAM module calls a set of PAM functions, which then process the information in the configuration files and return the result to the requesting application.

To simplify the creation and maintenance of PAM modules, common default configuration files for the types `auth`, `account`, `password`, and `session` modules have been introduced. These are retrieved from every application's PAM configuration. Updates to the global PAM configuration modules in `common-*` are thus propagated across all PAM configuration files without requiring the administrator to update every single PAM configuration file.

The global PAM configuration files are maintained using the **`pam-config`** tool. This tool automatically adds new modules to the configuration, changes the configuration of existing ones or deletes modules (or options) from the configurations. Manual intervention in maintaining PAM configurations is minimized or no longer required.

2.1 An example of PAM configuration

To demonstrate a real use case example of PAM configuration, the configuration of sshd has been used in this section:

EXAMPLE 1: PAM CONFIGURATION FOR SSHD (`/etc/pam.d/sshd`)

```
#%PAM-1.0 ❶
auth     requisite      pam_nologin.so                          ❷
auth     include        common-auth                             ❸
account  requisite      pam_nologin.so                          ❷
account  include        common-account                          ❸
password include        common-password                         ❸
session  required       pam_loginuid.so                         ❹
session  include        common-session                          ❸
session  optional       pam_lastlog2.so   silent noupdate showfailed ❺
```

❶ Declares the version of this configuration file for PAM 1.0. This is merely a convention, but could be used in the future to check the version.

❷ Checks, if `/etc/nologin` exists. If it does, no user other than `root` may log in.

❸ Refers to the configuration files of four module types: `common-auth`, `common-account`, `common-password`, and `common-session`. These four files hold the default configuration for each module type.

4. Sets the login UID process attribute for the process that was authenticated.
5. Displays and manages user last login information using a Y2038-safe database.

By including the configuration files instead of adding each module separately to the respective PAM configuration, you automatically get an updated PAM configuration when an administrator changes the defaults.

The first include file (`common-auth`) calls modules of the `auth` type: `pam_env.so`, `pam_gnome_keyring.so` and `pam_unix.so`. See *Example 2, "Default configuration for the `auth` section (`common-auth`)"*. Keep in mind that the modules may differ according to your installation.

EXAMPLE 2: DEFAULT CONFIGURATION FOR THE `auth` SECTION (`common-auth`)

```
auth  required  pam_env.so                  ❶
auth  optional  pam_gnome_keyring.so        ❷
auth  required  pam_unix.so  try_first_pass ❸
```

1. `pam_env.so` loads `/etc/security/pam_env.conf` to set the environment variables as specified in this file. It can be used to set the `DISPLAY` variable to the correct value, because the `pam_env` module knows about the location from which the login is taking place.
2. `pam_gnome_keyring.so` checks the user's login and password against the GNOME key ring
3. `pam_unix` checks the user's login and password against `/etc/passwd` and `/etc/shadow`.

The whole stack of `auth` modules is processed before `sshd` gets any feedback about whether the login has succeeded. All modules of the stack having the `required` control flag must be processed successfully before `sshd` receives a message about the positive result. If one of the modules is not successful, the entire module stack is still processed and only then is `sshd` notified about the negative result.

When all modules of the `auth` type have been successfully processed, another include statement is processed, in this case, that in *Example 3, "Default configuration for the `account` section (`common-account`)"*. `common-account` contains only one module, `pam_unix`. If `pam_unix` returns the result that the user exists, sshd receives a message announcing this success and the next stack of modules (`password`) is processed, shown in *Example 4, "Default configuration for the `password` section (`common-password`)"*.

EXAMPLE 3: DEFAULT CONFIGURATION FOR THE `account` SECTION (`common-account`)

```
account  required  pam_unix.so  try_first_pass
```

EXAMPLE 4: DEFAULT CONFIGURATION FOR THE `password` SECTION (`common-password`)

```
password  requisite  pam_cracklib.so
```

```
password  optional   pam_gnome_keyring.so  use_authtok
password  required   pam_unix.so  use_authtok nullok shadow try_first_pass
```

Again, the PAM configuration of `sshd` involves only an include statement referring to the default configuration for `password` modules located in `common-password`. These modules must successfully be completed (control flags `requisite` and `required`) whenever the application requests the change of an authentication token.

Changing a password or another authentication token requires a security check. This is achieved with the `pam_cracklib` module. The `pam_unix` module used afterward carries over any old and new passwords from `pam_cracklib`, so the user does not need to authenticate again after changing the password. This procedure makes it impossible to circumvent the checks carried out by `pam_cracklib`. Whenever the `account` or the `auth` type are configured to complain about expired passwords, the `password` modules should also be used.

