ORACLE OPEN WORLD
MySQL Central @ OPENWORLD
October 25-29, 2015
San Francisco

#MySQLCentral

# The State of the Dolphin: 1.6M QPS (SQL) with MySQL 5.7


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# A Year of Anniversaries!

20 Years: MySQL

10 Years: Oracle stewardship of InnoDB

5 Years: Oracle stewardship of MySQL

**Thank You!**

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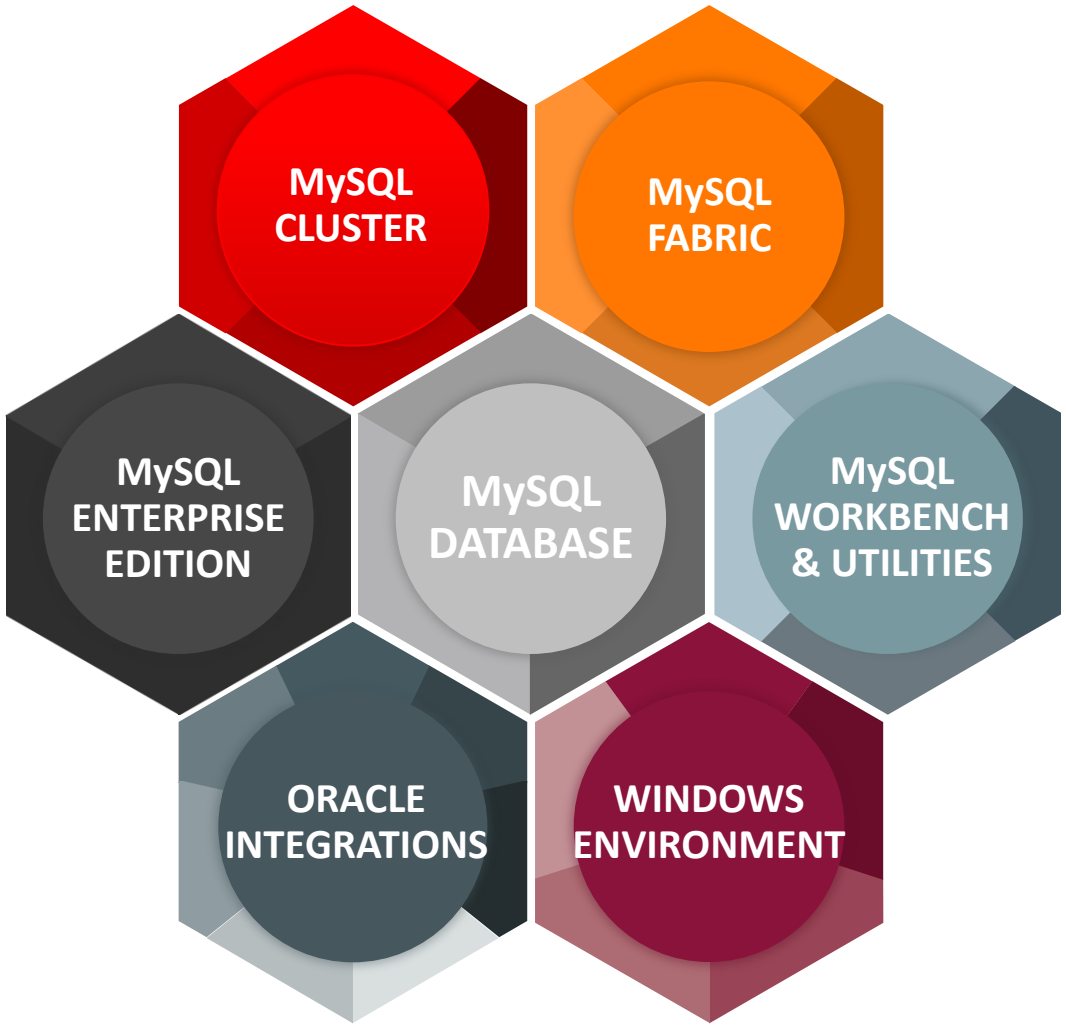
# The Best MySQL Solutions Ever

## Investing & Innovating for You

- ✓ Performance
- ✓ Scalability
- ✓ Manageability
- ✓ Reliability
- ✓ Security
- ✓ Flexibility

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# MySQL 5.7 is GA!

## Performance & Scalability

- 3 X Faster than MySQL 5.6
- Enhanced InnoDB: faster online & bulk load operations
- Replication Improvements (incl. multi-source, multi-threaded slaves...)
- New Optimizer Cost Model: greater user control & better query performance

## Manageability

- Native JSON Support
- Improved Security: safer initialization, setup & management
- Performance Schema Improvements
- MySQL SYS Schema

And many more new features and enhancements. Learn more at: dev.mysql.com

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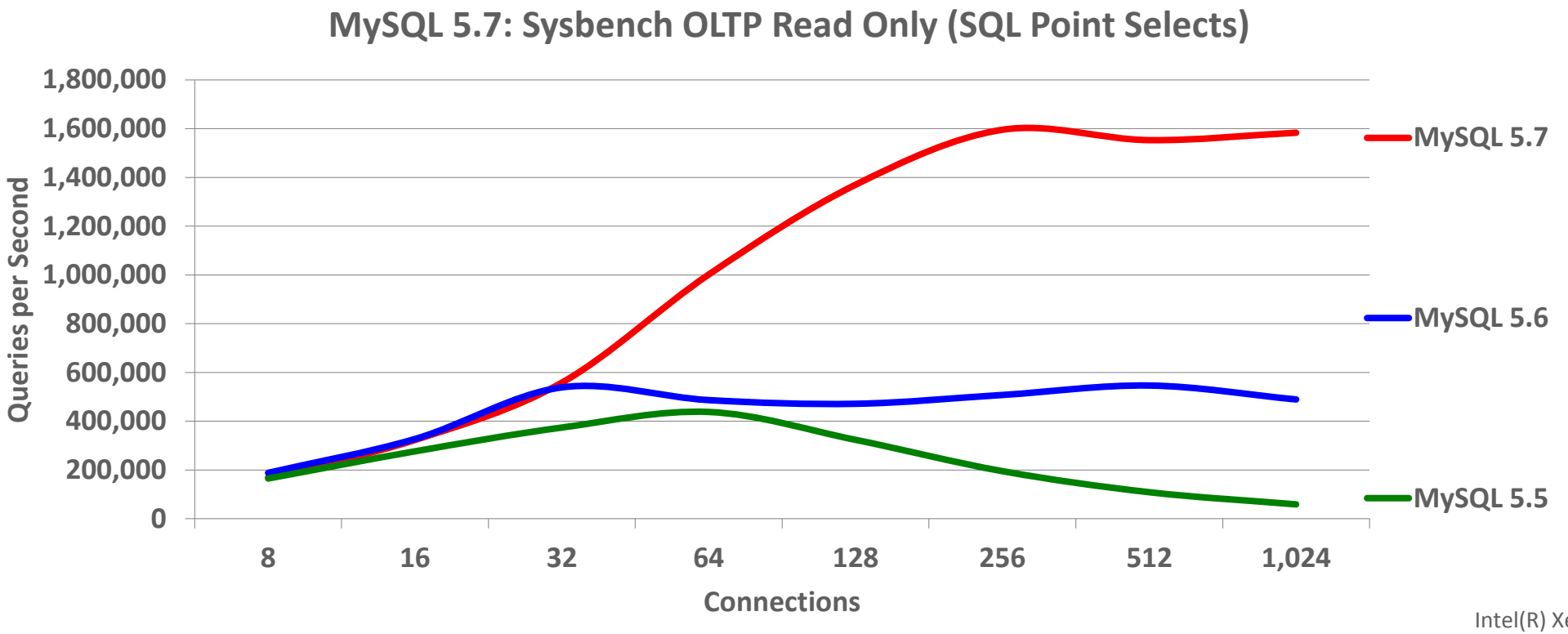
# MySQL 5.7 Sysbench Benchmark: SQL Point Selects

## 3x Faster than MySQL 5.6

**1,600,000 QPS**




http://dimitrik.free.fr/blog/archives/2015/10/mysql-performance-yes-we-can-do-more-than-16m-qps-sql-on-mysql-57-ga.html

Intel(R) Xeon(R) CPU E7-8890 v3
4 sockets x 18 cores-HT (144 CPU threads)
2.5 Ghz, 512GB RAM
Linux kernel 3.16

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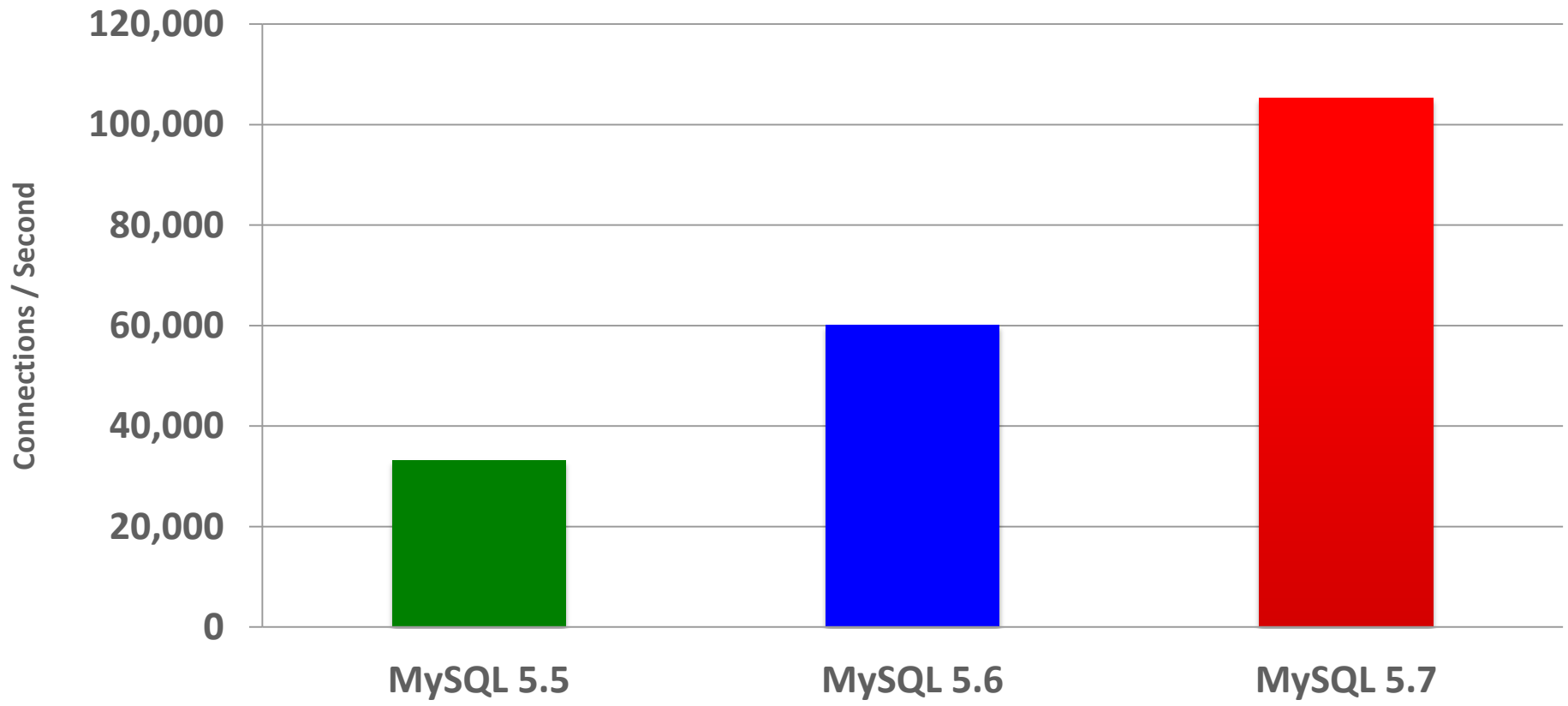
# MySQL 5.7: Connections per Second

