BaroPAM Guide(OpenLDAP)

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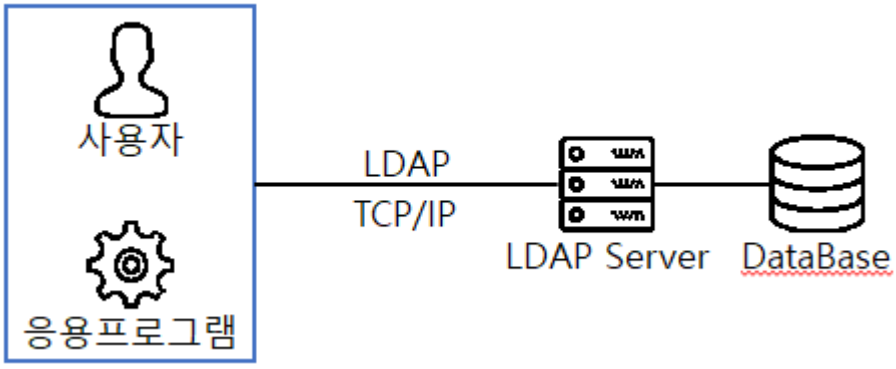
1. OpenLDAP authentication

1.1 Abstract

OpenLDAP is a representative open-source directory service software that implements the Lightweight Directory Access Protocol (LDAP).

While general relational databases (such as MySQL and Oracle) are optimized for complex relationships and frequent data modifications, directory services like OpenLDAP are specialized for hierarchically managing "information that is frequently read but rarely changes."

LDAP is a platform-independent protocol. Many common Linux distributions include OpenLDAP software for LDAP support. This software runs on BSD variants, AIX, Android, HP-UX, macOS, Solaris, Microsoft Windows (NT and derivatives, e.g., 2000, XP, Vista, Windows 7, etc.), and Z/OS.



1.2 Key Features of OpenLDAP

1) Hierarchical Structure (Tree Structure)

Data is stored in a tree format, allowing the organizational chart (Headquarters > Department > Team > Individual) to be accurately reflected.

2) High-Performance Search

Search tasks, such as verifying specific user permissions among tens of thousands of user records, are extremely fast.

3) Standard Protocol

Since it adheres to a standard LDAP protocol independent of any specific enterprise, it offers excellent compatibility with Linux, Windows, various network equipment, and cloud solutions.

4) Flexible Authentication Scheme

It provides broad support ranging from simple password authentication to encrypted authentication using SASL and TLS/SSL.

1.3 Main components

1) slapd (Standalone LDAP Daemon)

It is a core server program that receives client requests and processes data.

2) LDIF (LDAP Data Interchange Format)

It is a standard method for displaying data in text form, used for data backup or batch registration.

3) Schema

It is a set of rules that defines the format of data to be stored in a directory (e.g., names are strings, phone numbers are numbers, etc.).

1.4 Use cases

1) Integrated ID Management (Single Sign-On, SSO)

Accounts for all internal servers (Linux SSH), VPNs, internal bulletin boards, and email systems are integrated and managed through a single OpenLDAP. Users can log in to all systems using a single ID.

2) Access Control

Access is restricted so that only users belonging to specific groups can connect to specific servers or access specific folders.

3) Address Book Server

Contact and email information of employees within the company are managed and shared centrally.

1.5 Data identification example

Data within OpenLDAP has a unique address called a DN (Distinguished Name).

```
uid=kim, ou=dev, dc=company, dc=com
```

dc (Domain Component): Domain information (company.com)
ou (Organizational Unit): Organizational unit (Development Team)
uid (User ID): User ID (kim)

OpenLDAP is considered an essential infrastructure solution, particularly for enhancing security and user management in Linux server environments.

2. OpenLDAP Installation and Setup

2.1 Install OpenLDAP

Since openldap-servers does not exist in the default repository, add it to the repository.

```
[root@baropam ~]# dnf config-manager --set-enabled plus
[root@baropam ~]# dnf repolist
Repository ID                                 Repository name
appstream                                     Rocky Linux 9 - AppStream
baseos                                        Rocky Linux 9 - BaseOS
extras                                        Rocky Linux 9 - Extras
plus                                          Rocky Linux 9 - Plus
```

First, install the OpenLDAP and SASL related packages.

```
[root@baropam ~]# dnf -y install openldap-servers openldap-clients cyrus-sasl cyrus-sasl-plain
```

When attempting to remove installed OpenLDAP ➔ **dnf -y erase openldap-servers openldap-clients cyrus-sasl cyrus-sasl-plain**

2.2 OpenLDAP settings

1) OpenLDAP Execution and Initialization

Create and run the OpenLDAP service (slapd) for automatic startup.

```
[root@baropam ~]# systemctl enable --now slapd
Created symlink /etc/systemd/system/slapd.service → /usr/lib/systemd/system/slapd.service.
Created symlink /etc/systemd/system/multi-user.target.wants/slapd.service →
/usr/lib/systemd/system/slapd.service.

[root@baropam ~]# systemctl start slapd
```

To configure the OpenLDAP (slapd) daemon to restart automatically when a problem occurs, utilizing the features of systemd, Linux's service management tool, is the most standard and powerful method.

Since OpenLDAP itself does not have a separate option to self-restart in the event of a process crash, it must be configured to monitor and recover at the system level.

The most recommended method is to add a Restart option to the service unit file.

```
[root@baropam ~]# vi /usr/lib/systemd/system/slapd.service

[Unit]
Description=OpenLDAP Server Daemon
After=syslog.target network-online.target
```

```
Documentation=man:slapd
Documentation=man:slapd-config
Documentation=man:slapd-mdb
Documentation=file:///usr/share/doc/openldap-servers/guide.html

[Service]
Type=forking
ExecStartPre=/usr/libexec/openldap/check-config.sh
ExecStart=/usr/sbin/slapd -u ldap -h "ldap:/// ldaps:/// ldapi:///"

Restart=on-failure
RestartSec=5s
StartLimitIntervalSec=600
StartLimitBurst=5

[Install]
WantedBy=multi-user.target
Alias=openldap.service
```

The configured Restart option types and trigger conditions are as follows.

Option	Description
no	Default, do not automatically restart the service.
always	Unconditional restart regardless of termination status (normal/abnormal) or signal.
on-success	Restart only when the service was cleanly terminated. (Exit code 0)
on-failure	Recommended, restart only in case of abnormal termination (non-zero exit code, process kill, timeout, etc.)
on-abnormal	Restart only when the process terminates abnormally (termination by signal, timeout, etc.).
on-abort	Restart only when the process is terminated by an uncaught signal.

Important auxiliary options used with Restart are generally configured together with the following options to prevent infinite loops and ensure stability, rather than using the Restart option alone.

