SE Linux fun with MySQL and friends

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Who are we?
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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
- Currently Lead Database Consultant
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- Living in Campana, Argentina
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Helping businesses use data to compete and win

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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:

```bash
[root@localhost ~]# semanage user -l

<table>
<thead>
<tr>
<th>SELinux User</th>
<th>Labeling</th>
<th>MLS/</th>
<th>MLS/</th>
<th>SELinux Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>guest_u</td>
<td>user</td>
<td>s0</td>
<td>s0</td>
<td>guest_r</td>
</tr>
<tr>
<td>root</td>
<td>user</td>
<td>s0</td>
<td>s0-s0:c0.c1023</td>
<td>staff_r sysadm_r system_r unconfined_r</td>
</tr>
<tr>
<td>staff_u</td>
<td>user</td>
<td>s0</td>
<td>s0-s0:c0.c1023</td>
<td>staff_r sysadm_r system_r unconfined_r</td>
</tr>
<tr>
<td>user_u</td>
<td>user</td>
<td>s0</td>
<td>s0</td>
<td>user_r</td>
</tr>
<tr>
<td></td>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[root@localhost ~]# semanage login -a -s user_u john

[root@localhost ~]# semanage login -l

<table>
<thead>
<tr>
<th>Login Name</th>
<th>SELinux User</th>
<th>MLS/MCS Range</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>default</strong></td>
<td>unconfined_u</td>
<td>s0-s0:c0.c1023</td>
<td>*</td>
</tr>
<tr>
<td>john</td>
<td>user_u</td>
<td>s0</td>
<td>*</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```
SE Linux: users, policies, contexts

- **SE Linux 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
  -rw-rw-xrwx. 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(/.*)?
/etc/my.cnf.d(/.*)?
/var/log/mysql.*
/var/lib/mysql(-files|-keyring)?(/.*)?
/var/run/mysqld(/.*)?
/usr/sbin/mysqld(-max)?
/usr/lib/systemd/system/mysqld.*
/etc/my.cnf
/root/\./my.cnf
/usr/sbin/ndbd
/usr/libexec/mysqld
/usr/bin/mysqld_safe
/usr/bin/mysqld_upgrade
/etc/rc/d/init.d/mysqld
/var/lib/mysql/mysql\./sock
/home/**/\./my.cnf
```

```
all files           system_u:object_r:mysqld_etc_t:s0
all files           system_u:object_r:mysqld_etc_t:s0
regular file        system_u:object_r:mysqld_log_t:s0
all files           system_u:object_r:mysqld_db_t:s0
all files           system_u:object_r:mysqld_var_run_t:s0
all files           system_u:object_r:mysqld_exec_t:s0
all files           system_u:object_r:mysqld_unit_file_t:s0
all files           system_u:object_r:mysqld_etc_t:s0
all files           system_u:object_r:mysqld_home_t:s0
all files           system_u:object_r:mysqld_exec_t:s0
all files           system_u:object_r:mysqld_exec_t:s0
all files           system_u:object_r:mysqld_exec_t:s0
all files           system_u:object_r:mysqld_exec_t:s0
all files           system_u:object_r:mysqld_exec_t:s0
regular file        system_u:object_r:mysqld_exec_t:s0
regular file        system_u:object_r:mysqld_exec_t:s0
regular file        system_u:object_r:mysqld_exec_t:s0
```

MySQL and SELinux
Custom data directory

[root@localhost ~]# mkdir -p /data/mysql
[root@localhost ~]# chown mysql:mysql /data/mysql/
[root@localhost ~]# ls -hla /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="sdal" 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.
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 ..
```

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
drw-r-xr-x. mysql mysql unconfined_u:object_r: mysqld_db_t:s0 .
drw-r-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] 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!

```bash
[root@localhost ~]# cat /var/log/audit/audit.log | audit2allow -w -a
```
Custom port

- Setting the `nis_enabled` boolean works...

```
[root@localhost ~]# setsebool -P nis_enabled 1
[root@localhost ~]# systemctl start mariadb.service
[root@localhost ~]# netstat -ntlp
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)

```bash
[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
```
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 unconfined_u:object_r: var_lib_t:s0 proxysql.db
-rw-------. proxysql proxysql unconfined_u:object_r: var_lib_t:s0 proxysql.pid
-rw-------. proxysql proxysql unconfined_u:object_r: var_lib_t:s0 proxysql.log
-rw-------. proxysql proxysql unconfined_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

```
[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 ~]#
```

Seems to work?
... but not in crontab!
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
After a few iterations this is the policy we ended up with:

```plaintext
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 ===

[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
```

Great success!
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, ...
Thank you!