**1.7x Faster than MySQL 5.6**

**3x Faster than MySQL 5.5**

**100,000 Connections/Sec**

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Linux kernel 3.16

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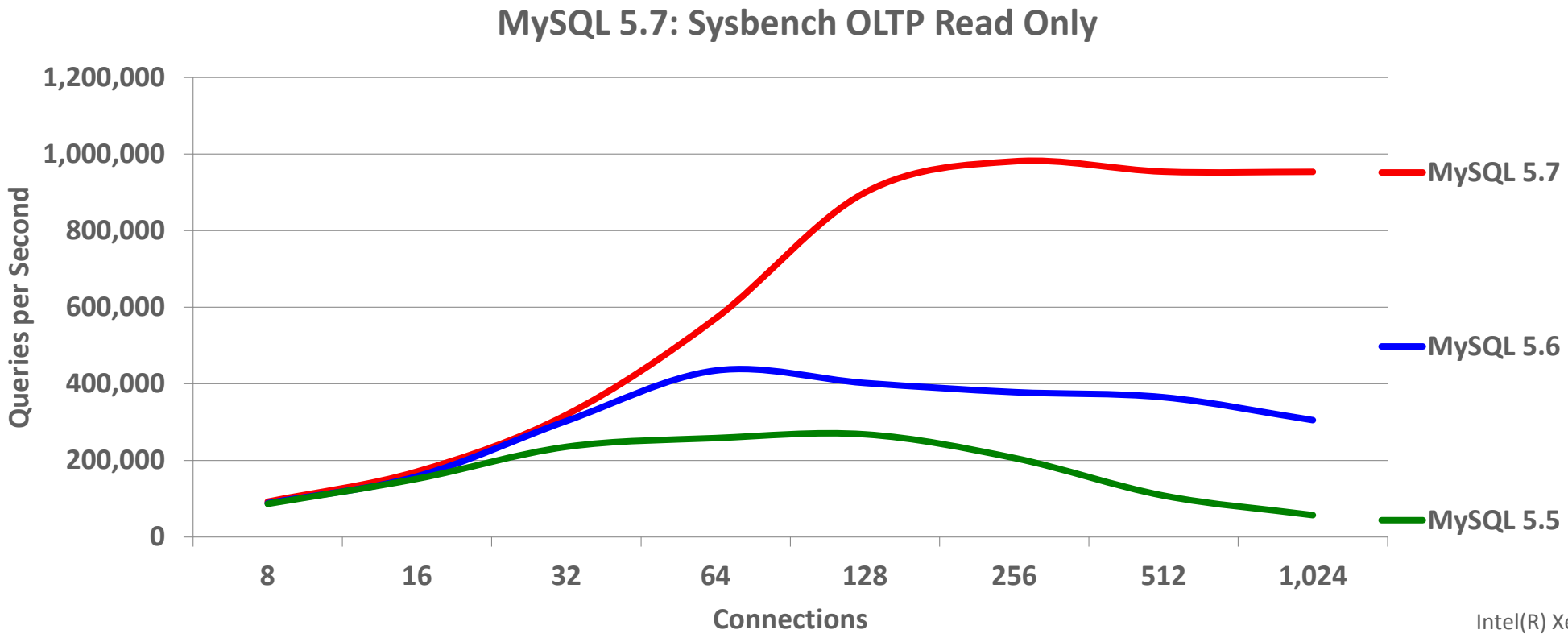
# MySQL 5.7 Sysbench Benchmark: Mixed OLTP Read Only

## 3x Faster than MySQL 5.6

**~ 1,000,000 QPS**




http://dimitrik.free.fr/blog/archives/2015/11/mysql-performance-1m-qps-on-mixed-oltp_ro-on-mysql-57-ga.html

Intel(R) Xeon(R) CPU E7-8890 v3
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Linux kernel 3.16

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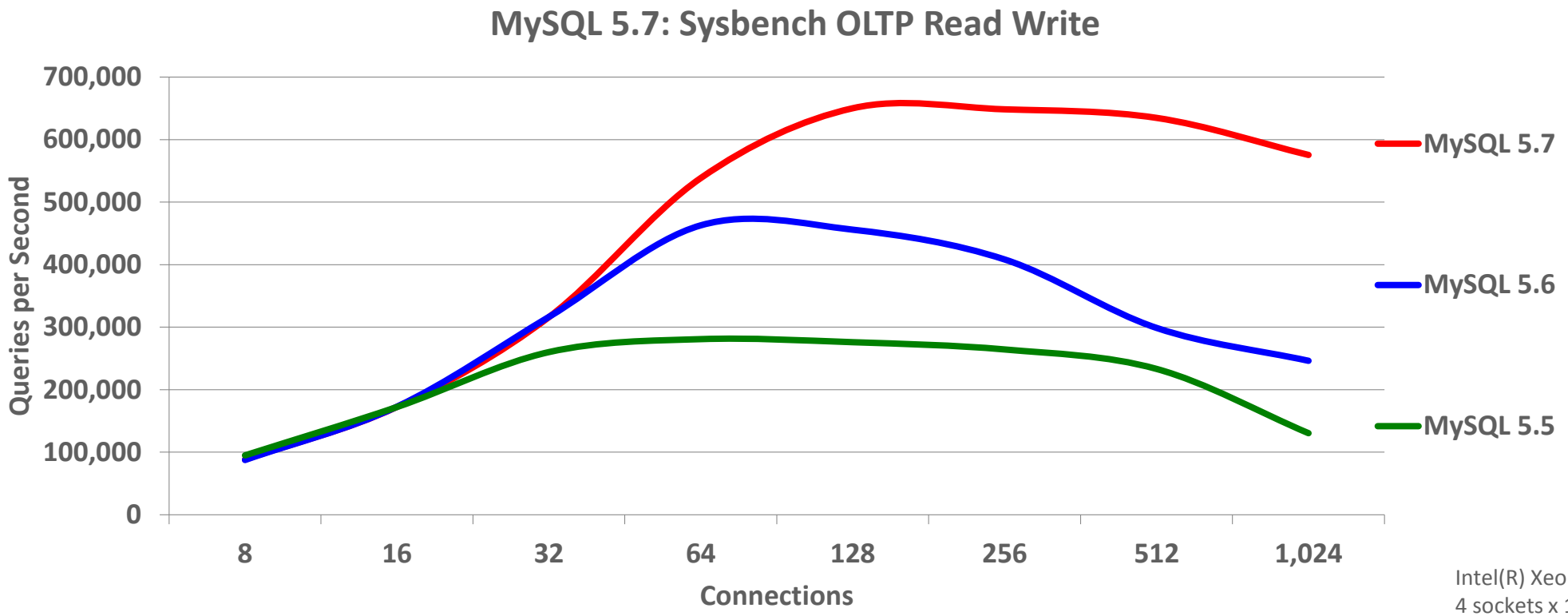
# MySQL 5.7 Sysbench Benchmark: OLTP Read Write

## 1.5x Faster than MySQL 5.6

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4 sockets x 18 cores-HT (144 CPU threads)
2.5 Ghz, 512GB RAM
Linux kernel 3.16

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# MySQL 5.7: Optimizer Improvements

**Queries execute faster, while using less CPU and disk space!**

- Optimizer and Parser refactoring
  - Readability, maintainability and stability
  - Separate parsing, optimizing, execution stages
  - Easier feature additions, with lessened risk
- New hint framework
  - Easier to manage
  - With support for additional new hints
- Improved JSON EXPLAIN
- EXPLAIN for running thread

- New Cost based Optimizer
  - Easier to extend
  - Configurable and tunable
    - mysql.server_cost and mysql.engine_cost tables
    - API for where data resides: on disk or in cache
- InnoDB for internal temp tables
- Better ONLY_FULL_GROUP_BY mode
- Many specific new optimizations
- Generated Columns & Functional Indexes

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# MySQL 5.7: Query Rewrite Plugin

- New pre and post parse query rewrite APIs
  - Users can write their own plug-ins
- Provides a post-parse query plugin
  - Rewrite problematic queries without the need to make application changes
  - Add hints
  - Modify join order
  - Many more …
- Improve problematic queries from ORMs, third party apps, etc
- Eliminates many legacy use cases for proxies

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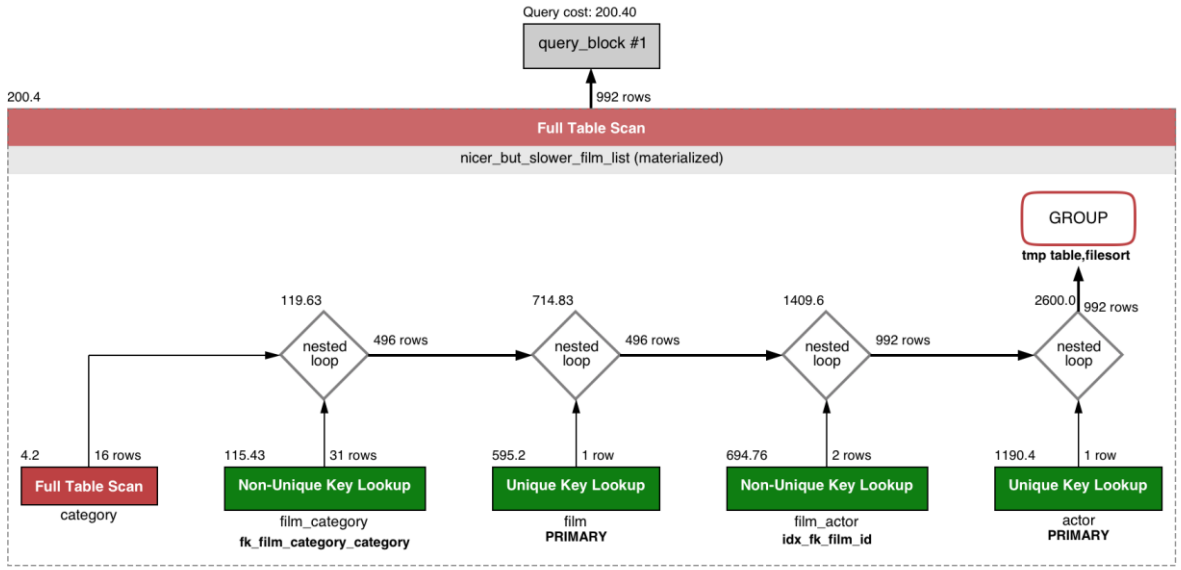
# MySQL 5.7: Optimizer - Cost Info in JSON EXPLAIN

- Expanded JSON EXPLAIN
  - Now includes all available cost info
  - Used for Visual Explain In MySQL Workbench




```
{
  "query_block": {
    "select_id": 1,
    "cost_info": {
      "query_cost": "200.40"
    },
    "table": {
      "table_name": "nicer_but_slower_film_list",
      "access_type": "ALL",
      "rows_examined_per_scan": 992,
      "rows_produced_per_join": 992,
      "filtered": 100,
      "cost_info": {
        "read_cost": "2.00",
        "eval_cost": "198.40",
        "prefix_cost": "200.40",
        "data_read_per_join": "852K"
      },
      "used_columns": [
        "FID",
        "title",
        "description",
        "category",
        "price",
        "length",
        "rating",
        "actors"
      ],
...
```

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# MySQL 5.7: JSON

- Native JSON data type
  - Native internal binary format for efficient processing & storage
- Built-in JSON functions
  - Allowing you to efficiently store, search, update, and manipulate Documents
- JSON Comparator
  - Allows for easy integration of Document data within your SQL queries
- Indexing of Documents using Generated Columns
  - InnoDB supports indexes on both stored and virtual Generated Columns
  - New expression analyzer automatically uses the best “functional” index available
- New inline syntax for easy SQL integration

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# MySQL 5.7: JSON and Text Datatype Comparison

**Unindexed** traversal of 206K documents

```
# With feature column as JSON type
SELECT DISTINCT
 feature->"$.type" as json_extract
FROM features;
+--------------+
| json_extract |
+--------------+
| "Feature"    |
+--------------+
1 row in set (1.25 sec)
```

```
# With feature column as TEXT type
SELECT DISTINCT
 feature->"$.type" as json_extract
FROM features;
+--------------+
| json_extract |
+--------------+
| "Feature"    |
+--------------+
1 row in set (12.85 sec)
```

**Explanation:** Binary format of JSON type is very efficient at searching. Storing as TEXT performs over 10x worse at traversal.