Option	Description
RestartSec	Wait time before attempting a restart. (e.g., 5s) Setting it too short may increase the system load.
StartLimitIntervalSec	The time range for calculating the number of failures. (e.g., 600 seconds)
StartLimitBurst	Maximum number of restarts allowed within the set time range. (e.g., 5 times)

Note: If a restart fails 5 or more times within 600 seconds, systemd determines that the service has a serious problem and stops attempting to restart it, leaving it in a failed state.

Apply changes)

```
[root@baropam ~]# systemctl daemon-reload
[root@baropam ~]# systemctl restart slapd.service
```

Note)
$ systemctl start slapd ->Service start
$ systemctl stop slapd ->Service stop

```
$  systemctl restart slapd ->Service restart
$  systemctl status  slapd ->Service status
```

2) Firewall allow

You must configure Firewalld to allow OpenLDAP packets.

```
[root@baropam ~]# firewall-cmd —permanent —add-service={ldap,ldaps}
success
```

To apply the changes, run the following command to reload the firewall.

```
 [root@baropam ~]# firewall-cmd —reload
success
```

3) Set administrator password

Base Dn : cn=admin,dc=example,dc=com, can be managed using the administrator password.

Password creation)

```
[root@baropam ~]# slappasswd
New password: baropam
Re-enter new password: baropam
{SSHA}052QoM5oM14WYbi3WkzcMPLQ27fFsxFt ←Copy required
```

Password DN creation)

```
[root@baropam ~]# vi admin_pass.ldif
dn: olcDatabase={2}mdb,cn=config
changetype: modify
replace: olcRootPW
olcRootPW: {SSHA}052QoM5oM14WYbi3WkzcMPLQ27fFsxFt ←Paste the copied password
```

Password DN applied)

```
[root@baropam ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f admin_pass.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
modifying entry "olcDatabase={2}mdb,cn=config"
```

4) Set the default DN

Create basic DN)

```
[root@baropam ~]# vi base_structure.ldif
# base_structure.ldif
dn: olcDatabase={2}mdb,cn=config
changetype: modify
```

```
replace: olcSuffix
olcSuffix: dc=example,dc=com

dn: olcDatabase={2}mdb,cn=config
changetype: modify
replace: olcRootDN
olcRootDN: cn=admin,dc=example,dc=com
```

Default DN applied)

```
[root@baropam ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f base_structure.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
modifying entry "olcDatabase={2}mdb,cn=config"

modifying entry "olcDatabase={2}mdb,cn=config"
```

5) Load default schema

```
[root@baropam ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/cosine.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
adding new entry "cn=cosine,cn=schema,cn=config"

[root@baropam ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/nis.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
adding new entry "cn=nis,cn=schema,cn=config"

[root@baropam ~]# ldapadd -Y EXTERNAL -H ldapi:/// -f /etc/openldap/schema/inetorgperson.ldif
SASL/EXTERNAL authentication started
SASL username: gidNumber=0+uidNumber=0,cn=peercred,cn=external,cn=auth
SASL SSF: 0
adding new entry "cn=inetorgperson,cn=schema,cn=config"
```

6) Default organization settings

Create basic organization DN)

```
[root@baropam ~]# vi initial_org.ldif
# Definition of the organization's root DIT (Directory Information Tree) entry
# dc=example,dc=com must be changed to match the default domain set during installation.
dn: dc=example,dc=com
objectClass: top
objectClass: dcObject
objectClass: organization
o: My Company
description: My Company's main LDAP directory
```

```
# Definition of Organizational Units (OU) for users
dn: ou=users,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: users
description: All user accounts in My Company

# Definition of Organizational Units (OU) for groups
dn: ou=groups,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: groups
description: All user groups in My Company

# Definition of Organizational Units (OU) for departments
dn: ou=departments,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: departments
description: Departments within My Company

# IT department OU definition (Located under department OU)
dn: ou=IT,ou=departments,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: IT
description: Information Technology Department

# HR department OU definition (Located under department OU)
dn: ou=HR,ou=departments,dc=example,dc=com
objectClass: top
objectClass: organizationalUnit
ou: HR
description: Human Resources Department
```

Apply basic organization DN)

```
[root@baropam ~]# ldapadd -x -W -D "cn=admin,dc=example,dc=com" -f initial_org.ldif
Enter LDAP Password: baropam
adding new entry "dc=example,dc=com"

adding new entry "ou=users,dc=example,dc=com"

adding new entry "ou=groups,dc=example,dc=com"

adding new entry "ou=departments,dc=example,dc=com"

adding new entry "ou=IT,ou=departments,dc=example,dc=com"

adding new entry "ou=HR,ou=departments,dc=example,dc=com"
```

7) Test

baropam user DN creation)

```
[root@baropam ~]# vi add_nurit.ldif
dn: uid=honggildong,ou=HR,ou=departments,dc=example,dc=com
objectClass: top
objectClass: person
objectClass: organizationalPerson
objectClass: inetOrgPerson
cn: nurit
sn: nuri
givenName: it
mail: nurit@example.com
uid: nurit
userPassword: {SSHA}052QoM5oM14WYbi3WkzcMPLQ27fFsxFt
```

Apply baropam user DN)

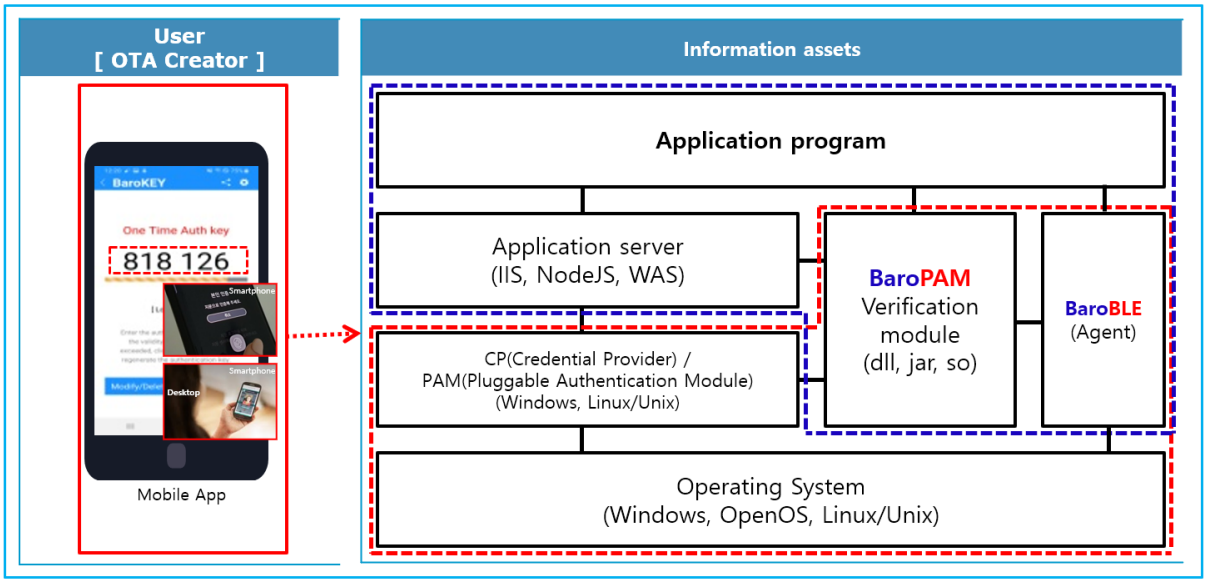
```
[root@baropam ~]# ldapadd -x -D "cn=admin,dc=example,dc=com" -W -f add_nurit.ldif
Enter LDAP Password: baropam
adding new entry "uid=honggildong,ou=HR,ou=departments,dc=example,dc=com"
```

