SELinux fun with MySQL and friends

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Who am I?

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- Living in Ghent, Belgium
- Bachelor Computer Science
- ~20 years Linux user / admin
- ~10 years PHP developer
- ~8 years MySQL DBA
- 3rd year at Pythian
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AGENDA

- What is SELinux
- MySQL and SELinux
- ProxySQL and SELinux
- Alternatives

What is SELinux

What is SELinux?

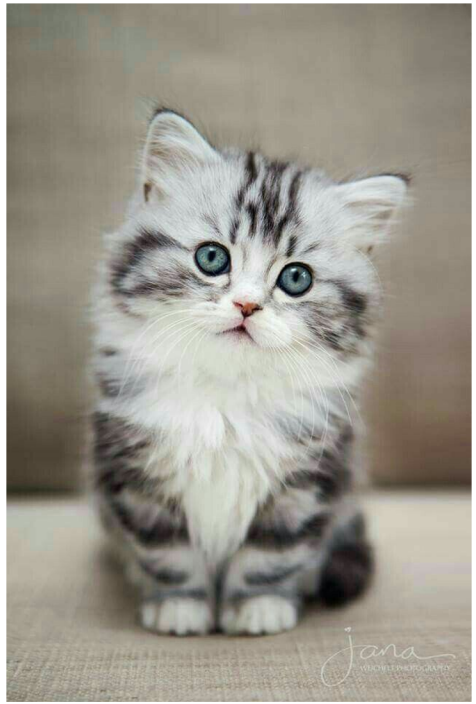
"Security-Enhanced Linux is a Linux kernel security module that provides a mechanism for supporting access control security policies, including mandatory access controls. SELinux is a set of kernel modifications and user-space tools that have been added to various Linux distributions. "
-- Wikipedia

- Originally developed by NSA and Red Hat
- Set of kernel modules to enhance security

What is SELinux?

- 3 modes
  - Enforcing
  - Permissive
  - Disabled
- Default installed on any Red Hat Enterprise Linux (RHEL) or CentOS distributions and set to "Enforcing" by default
- A wise man once said:

"Every time you disable SELinux a kitten dies!"



What is SELinux?

- Truth is - mostly the compliance / security teams will bite you if you disable SELinux
- Usually part of the security audit trails
- By default there is a **deny** policy
  - Anything you don't specifically allow will be denied.
- Useful tool to install: `policycoreutils-python`
  - This package provides a lot of tools to manage and define your SELinux policies.
- If you want to go more in depth the tool `policycoreutils-devel` might also be interesting

Check current SELinux status

- Use the tool `sestatus`

```
[root@localhost ~]# sestatus
SELinux status:                 enabled
SELinuxfs mount:                /sys/fs/selinux
SELinux root directory:         /etc/selinux
Loaded policy name:             targeted
Current mode:                   enforcing
Mode from config file:          enforcing
Policy MLS status:              enabled
Policy deny_unknown status:     allowed
Max kernel policy version:      31
```

- Quickly dynamically changing the status: `setenforce` / `getenforce`

```
[root@localhost ~]# getenforce
Enforcing
[root@localhost ~]# setenforce permissive
[root@localhost ~]# getenforce
Permissive
```

Remember the kittens!

SELinux: users, policies, contexts

- There is no 1:1 mapping between Linux system-users and SELinux users (however there can be).
- Use the `semanage` tool to manage the SELinux users and to map Linux system-users to SELinux users:

```
[root@localhost ~]# semanage user -l
                Labeling   MLS/       MLS/
SELinux User    Prefix     MCS Level  MCS Range                      SELinux Roles
guest_u         user       s0         s0                             guest_r
root            user       s0         s0-s0:c0.c1023                 staff_r sysadm_r system_r unconfined_r
staff_u         user       s0         s0-s0:c0.c1023                 staff_r sysadm_r system_r unconfined_r
user_u          user       s0         s0                             user_r
...
[root@localhost ~]# semanage login -a -s user_u john
[root@localhost ~]# semanage login -l
Login Name           SELinux User         MLS/MCS Range        Service
__default__          unconfined_u         s0-s0:c0.c1023       *
john                 user_u               s0                   *
...
```

