ORACLE

Secure Your Data Workshop

MySQL Enterprise Security

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Agenda

Achieve Compliance with MySQL Enterprise Security Features

- Workshop Overview
- Setup and Installation of:
  - Enterprise Audit
  - Enterprise Transparent Data Encryption
  - Enterprise Data Masking
  - Enterprise Firewall

Workshop Overview

- **Goals:**
  1. Create a OCI Compute server for hosting MySQL Enterprise Edition
  2. Install MySQL Enterprise Edition
  3. Overview & Setup Enterprise Audit, Enterprise Transparent Data Encryption, Enterprise Data Masking and Enterprise Firewall.

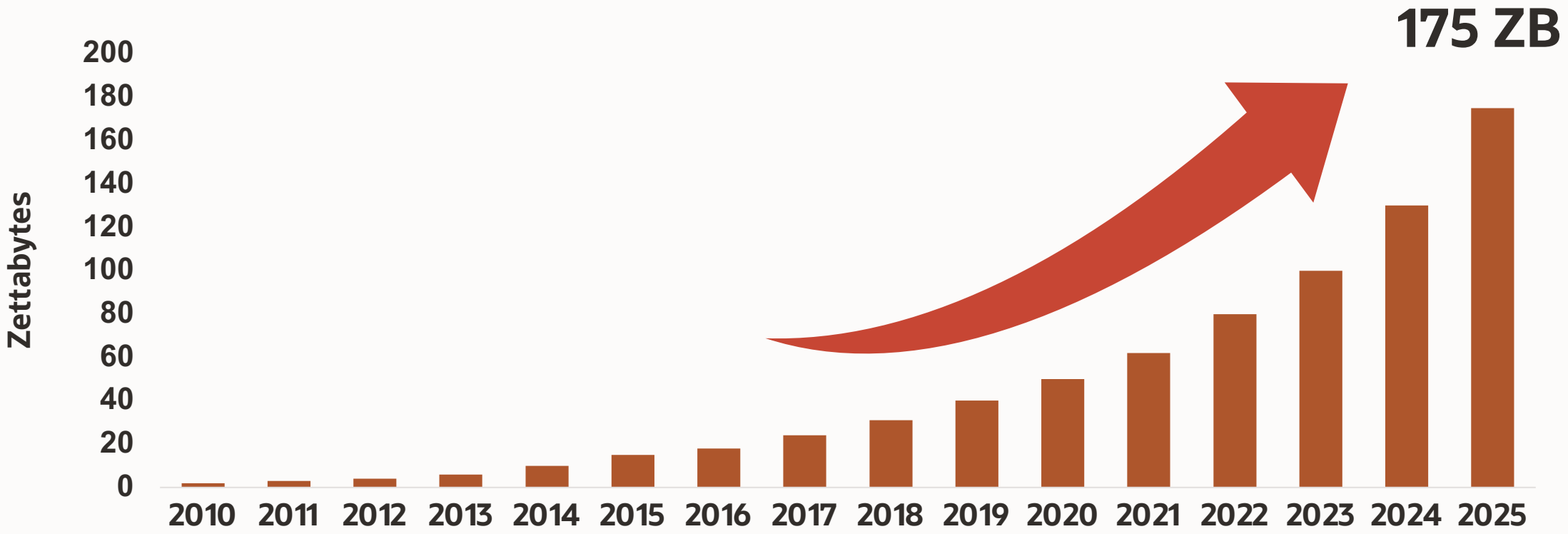
- **Not intended for:**
  - In-depth tutorial on Oracle Cloud Infrastructure
  - MySQL Training Class

- **Lab:**
  - https://bit.ly/MySQL_Workshop_Security

Why?

Data: Your Most Valuable Asset

Global Datasphere



Data Breaches – keep increasing…

Number of breaches in December 2023: 1,351

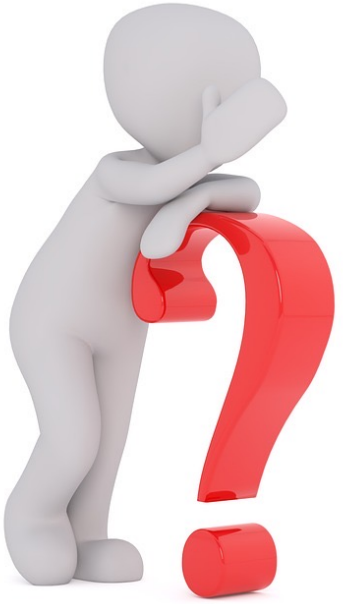
Unprotected Real Estate Wealth Network had more than 1.5 billion records stolen

Number of breached records in December 2023: 2,241,916,765

Popular parental control app Kid Security had more than 300 million records exposed

https://www.itgovernance.co.uk/blog/list-of-data-breaches-and-cyber-attacks-in-2023

What?



Data Protection Laws & Regulations

MySQL

EU General Data Protection Regulation (GDPR)