Look up personnel belonging to the HR department)

```
[root@baropam ~]# ldapsearch -x -b  "ou=HR,ou=departments,dc=example,dc=com" "(objectClass=person)"
cn
# extended LDIF
#
# LDAPv3
# base <ou=HR,ou=departments,dc=example,dc=com> with scope subtree
# filter: (objectClass=person)
# requesting: cn
#

# honggildong, HR, departments, example.com
dn: uid=honggildong,ou=HR,ou=departments,dc=example,dc=com
cn: nurit

# search result
search: 2
result: 0 Success

# numResponses: 2
# numEntries: 1
```

3. BaroPAM installation and Setup

The BaroPAM solution is a zerotrust security model based on the Pluggable Authentication Module (PAM) method that anyone can easily and immediately apply to various operating systems and applications that require secondary authentication (additional authentication) to enhance the security of information assets. It is a 3-step authentication solution with biometrics optimized for security.



3.1 Preparation before installing BaroPAM

To use the PAM module, the PAM package must be installed by default. To check the installation, run the following command. If it is not installed, use the command "**dnf install pam**" for Redhat series and "**sudo apt-get install pam**" for others.

```
[root]# rpm -qa | grep pam
pam_smb-1.1.7-7.2.1
pam_passwdqc-1.0.2-1.2.2
pam-0.99.6.2-14.el5_11
pam_krb5-2.2.14-22.el5
pam-devel-0.99.6.2-14.el5_11
pam_ccreds-3-5
pam_smb-1.1.7-7.2.1
pam_pkcs11-0.5.3-26.el5
pam-devel-0.99.6.2-14.el5_11
pam_passwdqc-1.0.2-1.2.2
pam-0.99.6.2-14.el5_11
pam_ccreds-3-5
pam_krb5-2.2.14-22.el5
pam_pkcs11-0.5.3-26.el5
```

To download and install the BaroPAM authentication module, connect with the **root** account and create a directory (/usr/baropam) to download and install the module as follows.

```
[root]# mkdir /usr/baropam
```

Grant permissions (read, write, execute) of the directory to download and install the BaroPAM module as follows.

```
[root]# chmod 777 /usr/baropam
```

3.2 Download BaroPAM installation module

After accessing the BaroPAM authentication module with the **root** account, move to the directory (/usr/baropam) to download and install the module, and download the module as follows.

```
[root] /usr/baropam > wget http://nuriapp.com/download/libpam_baro_auth-x.x.tar
```

When the download of the BaroPAM authentication module is complete, the **tar** file is decompressed as follows.

```
[root] /usr/baropam > tar -xvf libpam_baro_auth-x.x.tar
```

When the BaroPAM authentication module is unzipped, the following BaroPAM related modules are created in the baropam directory.

```
[root] /usr/baropam > ls -al
합계 180
drwxrwxrwx  7 root   root   4096  8월 23 09:59 .
drwxr-xr-x 17 root   root   4096  2월 10  2017 ..
-r--r--r--  1 root   root      8  3월 24  2021 .baro_acl
-r--r--r--  1 root   root    305  7월  2 14:41 .baro_auth
-r--r--r--  1 root   root    290  6월 30 12:55 .baro_curl
-r--r--r--  1 root    root   287  2월 28 12:19 .baro_sql
-rwxr-xr-x  1 root   root  69149  4월  6 19:12 baro_auth
-rwxr-xr-x  1 root   root  65072  6월 29 16:36 baro_curl
-rwxr-xr-x  1 root    root  57074  2월 28 12:18 baro_sql
drwxr-xr-x  2 root   root   4096  7월 20  2021 jilee
-rwxr-xr-x  1 root   root 152649  6월  9 08:19 pam_baro_auth.so
-rwxr-xr-x  1 root   root 116158  6월 30 12:54 pam_baro_curl.so
-rwxr-xr-x  1 root    root 170863  2월 28 12:18 pam_baro_sql.so
-rw-r--r--  1 root   root    221  6월 27 15:59 setauth.sh
-rw-r--r--  1 root   root    150  6월 29 16:29 setcurl.sh
-rw-r--r--  1 root    root   180  2월 28 12:19 setsql.sh
```

3.3 Create BaroPAM configuration file

1) PAM authentication (.baro_auth): Set environment setting information in File

The BaroPAM environment setting file must be created by executing the **baro_auth** program, and it

must be located under **/usr/baropam**, the directory of the BaroPAM authentication module.

Format)

```
baro_auth -r rate_limit -R rate_time -t cycle_time -k key_method -e encrypt_flag -A acl_type -a acl_filename -S secure_key -s filename
```

The configuration options of the BaroPAM configuration file are as follows.

Optino	Decumentation	Set value	Etc
-r	OTA key limited number of times (1~10)	3	
-R	OTA key time limit (15~600 sec)	30	
-t	OTA key authentication cycle (3~60 sec)	30	
-k	OTA key authentication method (app1, app256, app384, app512)	app512	
-e	Encryption of configuration files (yes or no)	no	
-A	Choose whether to allow or deny 2nd authentication	deny	
-a	ACL file name for the account to allow or deny from 2nd authentication (**file access permission is 444**)	/usr/baropam/.baro_acl	
-S	Secure key (license key) provided by the vendor	jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/	
-s	File name including the directory in which to create the BaroPAM configuration file	/usr/baropam/.baro_auth	

Note) The filename of the -s option is the name of the file including the directory where the BaroPAM configuration file will be created (**file access permission is 444**). If the hostname of the set server does not match, BaroPAM may not operate normally.

Ex of use)

```
[root] /usr/baropam > ./baro_auth -r 3 -R 30 -t 30 -k app512 -e no -A deny -a /usr/baropam/.baro_acl -S jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/ -s /usr/baropam/.baro_auth
```

If the BaroPAM environment setting file is set for each account, connect to the account and proceed with the work. (Not root)

```
[root] /usr/baropam > ./baro_auth -r 3 -R 30 -t 30 -k app512 -e no -A deny -a ~/.baro_acl -S jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/ -s ~/.baro_auth
```

1) Your emergency one-time authentication keys are:
   The emergency OTA key is a super authentication key that can be used to access the SSH server again in case you lose it when the OTA key generator, the BaroPAM app, is unavailable, so it is good to write it down somewhere.