SELinux: users, policies, contexts

- SELinux adds a `-Z` option to `ls` or `ps` to check the context of the process or the file.

```
[root@localhost ~]# ls -hlZ /var/lib/mysql/
...
-rw-rw----. mysql mysql system_u:object_r:mysqld_db_t:s0 ibdata1
-rw-rw----. mysql mysql system_u:object_r:mysqld_db_t:s0 ib_logfile0
-rw-rw----. mysql mysql system_u:object_r:mysqld_db_t:s0 ib_logfile1
drwx------. mysql mysql system_u:object_r:mysqld_db_t:s0 mysql
srwxrwxrwx. mysql mysql system_u:object_r:mysqld_var_run_t:s0 mysql.sock
drwx------. mysql mysql system_u:object_r:mysqld_db_t:s0 performance_schema
drwx------. mysql mysql system_u:object_r:mysqld_db_t:s0 test
...

[root@localhost ~]# ps -eZ | grep mysql
system_u:system_r:mysqld_safe_t:s0 4143 ?      00:00:00 mysqld_safe
system_u:system_r:mysqld_t:s0    4305 ?        00:00:00 mysqld
```

- Contexts are defined: `user:role:type:level`

MySQL and SELinux

MySQL and SELinux

- Out of the box experience is so that everything works!
- There is a predefined policy

```
[root@localhost ~]# semanage module -l | grep mysql
mysql                   100       pp
```

- MySQL contexts are predefined and pretty granular

```
[root@localhost ~]# semanage fcontext -l | grep mysql
/etc/mysql(/.*)?                                   all files          system_u:object_r:mysqld_etc_t:s0
/etc/my\.cnf\.d(/.*)?                              all files          system_u:object_r:mysqld_etc_t:s0
/var/log/mysql.*                                   regular file       system_u:object_r:mysqld_log_t:s0
/var/lib/mysql(-files|-keyring)?(/.*)?             all files          system_u:object_r:mysqld_db_t:s0
/var/run/mysqld(/.*)?                              all files          system_u:object_r:mysqld_var_run_t:s0
/usr/sbin/mysqld(-max)?                            regular file       system_u:object_r:mysqld_exec_t:s0
/usr/lib/systemd/system/mysqld.*                   regular file       system_u:object_r:mysqld_unit_file_t:s0
/etc/my\.cnf                                       regular file       system_u:object_r:mysqld_etc_t:s0
/root/\.my\.cnf                                    regular file       system_u:object_r:mysqld_home_t:s0
/usr/sbin/ndbd                                     regular file       system_u:object_r:mysqld_exec_t:s0
/usr/libexec/mysqld                                regular file       system_u:object_r:mysqld_exec_t:s0
/usr/bin/mysqld_safe                               regular file       system_u:object_r:mysqld_safe_exec_t:s0
/usr/bin/mysql_upgrade                             regular file       system_u:object_r:mysqld_exec_t:s0
/etc/rc\.d/init\.d/mysqld                          regular file       system_u:object_r:mysqld_initrc_exec_t:s0
/var/lib/mysql/mysql\.sock                         socket             system_u:object_r:mysqld_var_run_t:s0
/home/[^/]+/\.my\.cnf                              regular file       unconfined_u:object_r:mysqld_home_t:s0
```

Custom data directory

```
[root@localhost ~]# mkdir -p /data/mysql
[root@localhost ~]# chown mysql:mysql /data/mysql/
[root@localhost ~]# ls -hlZa /data/mysql/
drwxr-xr-x. mysql mysql unconfined_u:object_r:default_t:s0 .
drwxr-xr-x. root  root  unconfined_u:object_r:default_t:s0 ..

[root@localhost ~]# systemctl start mariadb.service
Job for mariadb.service failed because the control process exited with error code. See "systemctl status mariadb.service" and
"journalctl -xe" for details.

[root@localhost ~]# cat /var/log/audit/audit.log | audit2allow -w -a
type=AVC msg=audit(1578508437.315:664): avc:  denied  { write } for  pid=7047 comm="mysqld" name="mysql" dev="sda1" ino=1179650
scontext=system_u:system_r:mysqld_t:s0 tcontext=unconfined_u:object_r:default_t:s0 tclass=dir permissive=0
              Was caused by:
                            Missing type enforcement (TE) allow rule.

                            You can use audit2allow to generate a loadable module to allow this access.

[root@localhost ~]#
```