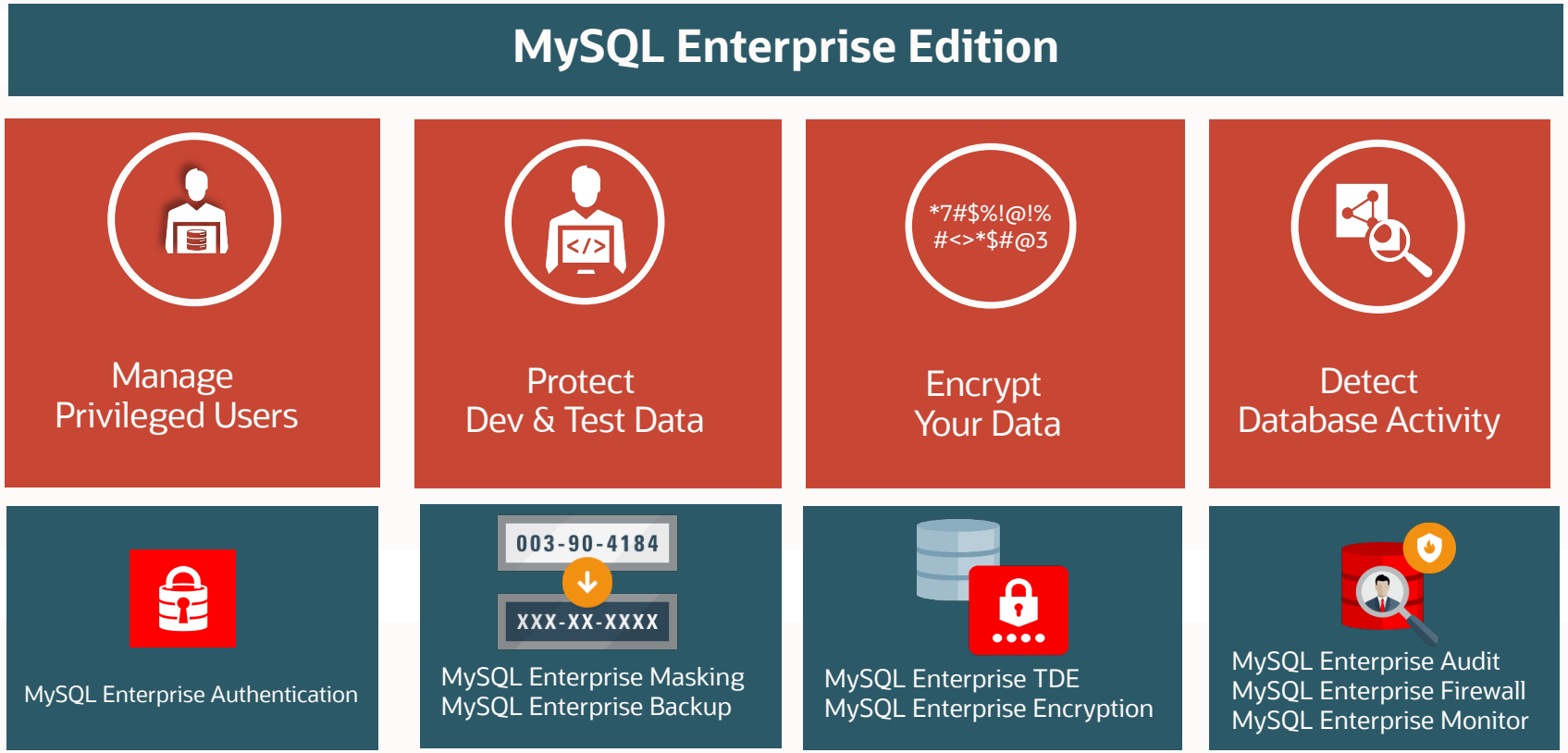
- GDPR is a European Union “EU”-wide framework
  - Protection of personal data of EU-based individuals
- Published May 2016, Enforced May 2018
- Fines for GDPR violations are
  - The greater of 20,000,000 Euros or 4% of annual revenue (R150, A83)
- Data must be processed with controls that provide *“appropriate security and confidentiality “*
    - Data privacy as a fundamental right
    - Defines Data protection responsibilities, baselines, principles
    - Provides Enforcement Powers
  - Exact security controls are not specified in the GDPR
    - What? But not How?

Regulatory Compliance

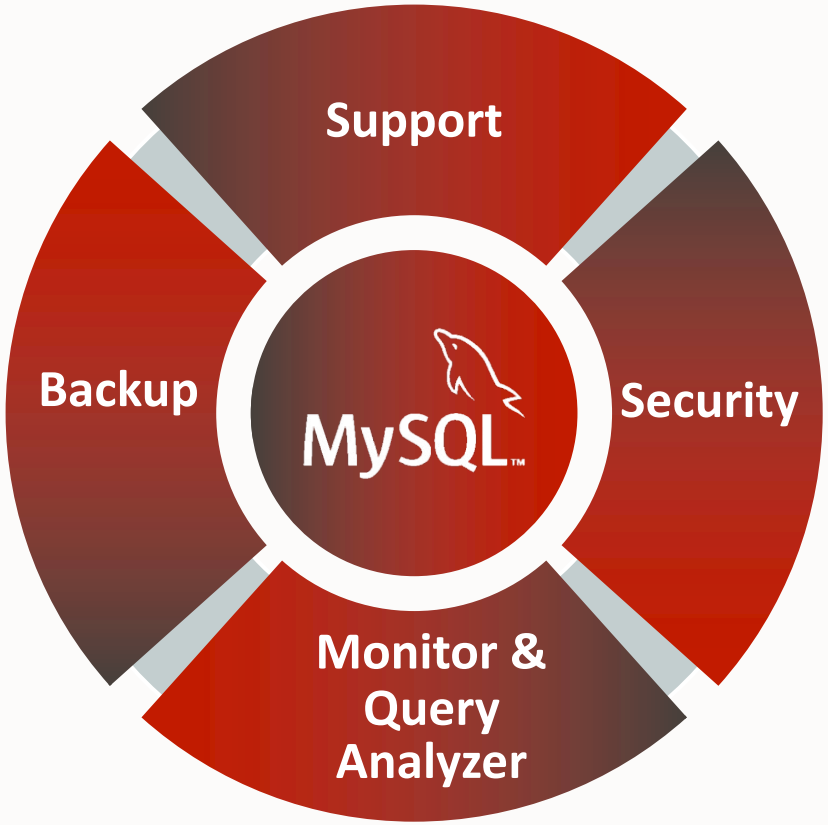
- **Regulations**
  - PCI – DSS: Payment Card Data
  - HIPAA: Privacy of Health Data
  - Sarbanes Oxley, GLBA, The USA Patriot Act:
    - Financial Data, NPI "personally identifiable financial information"
  - FERPA – Student Data
  - EU General Data Protection Directive: Protection of Personal Data (GDPR)
  - Data Protection Act (UK): Protection of Personal Data
- **Requirements**
  - Continuous Monitoring (Users, Schema, Backups, etc)
  - Data Protection (**Encryption**, Privilege Management, etc.)
  - Data Retention (Backups, User Activity, etc.)
  - Data **Auditing** (User activity, etc.)

How?