2) Enter "**y**" for all the questions that follow.
   Do you want me to update your "/usr/baropam/.baro_auth" file (y/n) **y**
   Preventing man-in-the-middle attacks (y/n) **y**

The contents set in **.baro_auth**, the BaroPAM environment setting file, are as follows.

```
[root] /usr/baropam > cat .baro_auth
" AUTH_KEY
" RATE_LIMIT 3 30
" KEY_METHOD app512
```

```
" CYCLE_TIME 30
" SECURE_KEY jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/
" ACL_NAME /usr/baropam/.baro_acl
" ACL_TYPE deny
" DISALLOW_REUSE
33458936
19035576
15364353
54649370
84342192
```

The setting items of **.baro_auth**, a BaroPAM configuration file, are as follows.

Item	Decumentation	Set value	Etc
AUTH_KEY	Authentication delimiter (fixed)		
RATE_LIMIT	OTA key limit count (1~10), time limit (15~600 sec)	3 30	
KEY_METHOD	OTA key authentication method (app1, app256, app384, app512: app	app512	
CYCLE_TIME	OTA key authentication cycle (3~60 sec)	30	
SECURE_KEY	Secure key (license key) provided by the vendor	jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/	
ACL_TYPE	Differentiate between allow and deny in 2nd authentication	deny	
ACL_NAME	ACL Filename for the account to be allowed or excluded from 2nd authentication (**file access permission is 444**)	/usr/baropam/.baro_acl	
DISALLOW_REUSE or ALLOW_REUSE	To prevent a man-in-the-middle attack, if "**DISALLOW_REUSE**" is set, other users cannot log in during the authentication cycle of the OTA key. If allowed, set "**ALLOW_REUSE**".	DISALLOW_REUSE	

2) PAM authentication (.baro_sql): Set environment configuration information in MariaDB

Connection information for linking with Mariadb, where BaroPAM configuration information exists, must be created by running the **baro_sql** program, and must be located under **/usr/baropam**, the directory of the BaroPAM authentication module.

Format)

```
baro_sql -H hostname -u username -p password -d dbname -P portno -r rate_limit -R rate_time -t
cycle_time -k key_method -e encrypt_flag -A acl_type -a acl_filename -S secure_key -s filename
```

The configuration options of the BaroPAM configuration file are as follows.

Optino	Decumentation	Set value	Etc
-H	Hostname or IP address of the MariaDB server	nurit.co.kr	
-u	MariaDB username	nurit	
-p	Password for the MariaDB user	baropam	
-d	MariaDB name to connect to	baropamdb	

-p	Port number of the MariaDB server	3308	
-r	OTA key limited number of times (1~10)	3	
-R	OTA key time limit (15~600 sec)	30	
-t	OTA key authentication cycle (3~60 sec)	30	
-k	OTA key authentication method (app1, app256, app384, app512)	app512	
-e	Encryption of configuration files (yes or no)	no	
-A	Choose whether to allow or deny 2nd authentication	deny	
-a	ACL file name for the account to allow or deny from 2nd authentication (file access permission is 444)	/usr/baropam/.baro_acl	
-S	Secure key (license key) provided by the vendor	jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/	
-s	File name including the directory in which to create the BaroPAM configuration file	/usr/baropam/.baro_sql	

Note) The filename of the -s option is the file name containing the directory where the BaroPAM configuration file will be created (**file access permission is 444**).

Ex of use)

```
[root] /usr/baropam > ./baro_sql -H nurit.co.kr -e no -u nurit -p baropams -d baropamdb -P 3306 -r 3 -R 30 -t 30 -k app512 -e no -A deny -a /usr/baropam/.baro_acl -S jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/ -s /usr/baropam/.baro_sql
```

1) Your emergency one-time authentication keys are:
   The emergency OTA key is a super authentication key that can be used to access the SSH server again in case you lose it when the OTA key generator, the BaroPAM app, is unavailable, so it is good to write it down somewhere.

2) Enter "**y**" for all the questions that follow.
   Do you want me to update your "/usr/baropam/.baro_sql" file (y/n) **y**
   Preventing man-in-the-middle attacks (y/n) **y**

The contents set in **.baro_sql**, the BaroPAM environment setting file, are as follows.

```
[root] /usr/baropam > cat .baro_sql
" AUTH_KEY
" HOSTNAME nurit.co.kr
" USERNAME nurit
" PASSWORD baropams
" DBNAME baropamdb
" PORTNO 3306
" RATE_LIMIT 3 30
" KEY_METHOD app512
" CYCLE_TIME 30
" SECURE_KEY jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/
" ACL_NAME /usr/baropam/.baro_acl
" ACL_TYPE deny
" DISALLOW_REUSE
33458936
19035576
15364353
54649370
84342192
```

The setting items of .baro_sql, a BaroPAM configuration file, are as follows.

Item	Documentation	Set value	Etc
AUTH_KEY	Authentication delimiter (fixed)		
HOSTNAME	Hostname or IP address of the MariaDB server	nurit.co.kr	
USERNAME	MariaDB username	nurit	
PASSWORD	Password for the MariaDB user	baropam	
DBNAME	MariaDB name to connect to	baropamdb	
PORTNO	Port number of the MariaDB server	3308	
RATE_LIMIT	OTA key limit count (1~10), time limit (15~600 sec)	3 30	
KEY_METHOD	OTA key authentication method (app1, app256, app384, app512: app)	app512	
CYCLE_TIME	OTA key authentication cycle (3~60 sec)	30	
SECURE_KEY	Secure key (license key) provided by the vendor	jlqlcHbVqdpj7b4PzBpM2DileBvmHFV/	
ACL_TYPE	Differentiate between allow and deny in 2nd authentication	deny	
ACL_NAME	ACL Filename for the account to be allowed or excluded from 2nd authentication (file access permission is 444)	/usr/baropam/.baro_acl	
DISALLOW_REUSE or ALLOW_REUSE	To prevent a man-in-the-middle attack, if "DISALLOW_REUSE" is set, other users cannot log in during the authentication cycle of the OTA key. If allowed, set "ALLOW_REUSE".	DISALLOW_REUSE	

Note) If connection is impossible due to a MariaDB issue, the configuration information set on the server will be applied.

3) cURL authentication (.baro_curl)

The name curl stands for "**client URL**" and was first released in 1997. That is, the client requests data from the server as a script. BaroPAM requests authentication by calling the http/https authentication site with curl.

The BaroPAM environment setting file must be created by executing the **baro_curl** program, and it must be located under **/usr/baropam**, the directory of the BaroPAM authentication module.

Format)

```
baro_curl -r rate_limit -R rate_time -t cycle_time -k key_method -e encrypt_flag -H hostname -u auth_url -s filename
```

The configuration options of the BaroPAM configuration file are as follows.