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# MySQL 5.7: Functional Indexes with JSON

From table scan on 206K documents to index scan on 206K materialized values

```
ALTER TABLE features ADD feature_type VARCHAR(30) AS (JSON_UNQUOTE(feature->'$.type'));
Query OK, 0 rows affected (0.01 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

Meta data change only (FAST).
Does not need to touch table.

```
ALTER TABLE features ADD INDEX (feature_type);
Query OK, 0 rows affected (0.73 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

Creates index only, does not touch row data.

```
SELECT DISTINCT feature_type FROM features;
+--------------+
| feature_type |
+--------------+
| "Feature"    |
+--------------+
1 row in set (0.06 sec)
```

Down from 1.25 sec to 0.06 sec

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# MySQL 5.7: Performance Schema

## Memory Instrumentation

- Aggregates statistics by
  - Type of memory used (caches, internal buffers, …)
  - Thread/account/user/host indirectly performing the memory operation
- Attributes include
  - Memory used (bytes)
  - Operation counts
  - High/Low Water Marks

## Statement Instrumentation

- Stored Procedures
- Stored Functions
- Prepared Statements
- Transactions

## Additional Information

- Replication slave status
- MDL lock instrumentation
- Status and variables per thread
- Server stage tracking
- Track long running SQL
- Improved configuration and ease-of-use
- All while reducing total footprint and overhead

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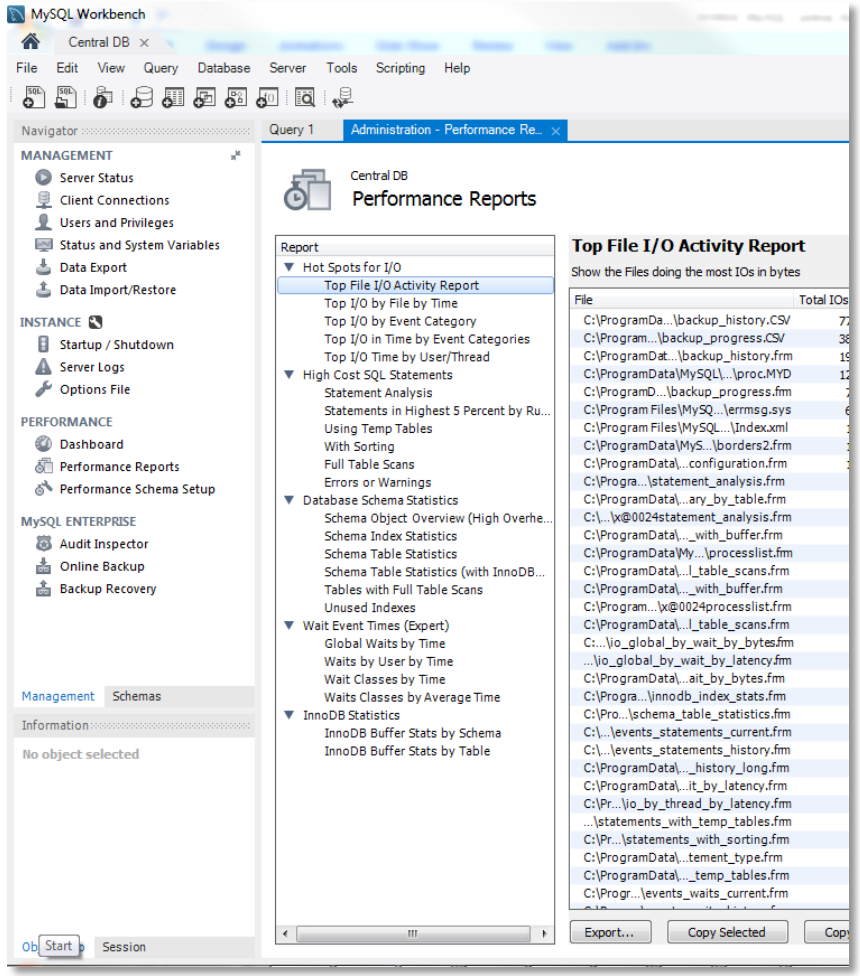
# MySQL 5.7: SYS Schema

## Helper objects for DBAs, Developers and Operations staff

- Helps simplify DBA / Ops tasks
  - Monitor server health, user, host statistics
  - Spot, diagnose, and tune performance issues
- Easy to understand views with insights into
  - IO hot spots, Locking, Costly SQL statements
  - Schema, table and index statistics
- SYS is similar to
  - Oracle V$ catalog views
  - Microsoft SQL DMVs (Dynamic Mgmnt Views)

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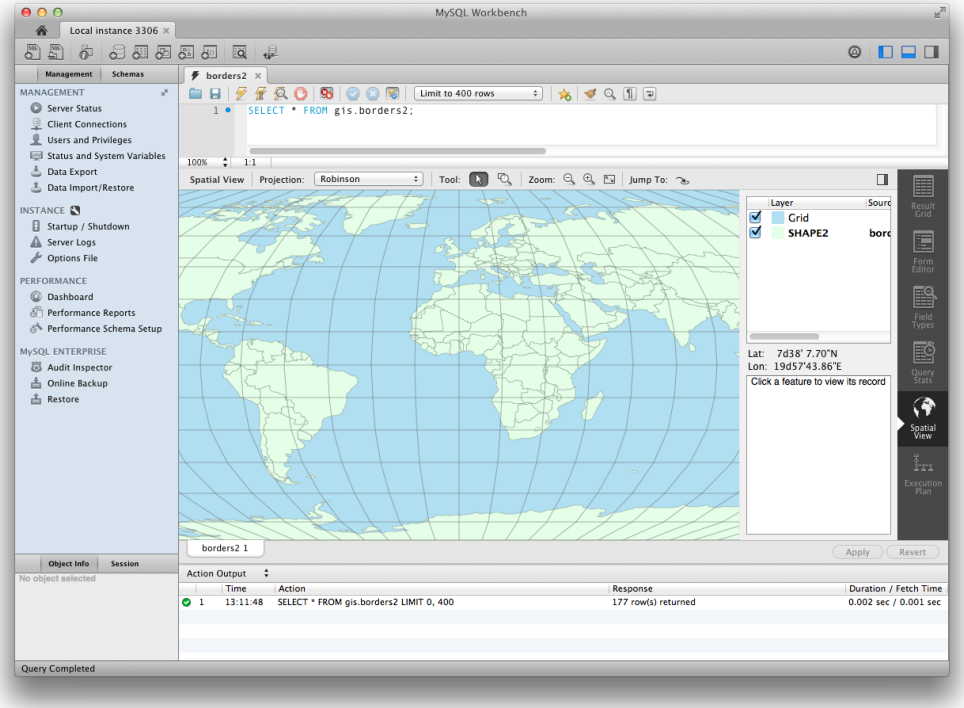
# MySQL 5.7: GIS Improvements

- Replaced custom code with Boost.Geometry
  - For spatial calculations
  - For spatial analysis
  - Enabling full OGC compliance
  - We're also Boost.Geometry contributors!
- InnoDB R-tree based spatial indexes
  - Full ACID, MVCC, & transactional support
  - Index records contain minimum bounding box
- GeoHash
- GeoJSON
- Helper functions such as `ST_Distance_Sphere()` and `ST_MakeEnvelope()`

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# MySQL 5.7: InnoDB Improvements

- Native Partitioning
  - Eliminates previous limitations
  - Eliminates resource usage problems
  - Transportable tablespace support
- Native Full-Text Search
  - Including full CJK support!
- Native Spatial Indexes
- Transparent page compression
- Support for 32K and 64K pages
  - Use with transparent page compression for very high compression ratios
- General TABLESPACE support
  - Store multiple tables in user defined shared tablespaces
- Support for MySQL Group Replication
  - High priority transactions
- Improved support for cache preloading
  - Load your hottest data loaded at startup
- Configurable fill-factor
  - Allows for improvements in storage footprint
- Improved bulk-data load performance
- Resize the InnoDB Buffer Pool online

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# MySQL 5.7: InnoDB Compression

**Thank you, SanDisk Fusion-io**

- Transparent Page Level Compression
  - Happens transparently in background threads
  - Managed entirely within the IO layer
  - Uses sparse file and "hole punching" support in OS kernels and File Systems
- Reduces IO
  - Improves MySQL performance
  - Improves storage efficiency
  - Reduces write cycles, thus increasing SSD lifespan
- Applies to all InnoDB data, including the system tablespace and UNDO logs

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# MySQL 5.7: Security Improvements

- AES 256 Encryption now the default
- Password rotation policies
  - Can be set globally, and at the user level
- Deployment: enable secure unattended install by default
  - Random password set on install
  - Remove anonymous accounts
  - Deployment without test account, schema, demo files
- Easier instance initialization and setup: mysqld –initialize
- New detection and support for systemd

- SSL
  - Enabled by default
  - Auto-detection of existing keys and certs
  - Auto generation of keys and certs when needed
  - New helper utility: `mysql_ssl_rsa_setup`
  - New `--require_secure_transport` option to prevent insecure communications
  - Added SSL support to binary log clients
- Extended Proxy User Support
  - Added Built-in Authentication Plugins support for Proxy Users
  - Allows multiple users to share a single set of managed privileges