Custom data directory

- Finding the correct data directory context

```
[root@localhost ~]# semanage fcontext -l | grep /var/lib/mysql
/var/lib/mysql(-files|-keyring)?(/.*)?             all files          system_u:object_r:mysqld_db_t:s0
/var/lib/mysql/mysql\.sock                         socket             system_u:object_r:mysqld_var_run_t:s0
```

- Setting the context on the new directory

```
[root@localhost ~]# semanage fcontext -a -t mysqld_db_t '/data/mysql(/.*)?'
[root@localhost ~]# ls -hlZa /data/mysql
drwxr-xr-x. root root unconfined_u:object_r:default_t:s0 .
drwxr-xr-x. root root unconfined_u:object_r:default_t:s0 ..
[root@localhost ~]#
```

Wait? What!

Custom data directory

- Applying the context to the folder

```
[root@localhost ~]# restorecon -v /data/mysql/
restorecon reset /data/mysql context unconfined_u:object_r:default_t:s0->unconfined_u:object_r:mysqld_db_t:s0

[root@localhost ~]# ls -hlZa /data/mysql
drwxr-xr-x. mysql mysql unconfined_u:object_r:mysqld_db_t:s0 .
drwxr-xr-x. root  root  unconfined_u:object_r:default_t:s0 ..
```

- Starting the server

```
[root@localhost ~]# systemctl start mariadb.service
[root@localhost ~]# systemctl status mariadb.service
● mariadb.service - MariaDB database server
...
   Active: active (running) since Thu 2020-01-09 08:40:40 UTC; 30s ago
...
 Main PID: 27027 (mysqld_safe)
   CGroup: /system.slice/mariadb.service
           ├─27027 /bin/sh /usr/bin/mysqld_safe --basedir=/usr
           └─27201 /usr/libexec/mysqld --basedir=/usr --datadir=/data/mysql --plugin-
dir=/usr/lib64/mysql/plugin --log-error=/var/log/mariadb/mariadb.log --pid-file=/var/run/mariadb/mariadb.pid
--socket=/var/lib/mysql/mysql.sock
```

Custom port

- We want our MySQL instance to run on port 3307 so we add `port = 3307` to the `[mysqld]` section in `my.cnf`
- Restarting the service

```
[root@localhost ~]# systemctl start mariadb.service
Job for mariadb.service failed because the control process exited with error code. See "systemctl status
mariadb.service" and "journalctl -xe" for details.


[root@localhost ~]# systemctl status mariadb.service
● mariadb.service - MariaDB database server
...
Jan 09 08:44:52 localhost.localdomain systemd[1]: mariadb.service: control process exited, code=exited
status=1
Jan 09 08:44:52 localhost.localdomain systemd[1]: Failed to start MariaDB database server.
Jan 09 08:44:52 localhost.localdomain systemd[1]: Unit mariadb.service entered failed state.
Jan 09 08:44:52 localhost.localdomain systemd[1]: mariadb.service failed.
```

Custom port

- checking journalctl

```
-- Unit mariadb.service has begun starting up.
Jan 09 08:44:46 localhost.localdomain mariadb-prepare-db-dir[27302]: Database MariaDB is probably initialized
in /data/mysql already, nothing is done.
Jan 09 08:44:46 localhost.localdomain mariadb-prepare-db-dir[27302]: If this is not the case, make sure the
/data/mysql is empty before running mariadb-prepare-db-dir.
Jan 09 08:44:46 localhost.localdomain mysqld_safe[27336]: 200109 08:44:46 mysqld_safe Logging to
'/var/log/mariadb/mariadb.log'.
Jan 09 08:44:46 localhost.localdomain mysqld_safe[27336]: 200109 08:44:46 mysqld_safe Starting mysqld daemon
with databases from /data/mysql
Jan 09 08:44:52 localhost.localdomain systemd[1]: mariadb.service: control process exited, code=exited
status=1
Jan 09 08:44:52 localhost.localdomain systemd[1]: Failed to start MariaDB database server.-- Subject: Unit
mariadb.service has failed
```