Option	Documentation	Set value	Etc
-r	OTA key limited number of times (1~10)	3	
-R	OTA key time limit (15~600 sec)	30	
-t	OTA key authentication cycle (3~60 sec)	30	
-k	OTA key authentication method (app1, app256, app384, app512: app)	app512	
-e	Encryption of configuration files (yes or no)	no	

-H	Server's hostname (uname -n)	nurit.co.kr	
-u	The URL to be called includes parameters such as host name (hostname), user account (username), authentication cycle (cycle_time), and OTA key (auth_key)	http://1.23.456.789/baropam/web/result_curl.jsp	
-s	File name including the directory in which to create the BaroPAM configuration file	/usr/baropam/.baro_curl	

Note) The filename of the -s option is the name of the file including the directory where the BaroPAM configuration file will be created (**file access permission is 444**). If the hostname of the set server does not match, BaroPAM may not operate normally. If the hostname is changed, it must be reflected in the relevant item of the environment setting.

Ex of use)

```
[root] /usr/baropam > ./baro_curl -r 3 -R 30 -t 30 -k app512 -e no -H nurit.co.kr -u
http://1.23.456.789/baropam/web/result_curl.jsp
```

1) Enter "**y**" for all the questions that follow.
Do you want me to update your "/usr/baropam/.baro_curl" file (y/n) **y**
Preventing man-in-the-middle attacks (y/n) **y**

The contents set in **.baro_curl**, a BaroPAM environment setting file, are as follows.

```
[root] /usr/baropam > cat .baro_curl
" AUTH_KEY
" RATE_LIMIT 3 30
" AUTH_URL http://1.23.456.789/baropam/web/result_curl.jsp
" KEY_METHOD app512
" CYCLE_TIME 30
" HOSTNAME baropam
" DISALLOW_REUSE
```

The setting items of **.baro_curl**, a BaroPAM configuration file, are as follows.

Item	Documentation	Set value	Etc
AUTH_KEY	Authentication delimiter (fixed)		
RATE_LIMIT	OTA key limit count (1~10), time limit (15~600 sec)	3 30	
AUTH_URL	The URL to be called includes parameters such as host name (hostname), user account (username), authentication cycle (cycle_time), and OTA key (auth_key)	http://1.23.456.789/baropam/web/result_curl.jsp	
KEY_METHOD	OTA key authentication method (app1, app256, app384, app512: app)	app512	
CYCLE_TIME	OTA key authentication cycle (3~60 sec)	30	
HOSTNAME	Server's hostname (uname -n)	nurit.co.kr	
DISALLOW_REUSE or ALLOW_REUSE	To prevent a man-in-the-middle attack, if "**DISALLOW_REUSE**" is set, other users cannot log in during the authentication cycle of the OTA key. If allowed, set "**ALLOW_REUSE**".	DISALLOW_REUSE	

3.4 BaroPAM environment settings

1) PAM authentication: Set environment setting information in File

To configure the BaroPAM module, enter it at the top as follows to configure **ldap, saslauthd** files.

```
[root] /usr/baropam > vi /etc/pam.d/ldap
#%PAM-1.0
auth     required  pam_env.so
auth     required  /usr/baropam/pam_baro_auth.so forward_pass secret=/usr/baropam/.baro_auth
encrypt=no
account  required  pam_unix.so

[root] /usr/baropam > vi /etc/pam.d/saslauthd
#%PAM-1.0
auth     required  /usr/baropam/pam_baro_auth.so forward_pass secret=/usr/baropam/.baro_auth
encrypt=no
auth     substack  password-auth
account  include   password-auth
```

For reference, the **secret** parameter sets the name of the BaroPAM configuration file, and the **encrypt** parameter sets the encryption/decryption flag (**yes** or **no**) of the BaroPAM configuration file.

If the BaroPAM environment setting file is set for each account, the way to set the **ldap, saslauthd** file to set the BaroPAM module is entered at the top as follows.

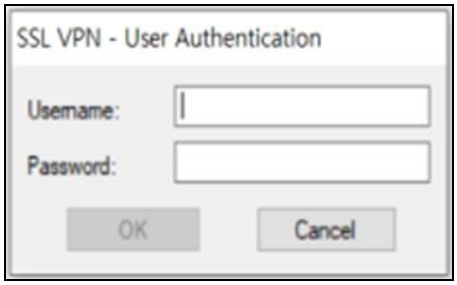
```
[root] /usr/baropam > vi /etc/pam.d/ldap
#%PAM-1.0
auth     required  pam_env.so
auth     required  /usr/baropam/pam_baro_auth.so forward_pass secret=${HOME}/.baro_auth encrypt=no
account  required  pam_unix.so

[root] /usr/baropam > vi /etc/pam.d/saslauthd
#%PAM-1.0
auth     required  /usr/baropam/pam_baro_auth.so forward_pass secret=${HOME}/.baro_auth encrypt=no
auth     substack  password-auth
account  include   password-auth
```

If you want to set different BaroPAM environment configuration files for each account in a specific directory instead of setting BaroPAM environment configuration files for each account, enter the following at the top to configure the BaroPAM module in the sshd file.

```
[root] /usr/baropam > vi /etc/pam.d/ldap
#%PAM-1.0
auth     required  pam_env.so
auth                          required          /usr/baropam/pam_baro_auth.so      forward_pass
secret=/usr/baropam/openldap/.${USER}_auth encrypt=no
account  required  pam_unix.so

[root] /usr/baropam > vi /etc/pam.d/saslauthd
#%PAM-1.0
auth                          required          /usr/baropam/pam_baro_auth.so      forward_pass
```

```
secret=/usr/baropam/openldap/.${USER}_auth encrypt=no
auth     substack  password-auth
account  include   password-auth
```

For programs like filezilla that cannot perform "**Interactive process**", the only way is to use the **forward_pass** option in PAM to enter the **OTA key** when entering the password. In this case, the openssh client, RDP (Remote Desktop Protocol) of Windows, Radius, filezilla, etc. all have no choice but to input like this.



When entering the **OTA key** like a password in the password input window (**Password:**) using **forward_pass**, enter the password first and then enter the **OTA key** without spaces. For example, if the password is "**baropam**" and the OTA key is "**123456**", enter "**baropam123456**".

Using **forward_pass**, you can enable **2nd authentication** for most services that require authentication.