Data Protection & Regulatory Compliance



MySQL Enterprise Edition



- ✓ MySQL Enterprise Audit
- ✓ MySQL Enterprise Transparent Data Encryption
- ✓ MySQL Enterprise Data Masking
- ✓ MySQL Enterprise Firewall

MySQL Enterprise Audit

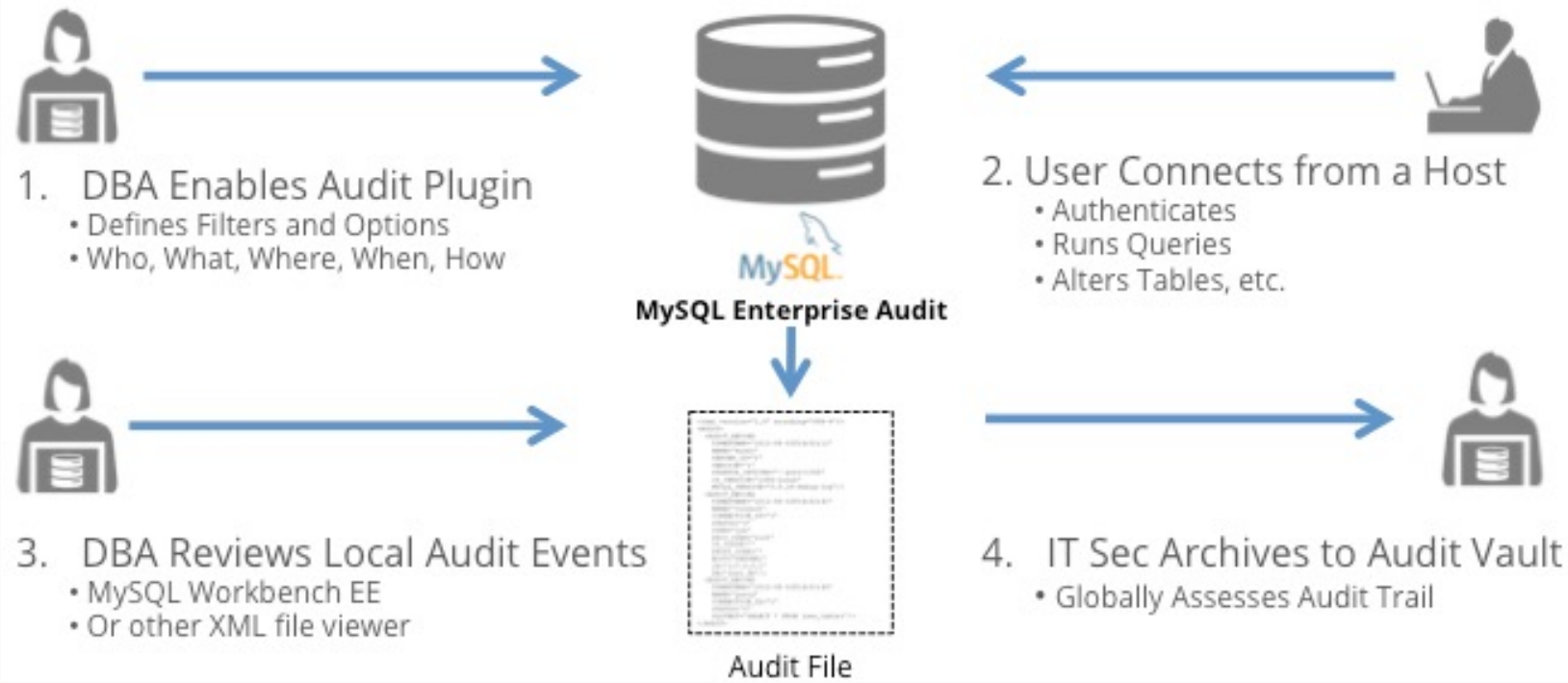
MySQL Enterprise Audit

- Out-of-the-box logging of connections, logins, and queries.
- Simple to fine grained policies for filtering and log rotation.
- Dynamically enabled & disabled.
- Various options for the Audit Logs:
  - XML-based audit stream
  - New 5.7.21+
    - JSON
    - Compression
    - Encryption
    - Remote Read Only SQL statement access
- Send data to a remote server / audit data vault
  - Oracle Audit Vault, Splunk, etc.

Adds regulatory compliance to MySQL applications (HIPAA, Sarbanes-Oxley, GDPR, etc.)

MySQL Enterprise Audit

Work Flow



Complete Audit Data

Complete event details

- Who
- What
- When
- Where
- How
- Status

- DB version
- OS version
- Options
- and more…

```
<?xml version="1.0" encoding="UTF-8"?>
<AUDIT>
  <AUDIT_RECORD
    TIMESTAMP="2012-08-02T14:52:12"
    NAME="Audit"
    SERVER_ID="1"
    VERSION="1"
    STARTUP_OPTIONS="--port=3306"
    OS_VERSION="i686-Linux"
    MYSQL_VERSION="5.5.28-debug-log"/>
  <AUDIT_RECORD
    TIMESTAMP="2012-08-02T14:52:41"
    NAME="Connect"
    CONNECTION_ID="1"
    STATUS="0"
    USER="joe"
    PRIV_USER="root"
    OS_LOGIN=""
    PROXY_USER=""
    HOST="SERVER1"
    IP="127.0.0.1"
    DB="joes_db"/>
  <AUDIT_RECORD
    TIMESTAMP="2012-08-02T14:53:45"
    NAME="Query"
    CONNECTION_ID="1"
    STATUS="0"
    SQLTEXT="SELECT * FROM joes_table;"/>
</AUDIT>
```

Audit Log File Formats

Log File Format

XML - audit_log_format=NEW

```
<?xml version="1.0" encoding="utf-8"?>
 <AUDIT>
 <AUDIT_RECORD>
   <TIMESTAMP>2019-10-03T14:06:33 UTC</TIMESTAMP>
    <RECORD_ID>1_2019-10-03T14:06:33</RECORD_ID>
    <NAME>Audit</NAME>
    <SERVER_ID>1</SERVER_ID>
    <VERSION>1</VERSION>
    <STARTUP_OPTIONS>/usr/local/mysql/bin/mysqld --
socket=/usr/local/mysql/mysql.sock --port=3306</STARTUP_OPTIONS>
     <OS_VERSION>i686-Linux</OS_VERSION>
     <MYSQL_VERSION>5.7.21-log</MYSQL_VERSION>
</AUDIT_RECORD>
```