- checking error log

```
200109  8:44:48 [Note] Server socket created on IP: '0.0.0.0'.
200109  8:44:48 [ERROR] Can't start server: Bind on TCP/IP port. Got error: 13: Permission denied
200109  8:44:48 [ERROR] Do you already have another mysqld server running on port: 3307 ?
200109  8:44:48 [ERROR] Aborting
```

Custom port

- Already in use?

```
[root@localhost ~]# netstat -lntp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name
tcp        0      0 0.0.0.0:111             0.0.0.0:*               LISTEN      1/systemd
tcp        0      0 0.0.0.0:22              0.0.0.0:*               LISTEN      2438/sshd
tcp        0      0 127.0.0.1:25            0.0.0.0:*               LISTEN      2674/master
tcp6       0      0 :::111                  :::*                    LISTEN      1/systemd
tcp6       0      0 :::22                   :::*                    LISTEN      2438/sshd
tcp6       0      0 ::1:25                  :::*                    LISTEN      2674/master
[root@localhost ~]#
```

Custom port

- SELinux also defines the port(s) a service can use!

```
[root@localhost ~]# cat /var/log/audit/audit.log | audit2allow -w -a
type=AVC msg=audit(1578559488.003:936): avc:  denied  { name_bind } for  pid=27525 comm="mysqld" src=3307
scontext=system_u:system_r:mysqld_t:s0 tcontext=system_u:object_r:unreserved_port_t:s0 tclass=tcp_socket
permissive=0
               Was caused by:
               The boolean nis_enabled was set incorrectly.
               Description:
               Allow nis to enabled

               Allow access by executing:
               # setsebool -P nis_enabled 1
```

Custom port

- Setting the `nis_enabled` boolean works...

```
[root@localhost ~]# setsebool -P nis_enabled 1
[root@localhost ~]# systemctl start mariadb.service
[root@localhost ~]# netstat -lntp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name
tcp        0      0 0.0.0.0:3307            0.0.0.0:*               LISTEN      27908/mysqld
...
[root@localhost ~]# systemctl stop mariadb.service
[root@localhost ~]# setsebool -P nis_enabled 0
[root@localhost ~]# systemctl start mariadb.service
Job for mariadb.service failed because the control process exited with error code. See "systemctl status
mariadb.service" and "journalctl -xe" for details.
```

- But what does `nis_enabled` do really?
  - Allows a process to bind to any port

Custom port

- ... the compliance team may or may not like that level of freedom (usually they don't)

```
[root@localhost ~]# semanage port -l | grep mysql
mysqld_port_t                  tcp      1186, 3306, 63132-63164
mysqlmanagerd_port_t           tcp      2273
[root@localhost ~]# semanage port -a -t mysqld_port_t -p tcp 3307
[root@localhost ~]# semanage port -l | grep mysql
mysqld_port_t                  tcp      3307, 1186, 3306, 63132-63164
mysqlmanagerd_port_t           tcp      2273
[root@localhost ~]# systemctl start mariadb.service
[root@localhost ~]# systemctl status mariadb.service
● mariadb.service - MariaDB database server
   Loaded: loaded (/usr/lib/systemd/system/mariadb.service; disabled; vendor preset: disabled)
   Active: active (running) since Thu 2020-01-09 09:07:34 UTC; 27s ago
  Process: 28313 ExecStartPost=/usr/libexec/mariadb-wait-ready $MAINPID (code=exited, status=0/SUCCESS)
  Process: 28278 ExecStartPre=/usr/libexec/mariadb-prepare-db-dir %n (code=exited, status=0/SUCCESS)
 Main PID: 28312 (mysqld_safe)
   CGroup: /system.slice/mariadb.service
           ├─28312 /bin/sh /usr/bin/mysqld_safe --basedir=/usr
           └─28501 /usr/libexec/mysqld --basedir=/usr --datadir=/data/mysql --plugin-
dir=/usr/lib64/mysql/plugin --log-error=/var/log/mariadb/mariadb.log --pid-file=/var/run/mariadb/mariadb.pid
--socket=/var/lib/mysql/mysql.sock --port=3307
```