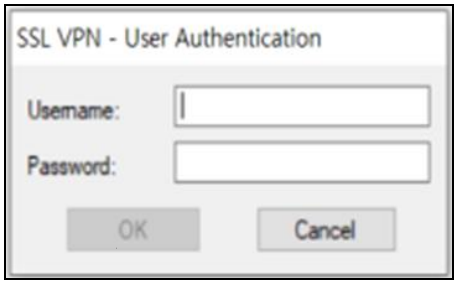
2) PAM authentication: Set environment configuration information in MariaDB

To configure the **BaroPAM** module, enter it at the top as follows to configure **ldap, saslauthd** files.

```
[root] /usr/baropam > vi /etc/pam.d/ldap
#%PAM-1.0
auth     required  pam_env.so
auth     required  /usr/baropam/pam_baro_sql.so forward_pass secret=/usr/baropam/.baro_sql
encrypt=no auth=openldap
account  required  pam_unix.so

[root] /usr/baropam > vi /etc/pam.d/saslauthd
#%PAM-1.0
auth     required  /usr/baropam/pam_baro_sql.so forward_pass secret=/usr/baropam/.baro_sql
encrypt=no auth=openldap
auth     substack  password-auth
account  include   password-auth
```

For reference, the **secret** parameter sets the name of the **BaroPAM** configuration file, and the **encrypt** parameter sets the encryption/decryption flag (**yes** or **no**) of the **BaroPAM** configuration file.

For programs like filezilla that cannot perform "**Interactive process**", the only way is to use the **forward_pass** option in PAM to enter the **OTA key** when entering the password. In this case, the openssh client, RDP (Remote Desktop Protocol) of Windows, Radius, filezilla, etc. all have no choice but to input like this.



When entering the OTA key like a password in the password input window (**Password:**) using **forward_pass**, enter the password first and then enter the OTA key without spaces. For example, if the password is "**baropam**" and the OTA key is "**123456**", enter "**baropam123456**".

Using **forward_pass**, you can enable **2nd authentication** for most services that require authentication.

3) cURL authentication

To configure the BaroPAM module, enter it at the top as follows to configure **ldap, saslauthd** files.

```
[root] /usr/baropam > vi /etc/pam.d/ldap
#%PAM-1.0
auth     required  pam_env.so
auth     required  /usr/baropam/pam_baro_curl.so forward_pass secret=/usr/baropam/.baro_curl
encrypt=no
account  required  pam_unix.so

[root] /usr/baropam > vi /etc/pam.d/saslauthd
#%PAM-1.0
auth     required  /usr/baropam/pam_baro_curl.so forward_pass secret=/usr/baropam/.baro_curl
encrypt=no
auth     substack  password-auth
account  include   password-auth
```

For reference, the **secret** parameter sets the name of the BaroPAM configuration file, and the **encrypt** parameter sets the encryption/decryption flag (yes or no) of the BaroPAM configuration file.

For programs like filezilla, which cannot perform "**Interactive process**", the only way is to use the **forward_pass** option in PAM to enter the password and OTA key together when entering the password. In this case, the openssh client, RDP (Remote Desktop Protocol) of Windows, Radius, filezilla, etc. all have no choice but to input like this.

When entering the OTA key like a password in the password input window (Password:) using forward_pass, enter the password first and then enter the OTA key without spaces. For example, if the password is "baropam" and the OTA key is "123456", enter "baropam123456".

Using forward_pass, you can enable 2nd authentication for most services that require authentication.

4) BaroPAM exclusive allow policy settings

SELinux (Security-Enhanced Linux) is a kernel security module that implements MAC(Mandatory Access Control) to enhance the security of Linux systems.

To use a simple analogy, if traditional Linux permissions operate on the principle that "users with permissions can access all accounts," SELinux acts as a "strict overseer" that restricts access to only specific modules (or files) belonging to specific authorized accounts, even if one has the necessary permissions.

① Key Roles and Features

First, implementation of MAC(Mandatory Access Control)

The existing traditional Linux DAC(Discretionary Access Control) had a weakness in that file owners could arbitrarily grant permissions (such as 777), allowing the entire system to be taken over if a hacker seized root privileges.

A distinguishing feature of SELinux is that security policies set by the system administrator take precedence. Even if a file has 777 permissions, processes not allowed by the policy cannot access it.

Second, Principle of Least Privilege

Grant only the permissions absolutely necessary for the process to operate.

Ex) The web server (Apache) process can only read the web content directory (httpd_sys_content_t) and is blocked from accessing user home directories or system configuration files.

Third, security context-based management

Manage all files, processes, and network ports by attaching "labels".

Format) User:Role:Type:Level

Among these, "Type" is the most critical element, and access is allowed only if the process type and file type match. (This is called Type Enforcement)

② Why you need it

Let's assume a hacker infiltrates the system by exploiting a vulnerability in the web server. In the absence of SELinux, the hacker could steal /etc/shadow (password file) or tamper with the authentication module through the web server (root privileges).

When SELinux is present, if the web server process attempts to access /etc/shadow, SELinux

immediately blocks it, stating, "The web server type does not have permission to read the system password type." There are no exceptions, even for root privileges.

③ How to set up

Previously, when configuring the BaroPAM environment on Red Hat-based systems, the entry "SELINUX=disabled" in the "/etc/sysconfig/selinux" file was changed; however, going forward, you should proceed in the following order without modifying the "/etc/sysconfig/selinux" file.

First, remove permissions for the /usr/baropam directory

```
[root@baropam baropam]# chattr -i /usr/baropam
```

Second, change SELinux to Permissive mode (for log collection)

```
[root@baropam baropam]# setenforce 0
[root@baropam baropam]# getenforce
Permissive
```

Third, BaroPAM test (sshd, su, sudo, login, gdm-password, etc.)

Configuration modules pam_baro_auth.so (default), pam_baro_sql.so (if using the web console)

Fourth, install the audit2allow tool

```
CentOS 8 / Rocky Linux / RHEL 8 or higher:
[root@baropam baropam]# dnf -y install policycoreutils-python-utils

CentOS 7 or lower:
[root@baropam baropam]# yum -y install policycoreutils-python

Ubuntu / Debian: If you are using Selinux
[root@baropam baropam]# apt -y install policycoreutils

Check installation
[root@baropam baropam]# audit2allow --version
audit2allow .1
```

Fifth, check the policy file location

```
[root@baropam baropam]# ls /etc/selinux/targeted/policy/
policy.33
```

Sixth, find denied entries and create a BaroPAM-exclusive allow policy

```
[root@baropam baropam]# grep "denied" /var/log/audit/audit.log | audit2allow -M baropam_policy -p
/etc/selinux/targeted/policy/policy.33
******************** serious ************************
To activate this policy package, do the following:
semodule -i baropam_policy.pp
```

Seventh, register the generated policy module

```
[root@baropam baropam]# semodule -i baropam_policy.pp
```

Eighth, declare the /usr/baropam directory as an 'authentication data only' zone

```
[root@baropam baropam]# semanage fcontext -a -t auth_cache_t "/usr/baropam(/.*)?"
File context for /usr/baropam(/.*)? already defined, modifying instead
```

Ninth, apply to actual files

```
[root@baropam baropam]# restorecon -Rv /usr/baropam
```

Tenth, change SELinux to Enforcing mode

```
[root@baropam baropam]# setenforce 1
[root@baropam baropam]# getenforce
Enforcing
```

Eleventh, BaroPAM test (sshd, su, sudo, login, gdm-password, etc.)