EXAMPLE 5: DEFAULT CONFIGURATION FOR THE `session` SECTION (`common-session`)

```
session  required  pam_limits.so
session  required  pam_unix.so  try_first_pass
session  optional  pam_umask.so
session  optional  pam_systemd.so
session  optional  pam_gnome_keyring.so auto_start only_if=gdm,gdm-password,lxdm,lightdm
session  optional  pam_env.so
```

As the final step, the modules of the `session` type (bundled in the `common-session` file) are called to configure the session according to the settings for the user in question. The `pam_limits` module loads the file `/etc/security/limits.conf`, which may define limits on the use of certain system resources. The `pam_unix` module is processed again. The `pam_umask` module can be used to set the file mode creation mask. Since this module carries the `optional` flag, a failure of this module would not affect the successful completion of the entire session module stack. The `session` modules are called a second time when the user logs out.

3 Configuration of PAM modules

Some PAM modules are configurable. The configuration files are located in `etc/security`. This section briefly describes the configuration files relevant to the sshd example—`pam_env.conf` and `limits.conf`.

3.1 pam_env.conf

`pam_env.conf` can be used to define a standardized environment for users that is set whenever the `pam_env` module is called. With it, preset environment variables using the following syntax:

```
VARIABLE  [DEFAULT=VALUE]  [OVERRIDE=VALUE]
```

`VARIABLE`
: Name of the environment variable to set.

`[DEFAULT=<value>]`
: Default *`VALUE`* the administrator wants to set.

`[OVERRIDE=<value>]`
: Values that may be queried and set by `pam_env`, overriding the default value.

A typical example of how `pam_env` can be used is the adaptation of the `DISPLAY` variable, which is changed whenever a remote login takes place. This is shown in *Example 6, "pam_env.conf"*.

EXAMPLE 6: PAM_ENV.CONF

```
REMOTEHOST  DEFAULT=localhost          OVERRIDE=@{PAM_RHOST}
DISPLAY     DEFAULT=${REMOTEHOST}:0.0  OVERRIDE=${DISPLAY}
```

The first line sets the value of the `REMOTEHOST` variable to `localhost`, which is used whenever `pam_env` cannot determine any other value. The `DISPLAY` variable in turn contains the value of `REMOTEHOST`. Find more information in the comments in `/usr/etc/security/pam_env.conf`.

3.2 pam_mount.conf.xml

The purpose of `pam_mount` is to mount user home directories during the login process, and to unmount them during logout in an environment where a central file server keeps all the home directories of users. With this method, it is not necessary to mount a complete `/home` directory where all the user home directories would be accessible. Instead, only the home directory of the user who is about to log in, is mounted.

After installing `pam_mount`, a template for `pam_mount.conf.xml` is available in `/usr/etc/security`. The description of the elements can be found in the manual page **`man 5 pam_mount.conf`**.

A basic configuration of this feature can be done with YaST. Select *Network Settings* › *Windows Domain Membership* › *Expert Settings* to A basic configuration of this feature can be done with YaST. To add the file server, select *Network Settings* › *Windows Domain Membership* › *Expert Settings*.

3.3 limits.conf

System limits can be set on a user or group basis in `limits.conf`, which is read by the `pam_limits` module. The file allows you to set hard limits, which may not be exceeded, and soft limits, which may be exceeded temporarily. For more information about the syntax and options, see the comments in `/etc/security/limits.conf`. The `/usr/etc/security` is only for distributions; administrators are not allowed to change this. The `pam_env.conf` follows the UAPI configuration file specification; administrators should follow that for their changes.

4 Configuring PAM using **pam-config**

The **pam-config** tool helps you configure the global PAM configuration files (`/etc/pam.d/common-*`) and several selected application configurations. For a list of supported modules, use the **pam-config --list-modules** command. Use the **pam-config** command to maintain your PAM configuration files. Add new modules to your PAM configurations, delete other modules or modify options to these modules. When changing global PAM configuration files, no manual tweaking of the PAM setup for individual applications is required.

A simple use case for **pam-config** involves the following:

1. **Auto-generate a fresh Unix-style PAM configuration.** Let **pam-config** create the simplest possible setup which you can extend later on. The **pam-config --create** command creates a simple Unix authentication configuration. Pre-existing configuration files not maintained by **pam-config** are overwritten, but backup copies are kept as `*.pam-config-backup`.