ProxySQL and SELinux

ProxySQL and SELinux

- ProxySQL contexts are not defined

```
[root@localhost ~]# sestatus
SELinux status:                 enabled
...
Current mode:                   enforcing
...
[root@localhost ~]# systemctl status proxysql
● proxysql.service - High Performance Advanced Proxy for MySQL
...
   Active: active (running) since Thu 2020-01-09 09:18:12 UTC; 4s ago
...
[root@localhost ~]# ps -eZ | grep proxysql
system_u:system_r:unconfined_service_t:s0 4421 ? 00:00:00 proxysql
system_u:system_r:unconfined_service_t:s0 4422 ? 00:00:13 proxysql
[root@localhost ~]# ls -hlZa /var/lib/proxysql/
drwxr-xr-x. proxysql proxysql unconfined_u:object_r:var_lib_t:s0 .
drwxr-xr-x. root     root     system_u:object_r:var_lib_t:s0   ..
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   proxysql.db
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   proxysql.log
-rw-r--r--. proxysql proxysql system_u:object_r:var_lib_t:s0   proxysql.pid
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   proxysql_stats.db
[root@localhost ~]#
```

ProxySQL and SELinux

- It works out of the box! Why should we bother?
- Our log rotation fails!

```
[root@localhost ~]# tail -f /var/log/cron /var/log/messages
==> /var/log/messages <==
Jan  9 10:02:01 localhost systemd: Created slice User Slice of root.
Jan  9 10:02:01 localhost systemd: Started Session 12 of user root.

==> /var/log/cron <==
Jan  9 10:02:01 localhost CROND[4502]: (root) CMD (/etc/logrotate-proxysql)

==> /var/log/messages <==
Jan  9 10:02:01 localhost logrotate: ALERT exited abnormally with [1]
Jan  9 10:02:01 localhost systemd: Removed slice User Slice of root.

[root@localhost ~]# tail /var/spool/mail/root
From: "(Cron Daemon)" <root@localhost.localdomain>
To: root@localhost.localdomain
Subject: Cron <root@localhost> /etc/logrotate-proxysql
Date: Thu,  9 Jan 2020 10:02:02 +0000 (UTC)

error: error renaming /var/lib/proxysql/proxysql.log.2.gz to /var/lib/proxysql/proxysql.log.3.gz:
Permission denied

[root@localhost ~]#
```

ProxySQL log rotation

Seems to work?
... but not in crontab!

```
[root@localhost ~]# logrotate -fv /etc/logrotate.d/proxysql
reading config file /etc/logrotate.d/proxysql
Allocating hash table for state file, size 15360 B

Handling 1 logs

rotating pattern: /var/lib/proxysql/proxysql.log  forced from command line (5 rotations)
empty log files are rotated, old logs are removed
considering log /var/lib/proxysql/proxysql.log
  log needs rotating
rotating log /var/lib/proxysql/proxysql.log, log->rotateCount is 5
dateext suffix '-20200109'
glob pattern '-[0-9][0-9][0-9][0-9][0-9][0-9][0-9][0-9]'
renaming /var/lib/proxysql/proxysql.log.5.gz to /var/lib/proxysql/proxysql.log.6.gz (rotatecount 5, logstart
1, i 5),
...
fscreate context set to system_u:object_r:var_lib_t:s0
renaming /var/lib/proxysql/proxysql.log to /var/lib/proxysql/proxysql.log.1
creating new /var/lib/proxysql/proxysql.log mode = 0600 uid = 997 gid = 993
running postrotate script
compressing log with: /bin/gzip
set default create context to system_u:object_r:var_lib_t:s0
set default create context
[root@localhost ~]#
```

To the audit log!