JSON – audit_log_format=JSON

```
{ "timestamp": "2019-10-03 14:21:56",
   "id": 0,
    "class": "audit",
    "event": "startup",
    "connection_id": 0,
    "startup_data": { "server_id": 1,
                      "os_version": "i686-Linux",
                "mysql_version": "5.7.21-log",
                "args": ["/usr/local/mysql/bin/mysqld",
                         "--loose-audit-log-format=JSON",
                         "--log-error=log.err",
                         "--pid-file=mysqld.pid",
                         "--port=3306" ] } }
```

Audit Log File Security

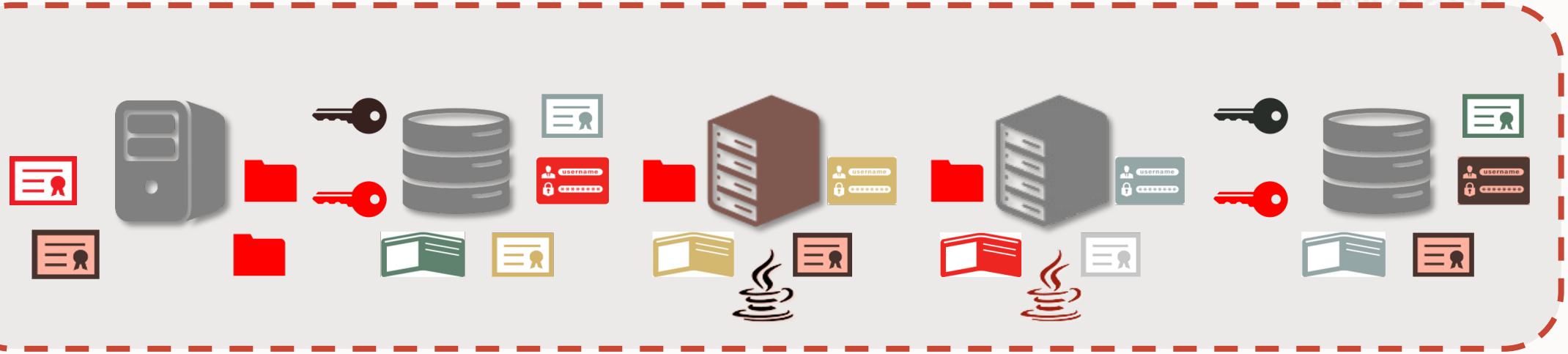
Compression

- Based upon gzip
- audit_log_compression=NONE|GZIP
- Adds .gz suffix to log files

Encryption

- Based upon AES-256-CBC
- audit_log_encryption=NONE|AES
- Uses **MySQL keyring plugin**
- Adds .*pwd_id*.enc suffix to log files

The Challenges of Key Management



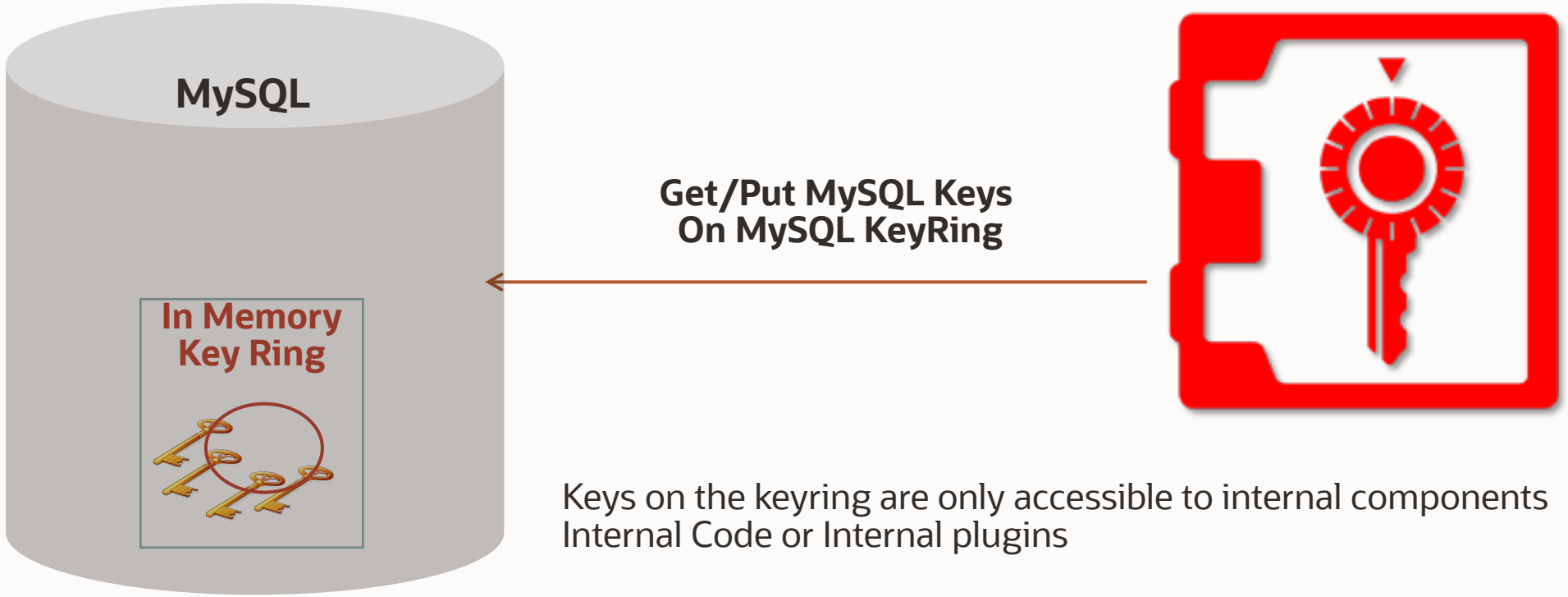
Management

- Proliferation of encryption wallets and keys
- Authorized sharing of keys
- Key availability, retention, and recovery
- Custody of keys and key storage files

Regulations

- Physical separation of keys from encrypted data
- Periodic key rotations
- Monitoring and auditing of keys
- Long-term retention of keys and encrypted data

MySQL Key Ring



Keys on the keyring are only accessible to internal components
Internal Code or Internal plugins

Key Rings are not persisted – in memory and protected in memory

ACLs - who key is for – for example InnoDB Tablespaces

Audit Filtering

Allows DBAs to “custom” design audit process

- Use very fine grained rules
  - Reduce audit log file size
  - Reduce File System IO and Storage / Increases performance (less items logged).
  - Increases audit log post processing efficiency – less data to process for immediate answers.
  - Defined using JSON

- Coarse grained rules
  - When you need to watch everything
  - Obsolete. Recommended is to use new audit log filtering.