5) ACL(Access Control list) settings

① In the case of PAM authentication (Set environment setting information in File) When using the BaroPAM module, if it is necessary to exclude from the ACL for the account to be excluded from the 2nd authentication, create an ACL file in the directory set when setting the BaroPAM environment, and enter the account to be excluded as follows. (**The file access permission for .baro_acl must be set to 444.**)

```
[root] /usr/baropam > vi .baro_acl
barokey
baropam
```

② In case of PAM authentication (Set environment configuration information in MariaDB), Mariadb's ACL setting table must be used.

6) NTP(Network Time Protocol) settings

Since BaroPAM is a time synchronization method, if the server's time is different from the current time, login to the server may not be possible because the OTA keys do not match.

Recently, as a method of time synchronization (time server time synchronization) for information assets, the system time can be set to the current time in the root account using NTP (Network Time Protocol).

To use NTP, the NTP package must be installed by default. To check the installation, run the following command. If it is not installed, use the command "**yum install ntp**" for Redhat, CentOS 8 or lower, and "**sudo apt-get install ntp**" for others.

```
[root]# rpm -qa | grep ntp
ntp-4.2.2p1-18.el5.centos
chkfontpath-1.10.1-1.1
```

The following command can be used to register the ntpd service in the startup program when booting the server and to check whether ntp is activated.

```
[root]# chkconfig ntpd on
[root]# chkconfig —list | grep ntp
ntpd            0:off  1:off  2:on  3:on  4:on  5:on  6:off
```

Check whether the ntpd daemon is active when booting the server using chkconfig. If it is off in level 3 and 5, it is not activated automatically. To activate automatically, you must change 3 and 5 to on (active) with the following command.

```
[root]# chkconfig —level 3 ntpd on
[root]# chkconfig —level 5 ntpd on
```

NTP servers operating in Korea are as follows.

```
server kr.pool.ntp.org
server time.bora.net
```

Set the NTP server operating in Korea in "**/etc/ntp.conf**", the configuration file for the ntpd daemon configuration, as follows.

```
[root]# vi /etc/ntp.conf
# Use public servers from the pool.ntp.org project.
# Please consider joining the pool (http://www.pool.ntp.org/join.html).
#server 0.centos.pool.ntp.org
#server 1.centos.pool.ntp.org
#server 2.centos.pool.ntp.org
#server 3.centos.pool.ntp.org
server kr.pool.ntp.org iburst minpoll 7 maxpoll 10
server time.bora.net   iburst minpoll 7 maxpoll 10
```

The **iburst** option is a kind of option setting that shortens the time required for synchronization.

The **minpoll** and **maxpoll** options are options that set the minimum and maximum intervals for requesting time information from the NTP server (Polling Interval) in the NTP settings

These values are not times in seconds, but exponential values calculated as powers of 2.

Actual polling interval (seconds) = $2^{\text{set value}}$

The minpoll (minimum polling interval) option specifies the shortest minimum interval at which an NTP client requests time information from an NTP server.

The default is usually set to 6, which means 2^6 = 64 seconds, meaning one request every 64 seconds.

The setting range is generally set from 3 (8 seconds), and the allowable range may vary depending on the environment.

The maxpoll (maximum polling interval) option specifies the longest maximum interval at which an NTP client requests time information from an NTP server.

The default is usually set to 10. 2^{10} = 1024 seconds, meaning one request every 1024 seconds.

The setting range is generally set to 17 (approximately 36.4 hours), but the allowable range may vary depending on the environment.

As the system clock accuracy improves, NTP gradually increases the polling interval (toward the maxpoll value) to reduce network traffic. Conversely, as the clock error increases or becomes unstable, NTP shortens the polling interval (toward the minpoll value) to quickly restore synchronization. These two values are crucial factors in determining the flexibility and efficiency of NTP synchronization.

After the setup for the ntpd daemon setup is complete, it is absolutely necessary to restart the NTP daemon after confirming that the NTP setup has been properly added.

```
[root]# /etc/init.d/ntpd restart
Stopping ntpd: [  OK  ]
Starting ntpd: [  OK  ]
```

You can check the ntpd time with the following command.

```
[root]# ntpq -p
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
*121.174.142.82  220.73.142.66    3 u  791 1024  377    9.333   -4.250   0.428
+time.bora.net   58.224.35.2      3 u  654 1024  367    2.926  -27.295  24.481
 183.110.225.61  .INIT.          16 u    - 1024    0    0.000    0.000   0.000
 LOCAL(0)        .LOCL.          10 l   39   64  377    0.000    0.000   0.001
```

* The displayed ip is the ntp server getting the current time

To use NTP, the NTP package must be installed by default. To check the installation, run the following command. If it is not installed, use the "**dnf install chrony**" command to install Redhat, CentOS 8 or later versions.

```
[root@baropam ~]# rpm -qa | grep chrony
chrony-3.5-1.el8.x86_64
```

NTP servers operating in Korea are as follows.

```
server kr.pool.ntp.org
server time.bora.net
```

Set the NTP server operating in Korea in "**/etc/chrony.conf**", the configuration file for the ntpd daemon configuration, as follows.

```
[root@baropam ~]# vi /etc/chrony.conf

# Use public servers from the pool.ntp.org project.
# Please consider joining the pool (http://www.pool.ntp.org/join.html).
#pool 2.centos.pool.ntp.org iburst
server kr.pool.ntp.org iburst minpoll 7 maxpoll 10
server time.bora.net   iburst minpoll 7 maxpoll 10

# Record the rate at which the system clock gains/losses time.
driftfile /var/lib/chrony/drift
```

```
# Allow the system clock to be stepped in the first three updates
# if its offset is larger than 1 second.
makestep 1.0 3

# Enable kernel synchronization of the real-time clock (RTC).
rtcsync

# Enable hardware timestamping on all interfaces that support it.
#hwtimestamp *

# Increase the minimum number of selectable sources required to adjust
# the system clock.
#minsources 2

# Allow NTP client access from local network.
allow 192.168.0.0/16

# Serve time even if not synchronized to a time source.
#local stratum 10

# Specify file containing keys for NTP authentication.
keyfile /etc/chrony.keys

# Get TAI-UTC offset and leap seconds from the system tz database.
leapsectz right/UTC

# Specify directory for log files.
logdir /var/log/chrony

# Select which information is logged.
#log measurements statistics tracking
```

After the setup for the ntpd daemon setup is complete, it is absolutely necessary to restart the NTP daemon after confirming that the NTP setup has been properly added. (Starting chrony service and registering drive when booting)

```
[root@baropam ~]# sudo systemctl enable chronyd
[root@baropam ~]# sudo systemctl restart chronyd
```

You can check the ntpd time with the following command.