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# MySQL Enterprise Edition

## What's New

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# MySQL Enterprise Edition

## Advanced Features

- Scalability
- High Availability
- Security
- Audit

## Management Tools

- Monitoring
- Backup
- Development
- Administration
- Migration

## Support

- Technical Support
- Consultative Support
- Oracle Certifications

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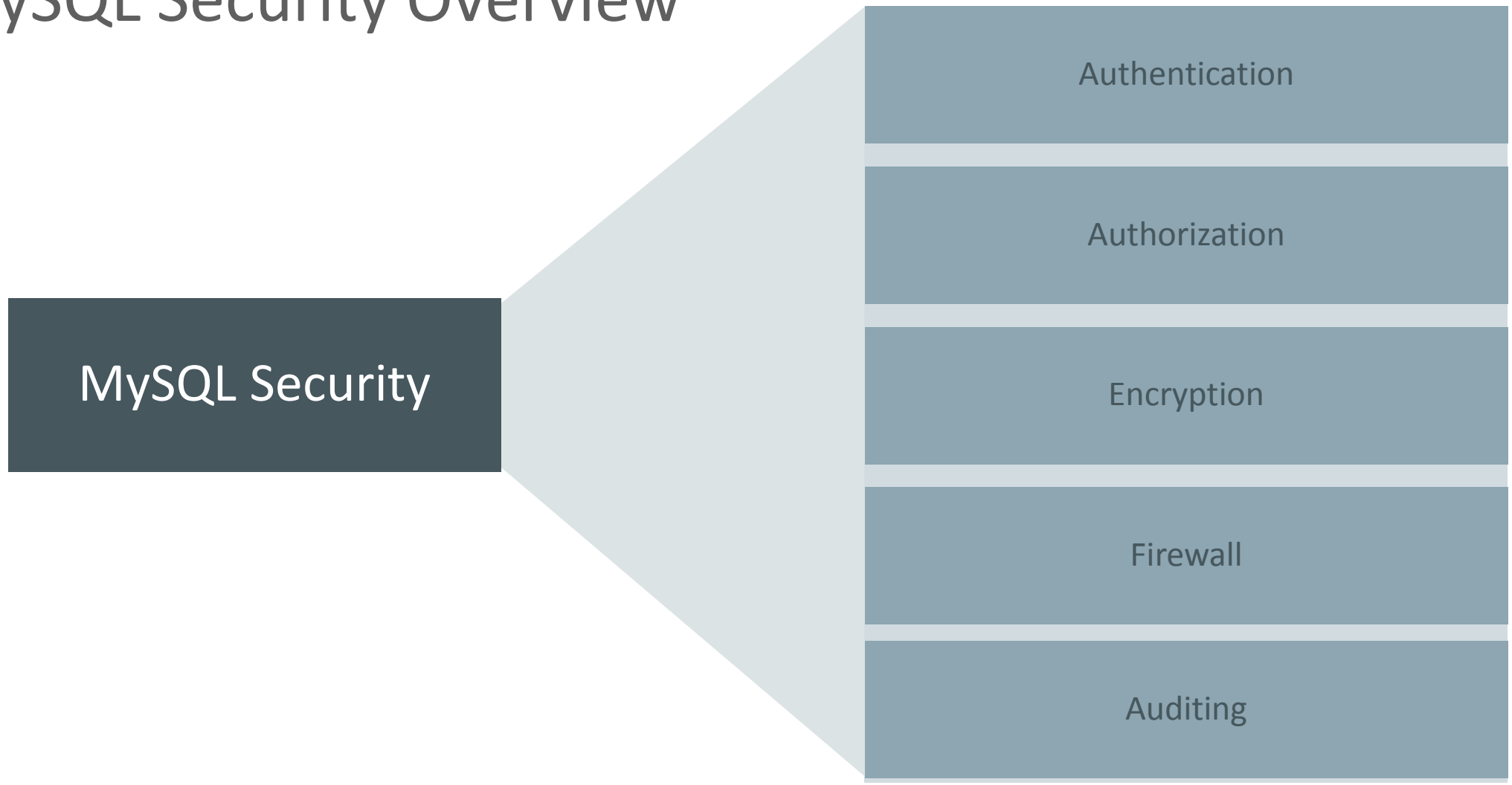
# MySQL Security Overview

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# MySQL Enterprise Authentication

Integrates MySQL with existing security infrastructures

- Integrate with Centralized Authentication Infrastructure
  - Centralized Account Management
  - Password Policy Management
  - Groups & Roles
- PAM (Pluggable Authentication Modules)
  - Standard interface (Unix, LDAP, Kerberos, others)
  - Windows
    - Access native Windows service - Use to Authenticate users using Windows Active Directory or to a native host

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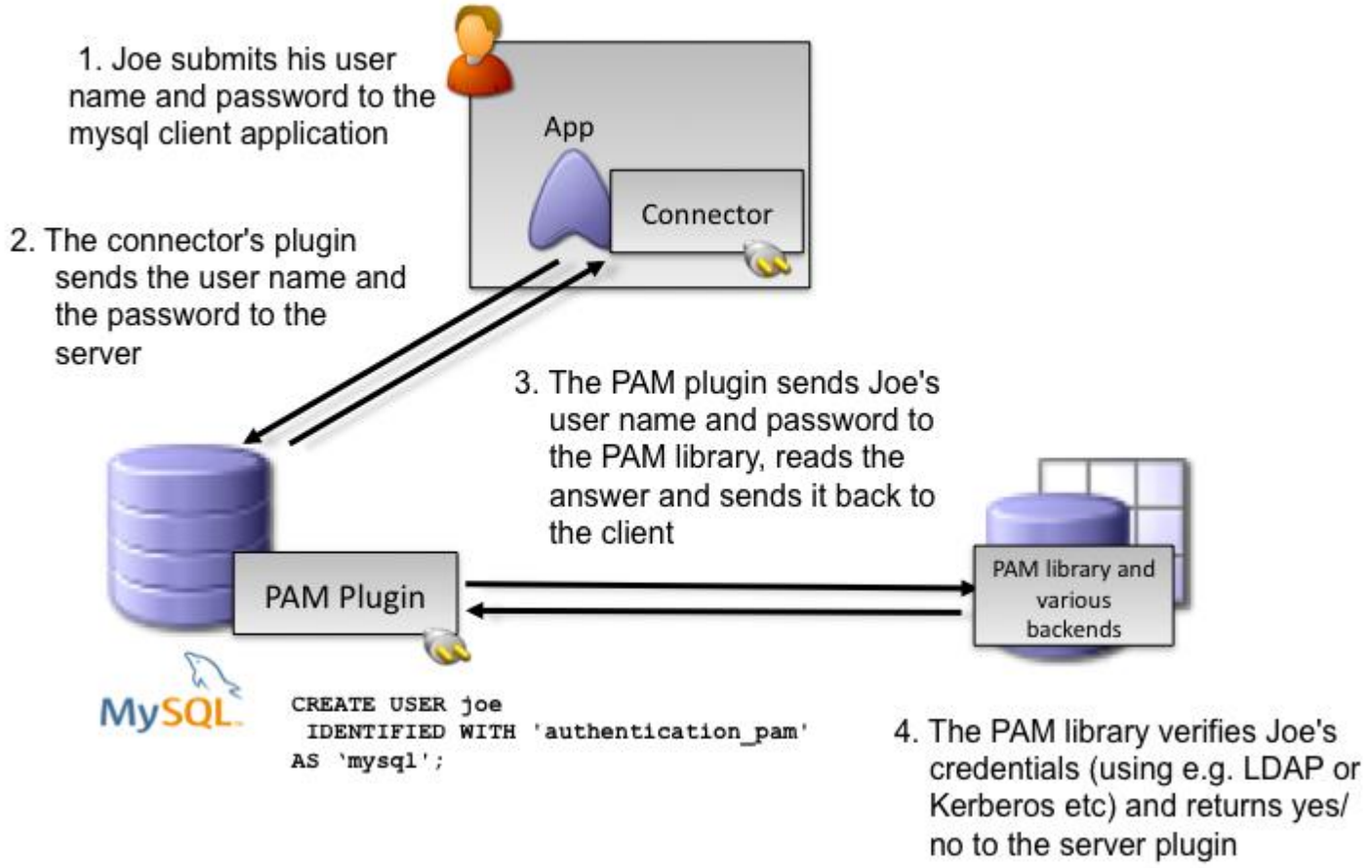
# MySQL Enterprise Authentication: PAM

- Standard Interface
  - LDAP
  - Unix/Linux
- Proxy Users

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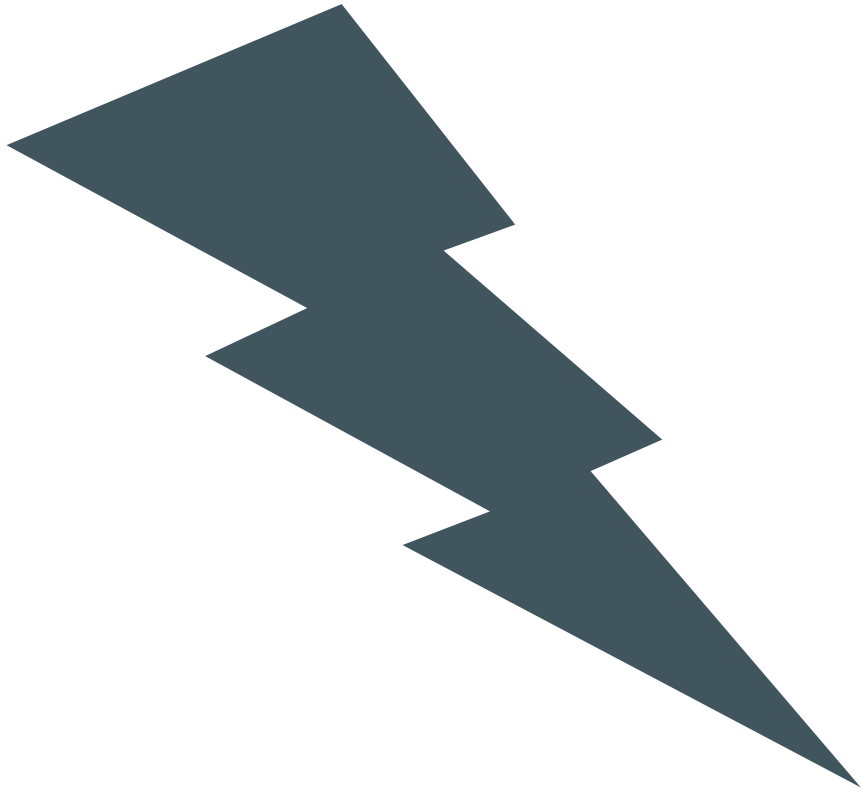
Prevent:

# SQL INJECTION ATTACKS



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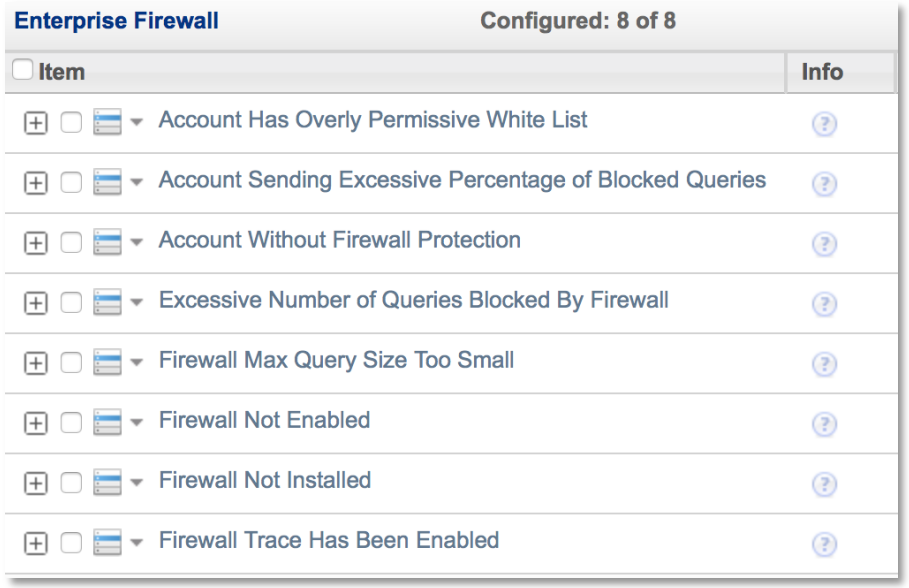
# MySQL Enterprise Firewall

- Real Time Protection
  - Queries analyzed and matched against White List
- Blocks SQL Injection Attacks
  - Positive Security Model
- Block Suspicious Traffic
  - Out of Policy Transactions detected & blocked
- Learns White 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*