Audit Log Filters

Expanded “Event” model

- Allows for very fine grained auditing

Simple but powerful

- Uses JSON to define filters

Event class	Event subclass
GENERAL	STATUS
CONNECTION	CONNECT
	CHANGE_USER
	DISCONNECT
TABLE_ACCESS	READ
	INSERT
	UPDATE
	DELETE
MESSAGE	INTERNAL
	USER

Comparison Audit to General Log

Connection

Audit Log output:


```
{
    "account": {
        "host": "",
        "user": "root"
    },
    "class": "general",
    "connection_id": 64,
    "event": "status",
    "general_data": {
        "command": "Query",
        "query": "select USER()",
        "sql_command": "select",
        "status": 0
    },
    "id": 2,
    "login": {
        "ip": "10.20.1.1",
        "os": "",
        "proxy": "",
        "user": "root"
    },
    "timestamp": "2019-12-19 00:43:02"
}
```


General Query Log output:

```
2019-12-19T00:43:02.532984Z 64 Connect  root@10.20.1.1 on  using
SSL/TLS
2019-12-19T00:43:02.533608Z 64 Query    select @@version_comment
limit 1
2019-12-19T00:43:02.551259Z 64 Query    select USER()
2019-12-19T00:43:15.373949Z 60 Quit
```

- *Not as detailed*
- *No means for filtering content*
- *Can be easily disabled*
- *No log management*

Audit - Filtering Connections

Connection Event Fields

Name	Type	Description
status	INT	Status of the event: 0: OK, otherwise error state
user.str	STRING	Connecting user string
connection_type	INT	TCP/IP, socket, named pipe, SSL, shared memory
… (many more)		

Log all connection events:

- Successful and failed connection attempts
- Disconnects
- User change during session (change_user command)

Filters can be SIMPLE

```
(root@localhost)[mysql]SET @f = '{ "filter": { "class": { "name": "connection" } } }';
Query OK, 0 rows affected (0.00 sec)

(root@localhost)[mysql]SELECT audit_log_filter_set_filter('log_conn_events', @f);
+-------------------------------------------------+
| audit_log_filter_set_filter('log_conn_events', @f) |
+-------------------------------------------------+
| OK                                              |
+-------------------------------------------------+
1 row in set (0.01 sec)

(root@localhost)[mysql]SELECT * FROM mysql.audit_log_filter;
+-----------------+-------------------------------------------+
| NAME            | FILTER                                    |
+-----------------+-------------------------------------------+
| log_conn_events | {"filter": {"class": {"name": "connection"}}} |
+-----------------+-------------------------------------------+
1 row in set (0.00 sec)
```

Filters can be Specific

Log failed SSL connection attempts:

```
{ "filter": {
   "class": {
    "name": "connection",
    "event": {
     "name": "connect",
     "log": {
      "and": [
       { "not": { "field": { "name": "status",
                             "value": 0 } } },
       { "field": { "name": "connection_type",
                    "value": "::ssl" }}]}}}}}
```

Audit – Filtering Tables

Table Event Fields

Name	Type	Description
connection_id	STRING	Unique connection id.
sql_command_id	UINT	SQL statement type (SELECT, INSERT…)
query	STRING	Query string accessing the table
table_database	STRING	Database (schema) name
table_name	STRING	Table name
… (many more)		

Rules can be Specific related to Tables

All deletions, insertions, updates on bank_database.accounts

```
{ "filter":{
   "class": {
    "name": "table_access",
    "event": {
     "name": [ "delete", "insert", "update" ],
     "log": {
       "and": [ { "field": { "name": "table_database.str",
                             "value": "bank_database" } },
                { "field": { "name": "table_name.str",
                             "value": "accounts" }}]}}}}}
```

MySQL Enterprise Transparent Data Encryption

MySQL Enterprise Security Transparent Data Encryption

At Rest Encryption Covers

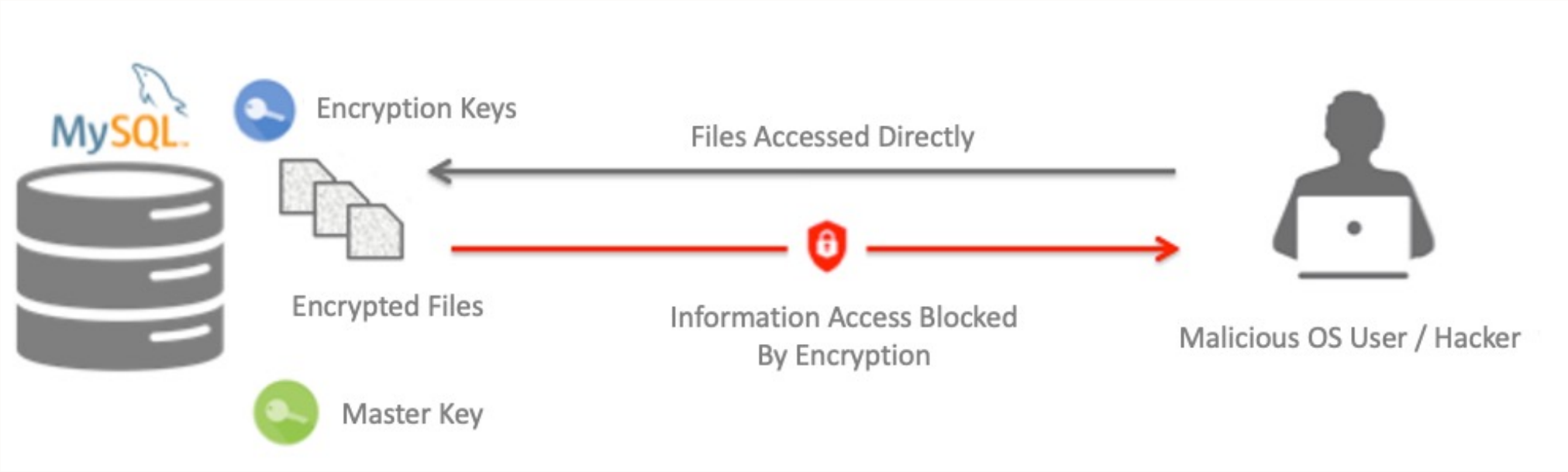
- InnoDB Tables and Tablespace
  - File Per Table Tablespace or General (Multi-Table) Tablespace
- MySQL System Tablespace
  - Data Dictionary Tables
- Binlog Encryption
- MySQL Enterprise Audit Logs
- MySQL Enterprise Backup Files
- Note: DBAs can optionally force Table Encryption
  - i.e. Users can only create encrypted tables