List of servers receiving time / list of servers registered in chrony.conf file)

```
[root@baropam ~]# chronyc sources -v
210 Number of sources = 2
MS Name/IP address         Stratum Poll Reach LastRx Last sample
===============================================================================
^* ec2-54-180-134-81.ap-nor>     2   6   377    43   -349us[-1059us] +/-   24ms
^- time.bora.net                 2   6   377    42  +1398us[+1398us] +/-   90ms
```

Server information receiving time)

```
[root@baropam ~]# chronyc tracking
Reference ID    : 36B48651 (ec2-54-180-134-81.ap-northeast-2.compute.amazonaw)
Stratum         : 3
Ref time (UTC)  : Sun Mar 22 07:07:43 2020
System time     : 0.000130027 seconds slow of NTP time
Last offset     : -0.000710122 seconds
RMS offset      : 0.000583203 seconds
Frequency       : 19.980 ppm fast
Residual freq   : +0.142 ppm
Skew            : 3.235 ppm
Root delay      : 0.013462566 seconds
Root dispersion : 0.017946836 seconds
Update interval : 65.0 seconds
Leap status     : Normal
```

Check information such as time status and synchronization)

```
[root@baropam ~]# timedatectl status
               Local time: Sun 2020-03-22 16:08:45 KST
           Universal time: Sun 2020-03-22 07:08:45 UTC
                 RTC time: Sun 2020-03-22 07:08:44
                Time zone: Asia/Seoul (KST, +0900)
System clock synchronized: yes
              NTP service: active
          RTC in local TZ: no
```

4. OpenLDAP integration testing

4.1 Environment setting

1) saslauthd configuration (relay role)

Configure saslauthd to look at the Rocky Linux system's PAM instead of the internal DB.

```
[root@baropam ~]# vi /etc/sysconfig/saslauthd
# Directory in which to place saslauthd's listening socket, pid file, and so
# on.  This directory must already exist.
SOCKETDIR=/run/saslauthd

# Mechanism to use when checking passwords.  Run "saslauthd -v" to get a list
# of which mechanism your installation was compiled with the ablity to use.
MECH=pam

# Additional flags to pass to saslauthd on the command line.  See saslauthd(8)
# for the list of accepted flags.
FLAGS=

[root@baropam ~]# systemctl enable saslauthd
Created       symlink       /etc/systemd/system/multi-user.target.wants/saslauthd.service       →
/usr/lib/systemd/system/saslauthd.service.

[root@baropam ~]# vi /usr/lib/systemd/system/saslauthd.service
[Unit]
Description=SASL authentication daemon.

[Service]
Type=forking
PIDFile=/run/saslauthd/saslauthd.pid
EnvironmentFile=/etc/sysconfig/saslauthd
ExecStart=/usr/sbin/saslauthd -m $SOCKETDIR -a $MECH $FLAGS
RuntimeDirectory=saslauthd

Restart=on-failure
RestartSec=5s
StartLimitIntervalSec=600
StartLimitBurst=5

[Install]
WantedBy=multi-user.target

[root@baropam ~]# systemctl daemon-reload
[root@baropam ~]# systemctl restart saslauthd.service
```

2) OpenLDAP (slapd) Configuration (Bypass/Proxy)

Configure OpenLDAP so that when it receives a request, it does not process it directly but passes it to SASL.

```
[root@baropam ~]# vi /etc/sasl2/slapd.conf
pwcheck_method: saslauthd
mech_list: plain login

[root@baropam ~]# systemctl restart slapd
```

4.2 Create user account

1) Create a Linux user account

Create a local account to test as follows.

```
[root@baropam ~]# useradd baropam
[root@baropam ~]# passwd baropam
Changing password for user raduser.
New password: baropam
Retype new password: baropam
passwd: all authentication tokens updated successfully.
```

2) Create OpenLDAP user account

baropam user DN creation)

To ensure that OpenLDAP user passwords are authenticated by the system instead of being stored (delegating authentication to saslauthd), you must use the format *{SASL}username* for the userPassword property.

```
[root@baropam ~]# vi add_baropam.ldif
dn: uid=baropam,ou=HR,ou=departments,dc=example,dc=com
objectClass: top
objectClass: inetOrgPerson
objectClass: posixAccount
objectClass: shadowAccount
sn: baropam
cn: baropam
uid: baropam
uidNumber: 1000
gidNumber: 1000
homeDirectory: /home/baropam
loginShell: /bin/bash
gecos: BaroPAM User
userPassword: {SASL}baropam
shadowLastChange: 0
shadowMax: 99999
shadowWarning: 7
```

Apply baropam user DN)

```
[root@baropam ~]# ldapadd -x -D "cn=admin,dc=example,dc=com" -W -f add_baropam.ldif
Enter LDAP Password: baropam
adding new entry "uid=baropam,ou=HR,ou=departments,dc=example,dc=com"
```

Look up personnel belonging to the HR department)

```
[root@baropam ~]# ldapsearch -x -b  "ou=HR,ou=departments,dc=example,dc=com" "(objectClass=person)"
cn
# extended LDIF
#
# LDAPv3
# base <ou=HR,ou=departments,dc=example,dc=com> with scope subtree
# filter: (objectClass=person)
# requesting: cn
#

# honggildong, HR, departments, example.com
dn: uid=honggildong,ou=HR,ou=departments,dc=example,dc=com
cn: nurit

# search result
search: 2
result: 0 Success

# numResponses: 2
# numEntries: 1
```

4.3 Integration testing

1) Verify integration within the server (saslauthd <-> BaroPAM)

Before using the OpenLDAP client, verify it first with testsaslauthd. Since testsaslauthd assumes the service name is an imap by default and requests authentication from PAM, you must create a symbolic link.

```
[root@baropam ~]# ln -s /etc/pam.d/saslauthd /etc/pam.d/imap

[root@baropam ~]# testsaslauthd -u baropam -p baropam935018
0: OK "Success."
```

On success: 0: Prints OK "Success."
On failure: 0: Prints NO "authentication failed"

Note)
$ systemctl start   saslauthd ->Service start
$ systemctl stop   saslauthd ->Service stop
$ systemctl restart saslauthd ->Service restart

$ systemctl status saslauthd ->Service status

2) Remote test from User (PC) (PC <-> OpenLDAP <-> saslauthd <-> BaroPAM)

Attempt SASL authentication on a PC using tools such as ldapwhoami.

```
[root@baropam ~]# ldapwhoami -h localhost -D "uid=baropam,ou=HR,ou=departments,dc=example,dc=com" -x -w "baropam566419"
dn:uid=baropam,ou=HR,ou=departments,dc=example,dc=com
```

On success: Prints dn: baropam,ou=HR,ou=departments,dc=example,dc=com
On failure: Invalid credentials (49) error occurred.

Note) If an error occurs, check the /var/log/messages and /var/log/secure logs to take action.

5. About BaroPAM

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