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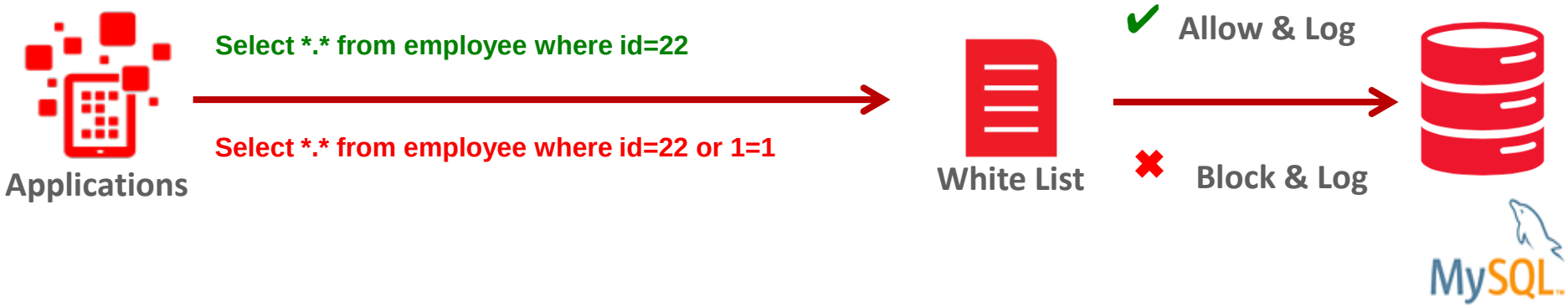
# MySQL Enterprise Firewall

- SQL Injection Protection with Positive Security Model




- Out of policy database transactions detected and blocked
- Logging & Analysis

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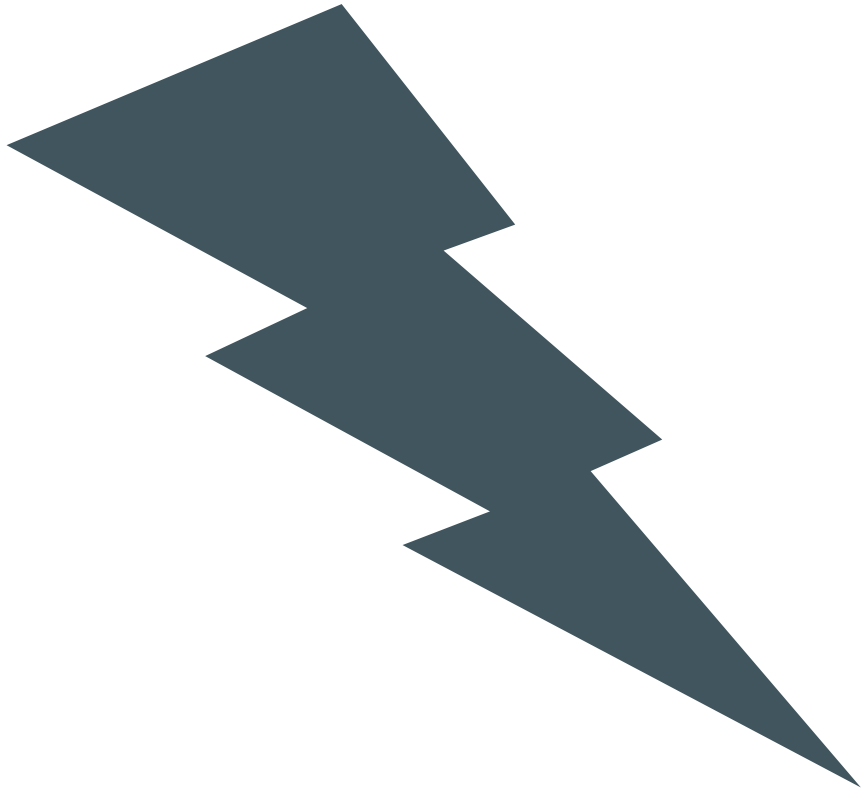
Keep:

# DATA SECURE AT ALL TIMES



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# MySQL Enterprise Encryption

- MySQL encryption functions
  - Symmetric encryption AES256 (All Editions)
  - Public-key / asymmetric cryptography – RSA
- Key management  functions
  - Generate public and private keys
  - Key exchange methods: DH
- Sign and verify data functions
  - Cryptographic hashing for digital signing, verification, & validation – RSA,DSA

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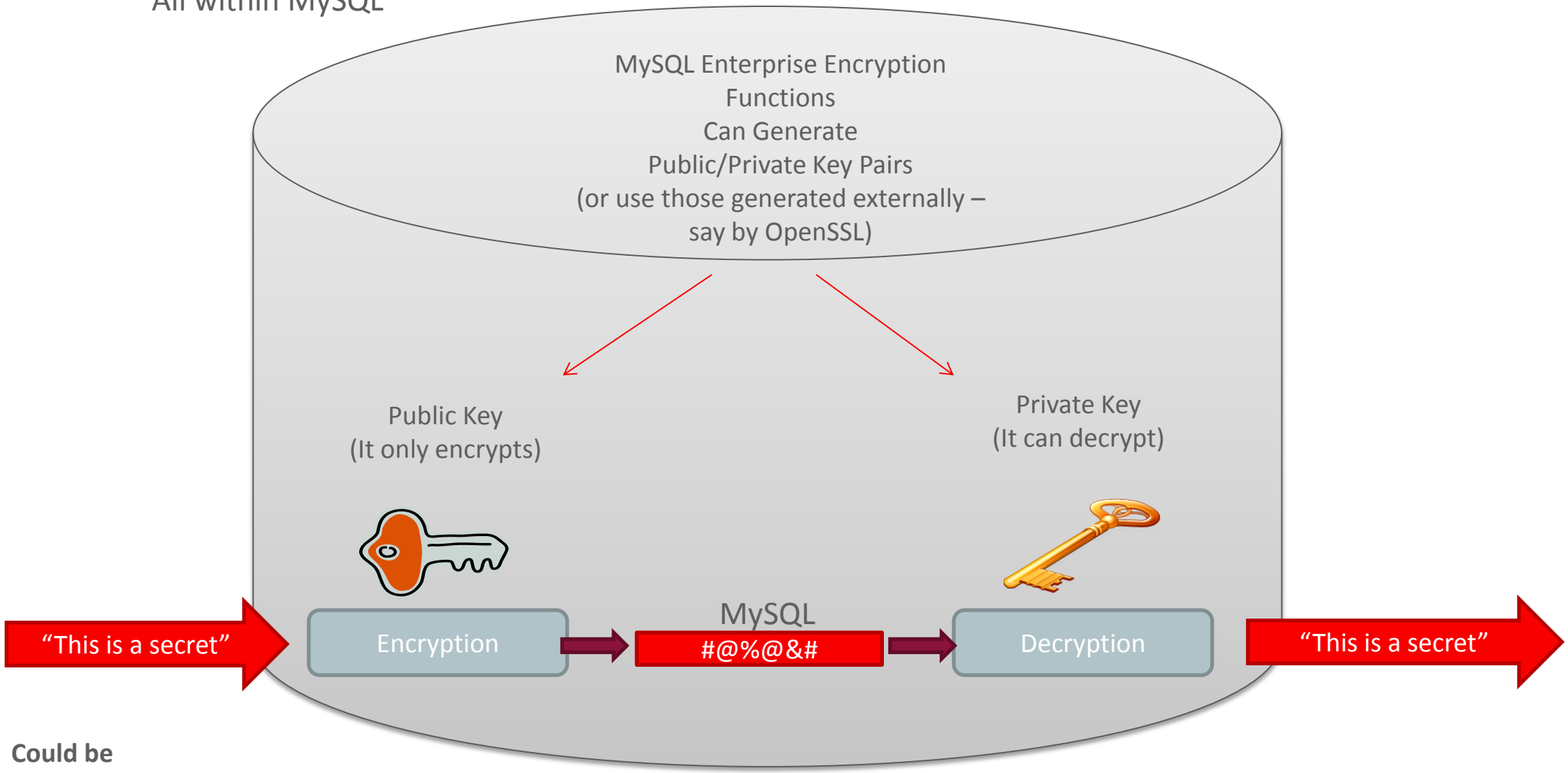
All within MySQL




**Could be**
**From Client App**
**Within MySQL (function call)**

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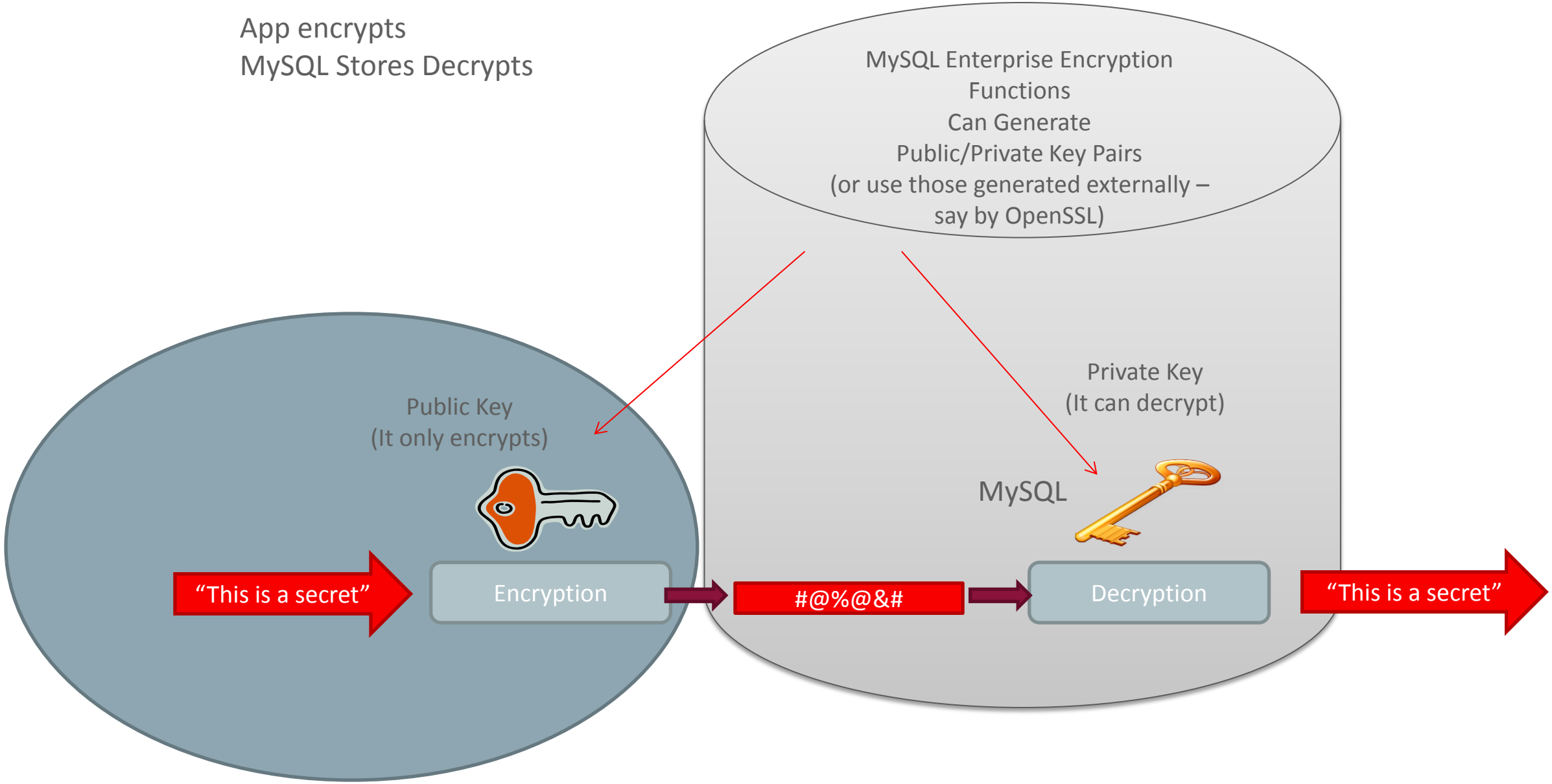
App encrypts
MySQL Stores Decrypts