MySQL Enterprise Security Transparent Data Encryption

- Data at Rest Encryption
  - [System | General | Data Dictionary] Tablespaces, Undo/Redo & Binary/Relay logs, Storage, OS File system
  - Policy to **enforce table encryption**
  - Strong Encryption – **AES 256**
- Transparent to applications and users
  - No application code, schema or data type changes
- Transparent to DBAs
  - Keys are hidden from DBAs, no configuration changes
- Requires Key Management
  - Protection, rotation, storage, recovery

MySQL Enterprise Transparent Data Encryption (TDE)

Protects against Attacks on Database Files



Encrypted Tablespace Files, Undo/Redo logs, Shared Tablespaces, and Binary & Relay logs

Keyring plugin - used to retrieve keys from Key Stores over Standardized **KMIP** protocol

MySQL Enterprise Data Masking

MySQL Enterprise Edition: Masking and De-Identification

De-identify, Anonymize Sensitive Data

Data De-Identification helps database customers improve security

Accelerates compliance for

- Government – GDPR, CHHS
- Financial - PCI
- Healthcare – HIPAA, Clinic Trials Data

Reduce IT costs by simplifying sanitizing production data

- Transforming sensitive data for use in analytics, testing, development, and more

Employee Table

ID	Last	First	SSN
1111	Smith	John	555-12-5555
1112	Templeton	Richard	444-12-4444

Random Data Generation **Masked View**

ID	Last	First	SSN
2874	Smith	John	XXX-XX-5555
3281	Templeton	Richard	XXX-XX-4444

MySQL Enterprise Edition: Masking and De-Identification

Data Masking

String data masking

- Mask a substring within a string : ArthXXXXnt
- Mask substrings at the beginning and at the end : XXthurDeXX