2. **Add a new authentication method.** Adding a new authentication method (for example, LDAP) to your stack of PAM modules comes down to a simple **pam-config --add --ldap** command. LDAP is added wherever appropriate across all `common-*-pc` PAM configuration files.

3. **Add debugging for test purposes.** To make sure the new authentication procedure works as planned, turn on debugging for all PAM-related operations. The **pam-config --add --ldap-debug** turns on debugging for LDAP-related PAM operations.

4. **Query your setup.** Before you finally apply your new PAM setup, check if it contains all the options you wanted to add. The **pam-config --query --*MODULE*** command lists both the type and the options for the queried PAM module.

5. **Remove the debug options.** Finally, remove the debug option from your setup when you are entirely satisfied with the performance of it. The **`pam-config --delete --ldap-debug`** command turns off debugging for LDAP authentication. In case you had debugging options added for other modules, use similar commands to turn these off.

For more information on the **`pam-config`** command and the options available, refer to the manual page of **`pam-config(8)`**.

5 Manually configuring PAM

If you prefer to manually create or maintain your PAM configuration files, make sure to disable **`pam-config`** for these files.

When you create your PAM configuration files from scratch using the **`pam-config --create`** command, it creates symbolic links from the `common-*` to the `common-*-pc` files. **`pam-config`** only modifies the `common-*-pc` configuration files. Removing these symbolic links effectively disables **`pam-config`**, because **`pam-config`** only operates on the `common-*-pc` files and these files are not put into effect without the symbolic links.



Warning: Include `pam_systemd.so` in configuration

If you are creating your own PAM configuration, make sure to include `pam_systemd.so` configured as `session optional`. Not including the `pam_systemd.so` can cause problems with `systemd` task limits. For details, refer to the man page of `pam_systemd.so`.

6 Configuring SLES to require U2F keys for local login

To provide more security during the local login to SLES, you can configure two-factor authentication using the `pam-u2f` framework and the U2F feature on YubiKeys and Security Keys.

For this, you must have a YubiKey device and install the required `pam-u2f` package on your system.

```
> sudo  zypper install pam_u2f
```

To set up U2F on your SLES system, you need to associate your key with your account on SLES. After that, configure your system to use the key. The procedure is described in the following sections.

6.1 Associating the U2F key with your account

To associate your U2F key with your account, proceed as follows:

1. Log in to your machine.
2. Insert your U2F key.
3. Create a directory for the U2F key configuration:

```
> sudo mkdir -p ~/.config/Yubico
```

4. Run the **`pamu2fcfg`** command that outputs configuration lines:

```
> sudo pamu2fcfg > ~/.config/Yubico/u2f_keys
```

5. When your device begins flashing, touch the metal contact to confirm the association.

We recommend using a backup U2F device, which you can set up by running the following commands:

1. Run:

```
> sudo pamu2fcfg -n >> ~/.config/Yubico/u2f_keys
```

2. When your device begins flashing, touch the metal contact to confirm the association.

You can move the output file from the default location to a directory that requires the `sudo` permission to modify the file to increase security. For example, move it to the `/etc` directory. To do so, follow the steps:

1. Create a directory in `/etc`:

```
> sudo mkdir /etc/Yubico
```

2. Move the created file:

```
> sudo mv ~/.config/Yubico/u2f_keys /etc/Yubico/u2f_keys
```



Note: Placing the `u2f_keys` to a non-default location

If you move the output file to a different directory than is the default (`$HOME/.config/Yubico/u2f_keys`), you need to add the path to the `/etc/pam.d/login` file as described in *Section 6.2, "Updating the PAM configuration"*.

6.2 Updating the PAM configuration

After you have created the U2F keys configuration, you need to adjust the PAM configuration on your system.

1. Open the file `/etc/pam.d/login`.
2. Add the line `auth required pam_u2f.so` to the file as follows:

```
#%PAM-1.0
auth      include    common-auth
auth      required   pam_u2f.so
account   include    common-account
password  include    common-password
session   optional   pam_keyinit.so revoke
session   include    common-session
#session  optional   pam_xauth.so
```

3. If you placed the `u2f_keys` file to a different location than `$HOME/.config/Yubico/u2f_keys`, you need to use the `authfile` option in the `/etc/pam.d/login` PAM file as follows:

```
#%PAM-1.0
auth     requisite pam_nologin.so
auth     include   common-auth
auth  required pam_u2f.so authfile=<PATH_TO_u2f_keys>
...
```

   where *<PATH_TO_u2f_keys>* is the absolute path to the `u2f_keys` file.

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