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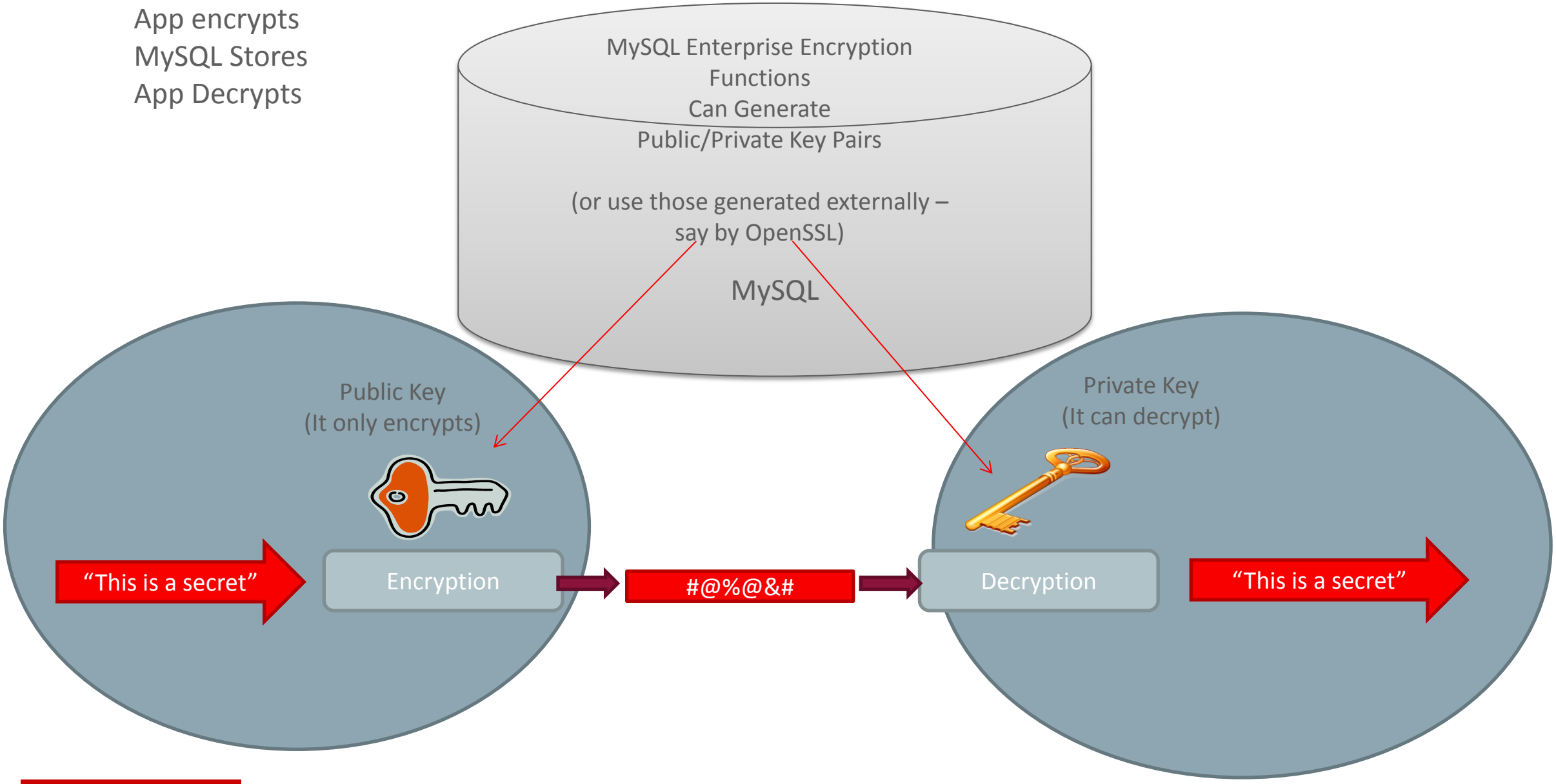
App encrypts
MySQL Stores
App Decrypts

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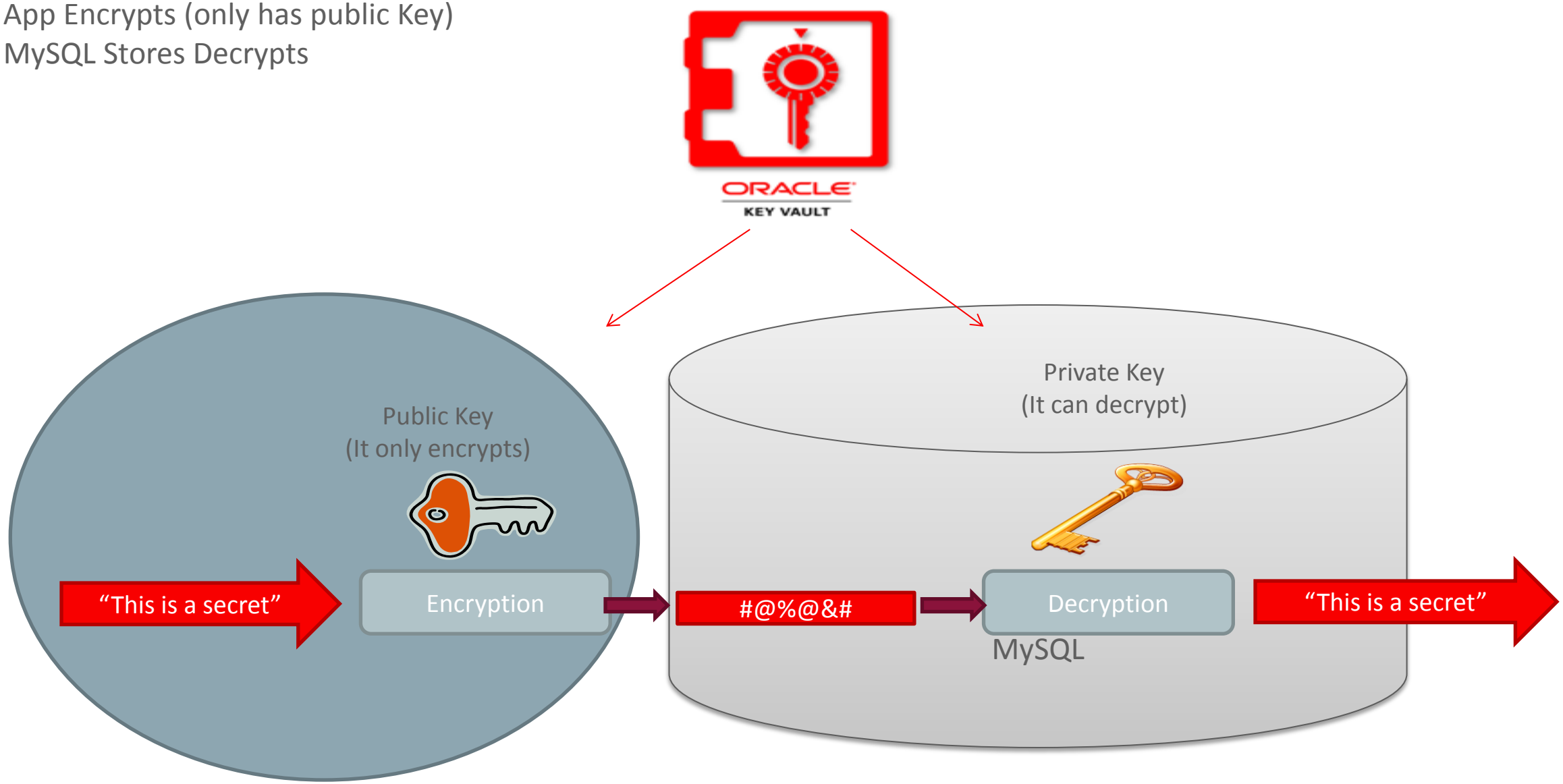
Oracle (or other) Key Vault Generates Keys
App Encrypts (only has public Key)
MySQL Stores Decrypts

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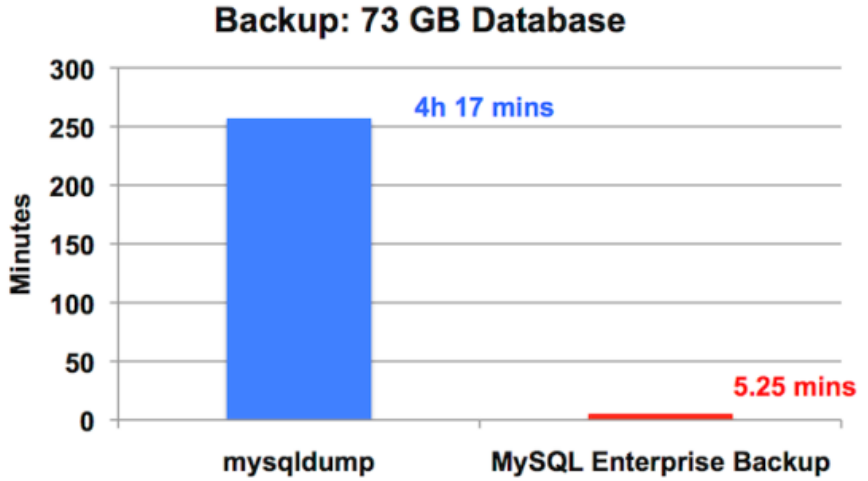
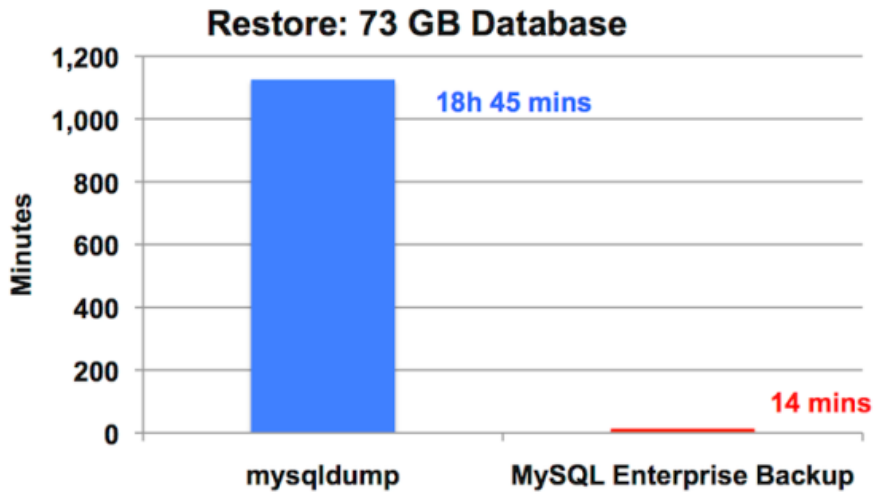
# MySQL Enterprise Backup 4.0

## New & Improved

- Online, non-locking backup and recovery
  - Complete MySQL instance backup (data and config)
  - Partial backup and restore
- Direct Cloud storage backups via Swift API
- Incremental backups & Point-in-time recovery
- Advanced compressed and encryption
- Optimistic backups
- Support for MySQL 5.7
  - General Tablespaces
- Improved SBT Backups to MMS Systems

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# Logging For Audit

- Proper logging is always a requirement for security.
  - FIPS, HIPAA, PCI-DSS, SOX, DISA STIG, …
- MySQL built-in logging infrastructure:
  - general log, error log, NDB logs.
- MySQL Enterprise Audit plugin:
  - Granularity made for auditing.
  - Can be modified live.
  - Contains additional details not found in other logs.
  - Compatible with Oracle Audit Vault.