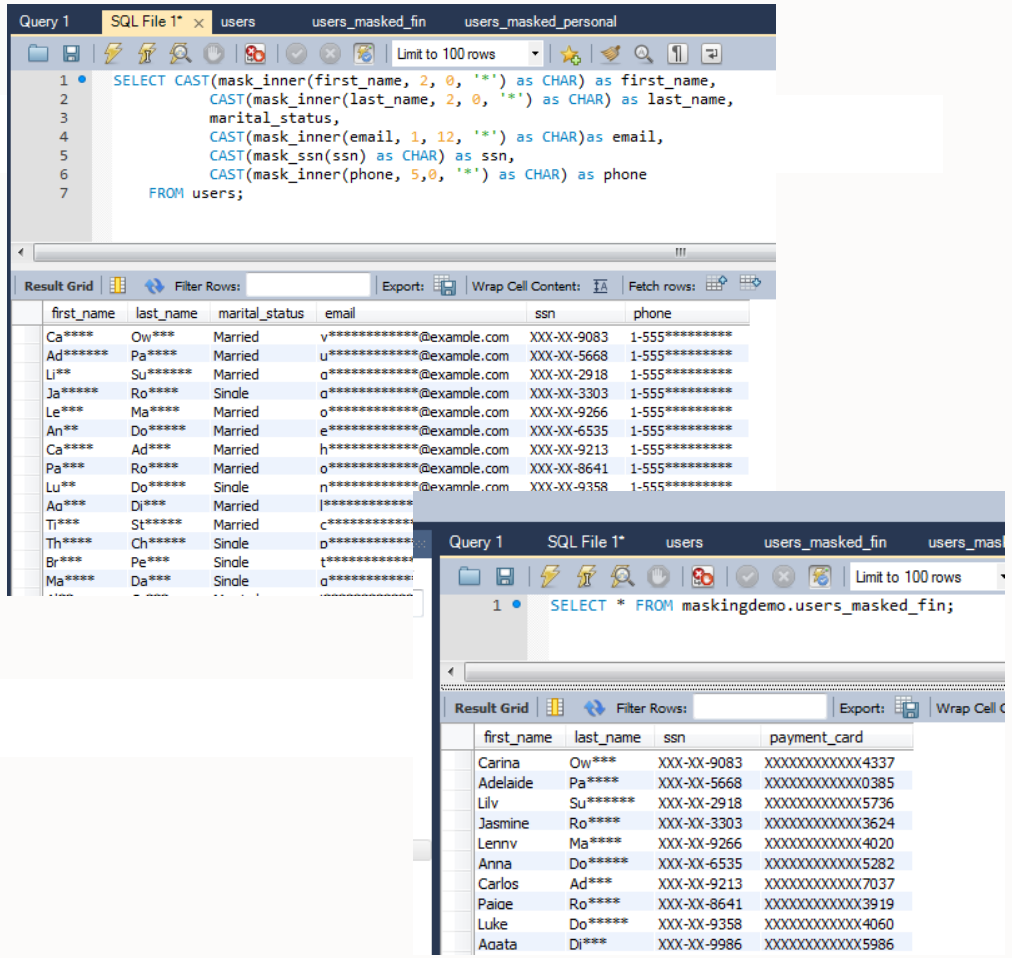
SSN masking : XXXX-XX-1234

Payment Card masking

- Strict: XXXXXXXXXXXXXX7395
- Relaxed: 493812XXXXXXXXX7395

Dictionary based masking

- gen_blacklist("007", "00designations", "Cover_identity") => Universal Exports



MySQL Enterprise Firewall

MySQL Enterprise Firewall

Real-time Database Intrusion Detection

Real Time Protection

- Queries analyzed and matched against Allow List

Blocks SQL Injection Attacks

- Positive Security Model

Block Suspicious Traffic

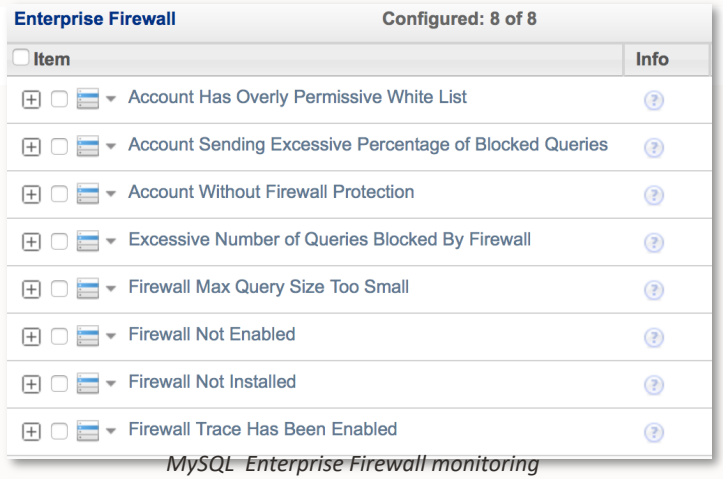
- Out of Policy Transactions detected & blocked

Learns Allow List

- Automated creation of approved list of SQL command patterns on a per user basis

Transparent

- No changes to application required



MySQL Enterprise Firewall monitoring

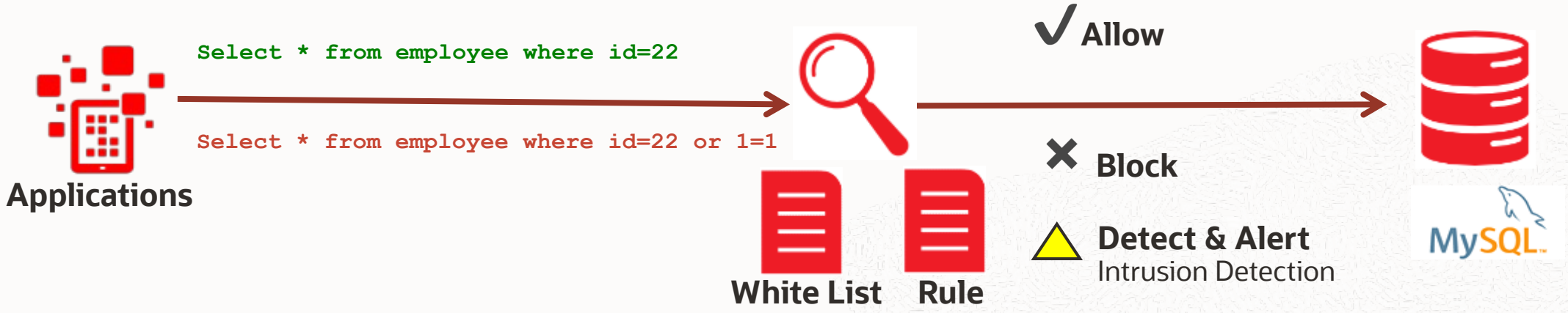
MySQL Enterprise Firewall

Block SQL Injection Attacks

- Allow: SQL Statements that match Whitelist
- Block: SQL statements that are not on Whitelist

Intrusion Detection System

- Detect: SQL statements that are not on Whitelist
  - SQL Statements execute and alert administrators