- Let's see what our audit log has to say about this

```
[root@localhost ~]# tail /var/log/audit/audit.log | audit2allow -w -a
type=AVC msg=audit(1578564661.266:480): avc:  denied  { rename } for  pid=4587
comm="logrotate" name="proxysql.log.3.gz" dev="sda1" ino=1835792
scontext=system_u:system_r:logrotate_t:s0-s0:c0.c1023
tcontext=system_u:object_r:var_lib_t:s0 tclass=file permissive=0
            Was caused by:
                        Missing type enforcement (TE) allow rule.

                        You can use audit2allow to generate a loadable module to allow
this access.
```

Let's create a policy for that!

```
[root@localhost ~]# tail /var/log/audit/audit.log | audit2allow -m proxysql > proxysql.te
[root@localhost ~]# cat proxysql.te

module proxysql 1.0;

require {
        type logrotate_t;
        type var_lib_t;
        class file rename;
}

#============= logrotate_t ==============
allow logrotate_t var_lib_t:file rename;

[root@localhost ~]# checkmodule -M -m -o proxysql.mod proxysql.te
checkmodule:  loading policy configuration from proxysql.te
checkmodule:  policy configuration loaded
checkmodule:  writing binary representation (version 19) to proxysql.mod
[root@localhost ~]# semodule_package -o proxysql.pp -m proxysql.mod
[root@localhost ~]# semodule -i proxysql.pp
[root@localhost ~]# semodule -l | grep proxysql
proxysql        1.0
[root@localhost ~]#
```

Still not working?

- This policy just allows for the rename

```
#============= logrotate_t ==============
allow logrotate_t var_lib_t:file rename;
```

- More operations are required to make this work.
- How to figure out all that is required for a process?
  1. Set SELinux to permissive
  2. Run the process
  3. Use audit2allow to generate policy file based on audit log
  4. Compile and load the policy
  5. Repeat 2-4 if still not working
  6. Set SELinux back to enforcing

Final policy

- After a few iterations this is the policy we ended up with:

```
module proxysql 1.0.0;

require {
        type var_lib_t;
        type logrotate_t;
        type unreserved_port_t;
        class tcp_socket name_connect;
        class file { create rename setattr unlink write };
}

#============= logrotate_t ==============
# Allow connecting to ProxySQL Admin port 6032
allow logrotate_t unreserved_port_t:tcp_socket name_connect;

# Allow modifying the log files in /var/lib/proxysql
allow logrotate_t var_lib_t:file { create rename setattr unlink write };
```

Great success!

- No more errors, and our logs are getting rotated

```
[root@localhost ~]# tail -f /var/log/cron /var/log/messages
==> /var/log/messages <==
Jan  9 10:25:01 localhost systemd: Created slice User Slice of root.
Jan  9 10:25:01 localhost systemd: Started Session 36 of user root.

==> /var/log/cron <==
Jan  9 10:25:01 localhost CROND[4808]: (root) CMD (/etc/logrotate-proxysql)

==> /var/log/messages <==
Jan  9 10:25:01 localhost systemd: Removed slice User Slice of root.

[root@localhost ~]# ls -hlZ /var/lib/proxysql/proxysql.log*
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   /var/lib/proxysql/proxysql.log
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   /var/lib/proxysql/proxysql.log.1.gz
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   /var/lib/proxysql/proxysql.log.2.gz
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   /var/lib/proxysql/proxysql.log.3.gz
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   /var/lib/proxysql/proxysql.log.4.gz
-rw-------. proxysql proxysql system_u:object_r:var_lib_t:s0   /var/lib/proxysql/proxysql.log.5.gz
```

Best solution?

- Is this the best solution? Probably not...
  - This allows logrotate in cron to delete, rename, .. any file (if it has the regular filesystem permissions to do so) in /var/lib
- What would be better?
  - We should define a ProxySQL SELinux policy
  - Define the granular contexts for all the different files the proxy creates (database files, log files, pid files, sockets, ...)
  - Ensure that the daemon runs as it's own SELinux user

Alternatives

Alternatives to SELinux

- Most well known alternative is "AppArmor"
- Default on SUSE Linux Enterprise Servers (SLES), openSUSE and Debian based platforms (including Ubuntu)
- Some key differences between SELinux and AppArmor
  - AppArmor is path based instead of inode, example creating a hardlink to a file/folder may change the accessibility of this object
  - Different methods of administration
  - SELinux supports a "remote policy server" for remote configuration of the policies
- Others are GrSecurity, RSBAC, ...