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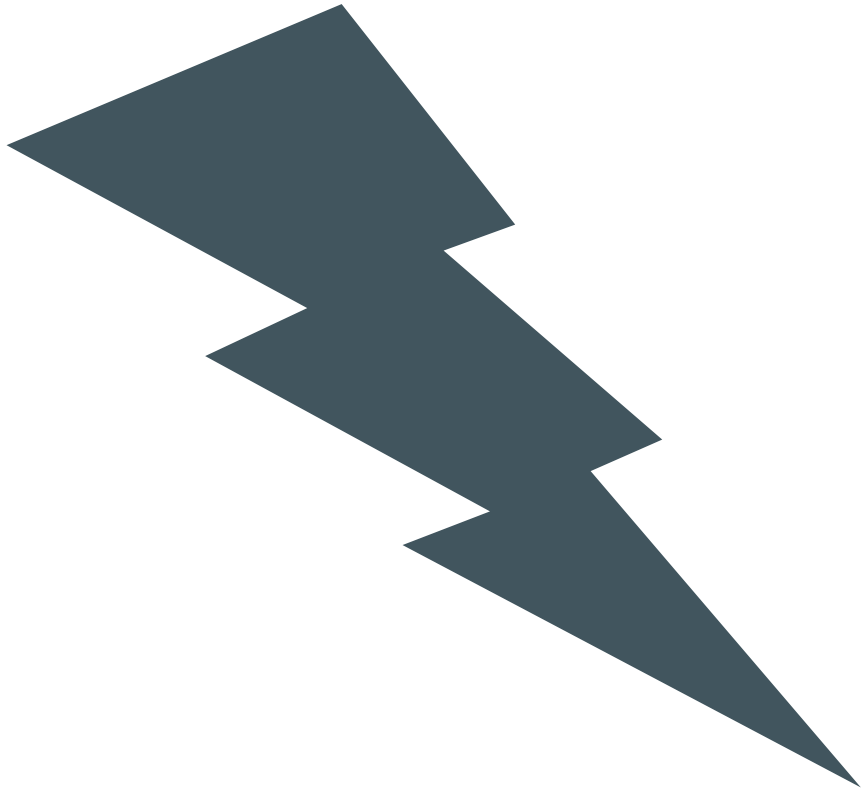
React:

**KNOW IMMEDIATELY**



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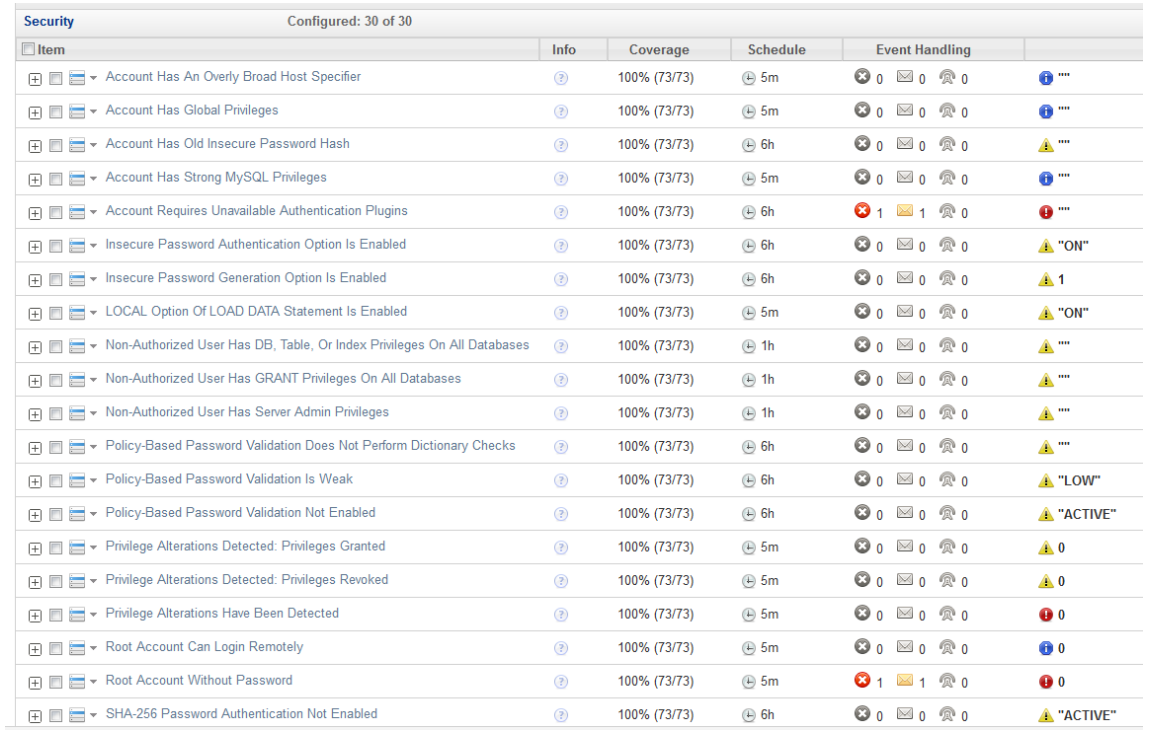
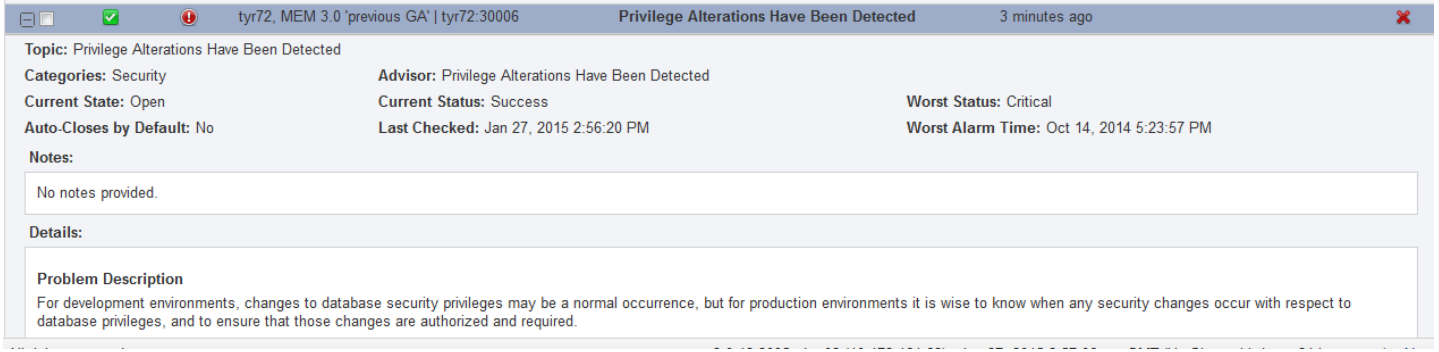
# MySQL Enterprise Monitor

- Includes over 250 Best Practices Advisors.
- Many of those Identify 30+ Security Issues and Risks.
- Alerts DBA of security changes.
- Includes Query Analyzer.
- Available for Oracle EM.



Security — Configured: 30 of 30

| Item | Info | Coverage | Schedule | Event Handling | |
|---|---|---|---|---|---|
| Account Has An Overly Broad Host Specifier | | 100% (73/73) | 5m | 0 0 0 | "" |
| Account Has Global Privileges | | 100% (73/73) | 5m | 0 0 0 | "" |
| Account Has Old Insecure Password Hash | | 100% (73/73) | 6h | 0 0 0 | "" |
| Account Has Strong MySQL Privileges | | 100% (73/73) | 5m | 0 0 0 | "" |
| Account Requires Unavailable Authentication Plugins | | 100% (73/73) | 6h | 1 1 0 | "" |
| Insecure Password Authentication Option Is Enabled | | 100% (73/73) | 6h | 0 0 0 | "ON" |
| Insecure Password Generation Option Is Enabled | | 100% (73/73) | 6h | 0 0 0 | 1 |
| LOCAL Option Of LOAD DATA Statement Is Enabled | | 100% (73/73) | 5m | 0 0 0 | "ON" |
| Non-Authorized User Has DB, Table, Or Index Privileges On All Databases | | 100% (73/73) | 1h | 0 0 0 | "" |
| Non-Authorized User Has GRANT Privileges On All Databases | | 100% (73/73) | 1h | 0 0 0 | "" |
| Non-Authorized User Has Server Admin Privileges | | 100% (73/73) | 1h | 0 0 0 | "" |
| Policy-Based Password Validation Does Not Perform Dictionary Checks | | 100% (73/73) | 6h | 0 0 0 | "" |
| Policy-Based Password Validation Is Weak | | 100% (73/73) | 6h | 0 0 0 | "LOW" |
| Policy-Based Password Validation Not Enabled | | 100% (73/73) | 6h | 0 0 0 | "ACTIVE" |
| Privilege Alterations Detected: Privileges Granted | | 100% (73/73) | 5m | 0 0 0 | 0 |
| Privilege Alterations Detected: Privileges Revoked | | 100% (73/73) | 5m | 0 0 0 | 0 |
| Privilege Alterations Have Been Detected | | 100% (73/73) | 5m | 0 0 0 | 0 |
| Root Account Can Login Remotely | | 100% (73/73) | 5m | 0 0 0 | 0 |
| Root Account Without Password | | 100% (73/73) | 5m | 1 1 0 | 0 |
| SHA-256 Password Authentication Not Enabled | | 100% (73/73) | 6h | 0 0 0 | "ACTIVE" |



tyr72, MEM 3.0 'previous GA' | tyr72:30006 — **Privilege Alterations Have Been Detected** — 3 minutes ago

**Topic:** Privilege Alterations Have Been Detected

**Categories:** Security
**Advisor:** Privilege Alterations Have Been Detected

**Current State:** Open
**Current Status:** Success
**Worst Status:** Critical

**Auto-Closes by Default:** No
**Last Checked:** Jan 27, 2015 2:56:20 PM
**Worst Alarm Time:** Oct 14, 2014 5:23:57 PM

**Notes:**

No notes provided.

**Details:**

**Problem Description**

For development environments, changes to database security privileges may be a normal occurrence, but for production environments it is wise to know when any security changes occur with respect to database privileges, and to ensure that those changes are authorized and required.

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# MySQL Enterprise Monitor 3.1

## Security

- Easily ensure all your MySQL assets are hardened and secure.
- Monitor MySQL Enterprise Firewall:
  - Detect SQL injection attacks and other common threats.
- Monitor MySQL Enterprise Audit:
  - Ensure regulatory compliance.
  - Know what happened when things go wrong.
- Change monitoring and tracking.
- Backup policy enforcement.