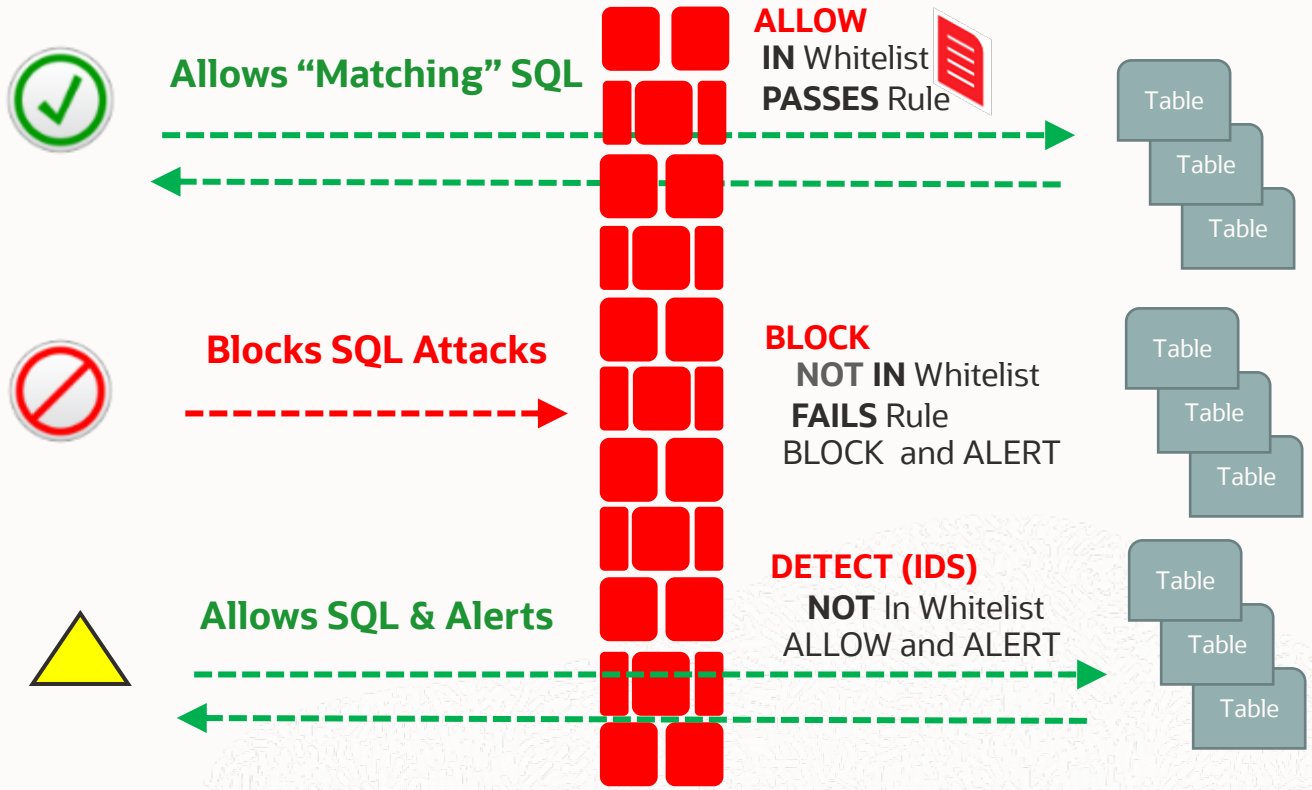


MySQL Enterprise Firewall: Operating Modes

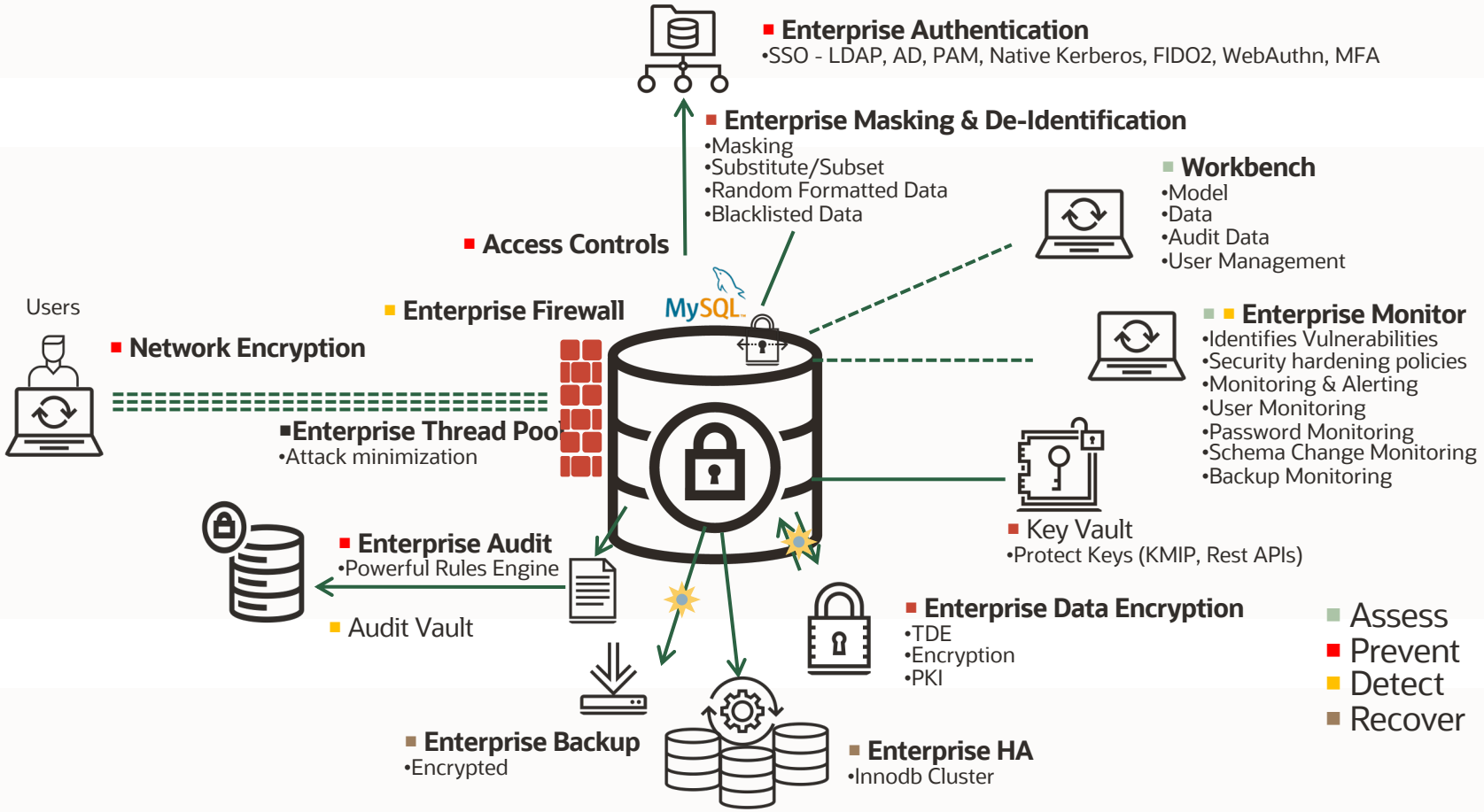
1. **ALLOW** – Execute SQL
   - SQL Matches Whitelist
   - SQL Passes Rule

2. **BLOCK** – Block the request
   - Not in Whitelist
   - SQL FAILs Rule
   - In Block Mode

3. **DETECT** – Execute SQL & Alert
   - Not in Whitelist
   - SQL FAILs Rule
   - In Alert Mode



MySQL Enterprise Security Architecture



Resources

MySQL Secure Deployment Guide

- https://dev.mysql.com/doc/mysql-secure-deployment-guide/8.0/en/

60+ blogs to dive into specific topics and features

- https://blogs.oracle.com/mysql/search.html?contentType=Blog-Post&default=security*
- https://dev.mysql.com/blog-archive/?cat=Security

Whitepapers

- https://www.mysql.com/why-mysql/white-papers/#en-22-40

On Demand Webinars

- https://www.mysql.com/news-and-events/on-demand-webinars/

Forums

- https://forums.mysql.com/

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