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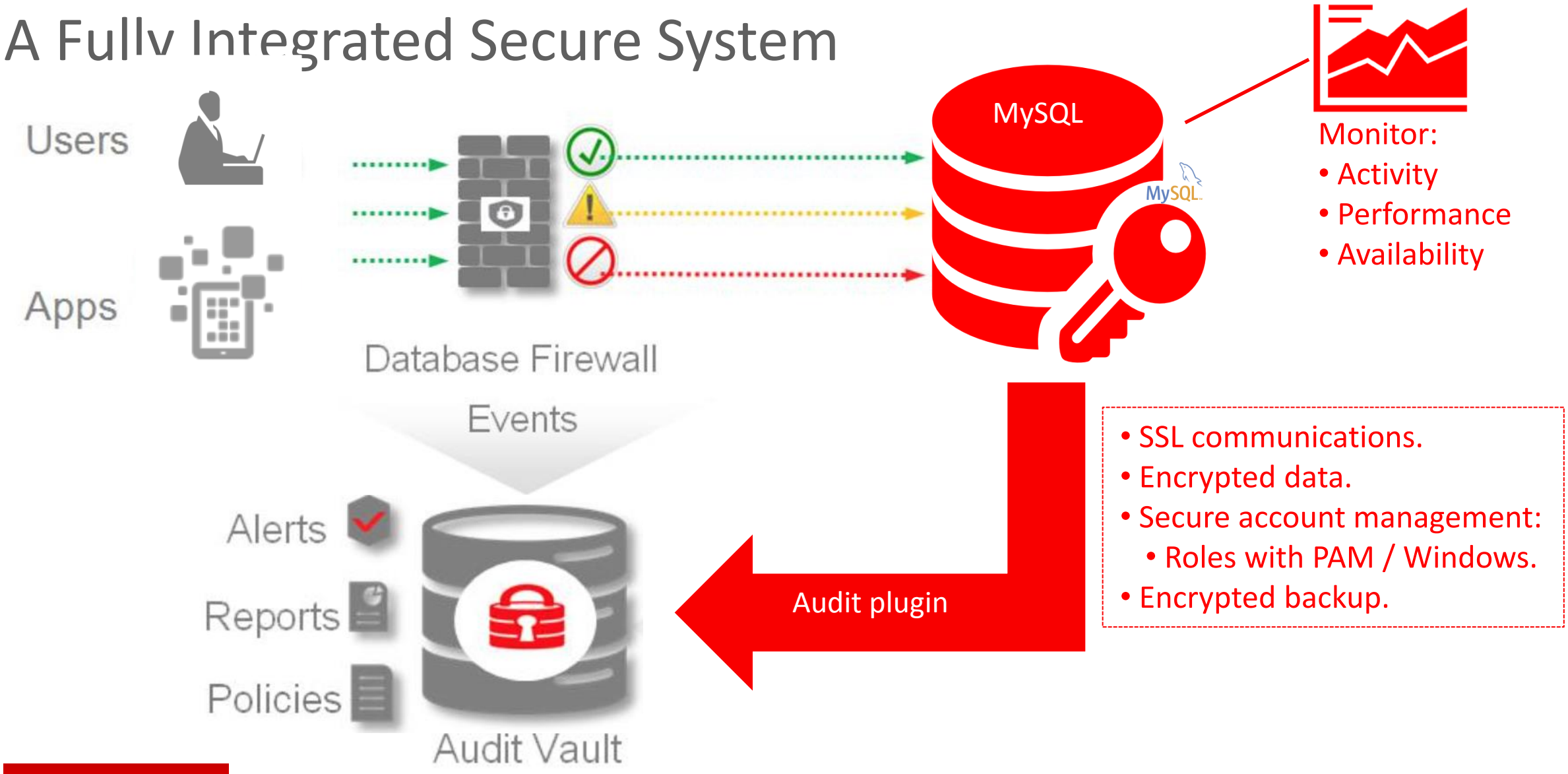
# A Fully Integrated Secure System

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# YesSQL - MySQL High Availability

Kathy Forte
kathy.forte@oracle.com


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# Goal of Today's Talk

To highlight our complete range of options to make MySQL application deployments Highly Available

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# Program Agenda

Complete range of options to make your MySQL application deployments Highly Available

1. **HA with Master-Slave Replication**
2. HA with MySQL Fabric (enhanced Master-Slave Replication)
3. HA with MySQL Group Replication
4. HA with MySQL Cluster Replication

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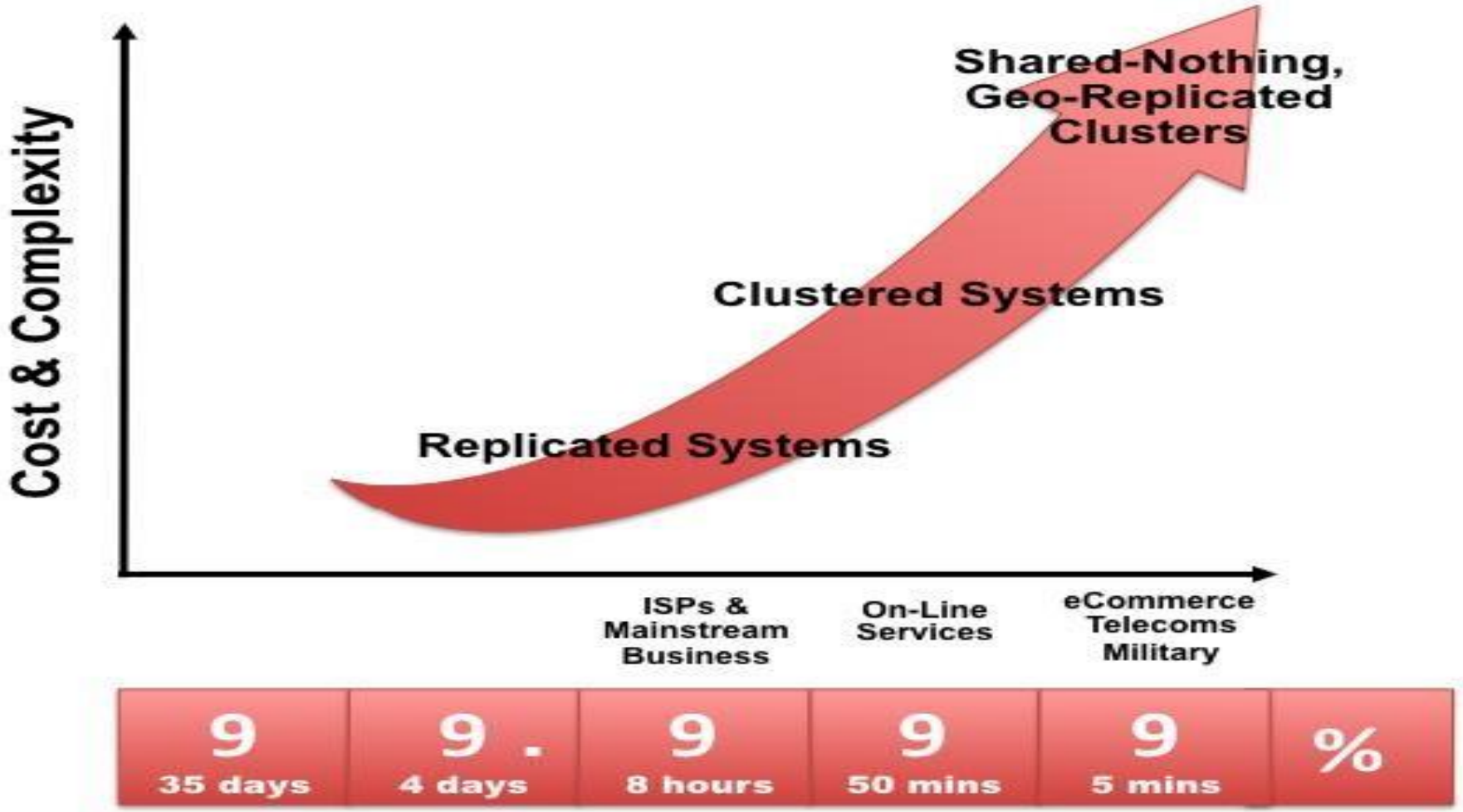
# Range of MySQL Replication Options

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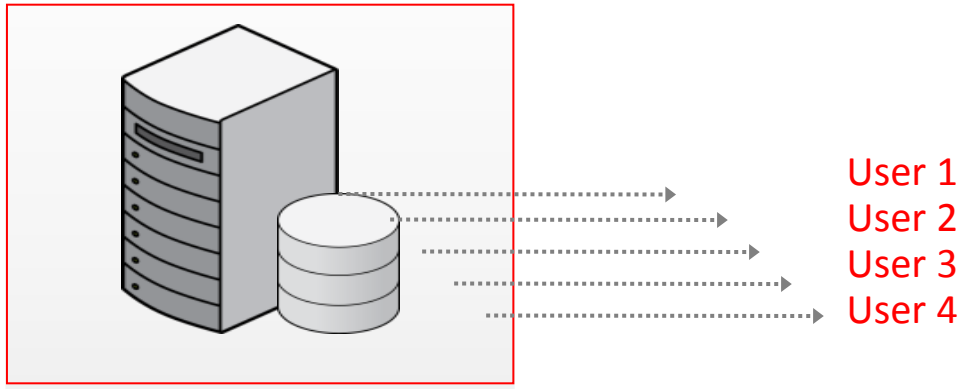
# Why Replicate?

- One Server

What if there's a crash?

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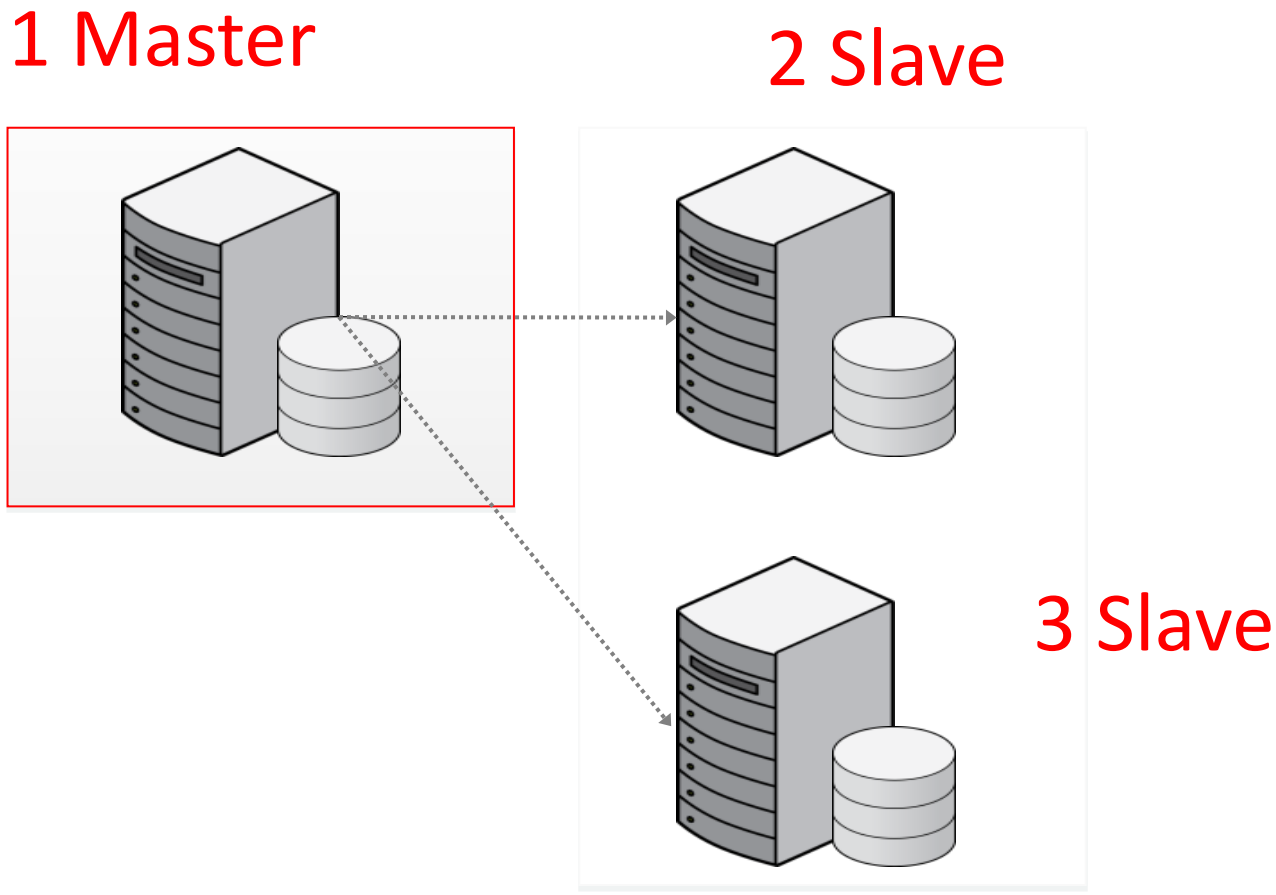
# Master-Slave Replication

- One Master, Two Slaves
- Asynchronous Replication

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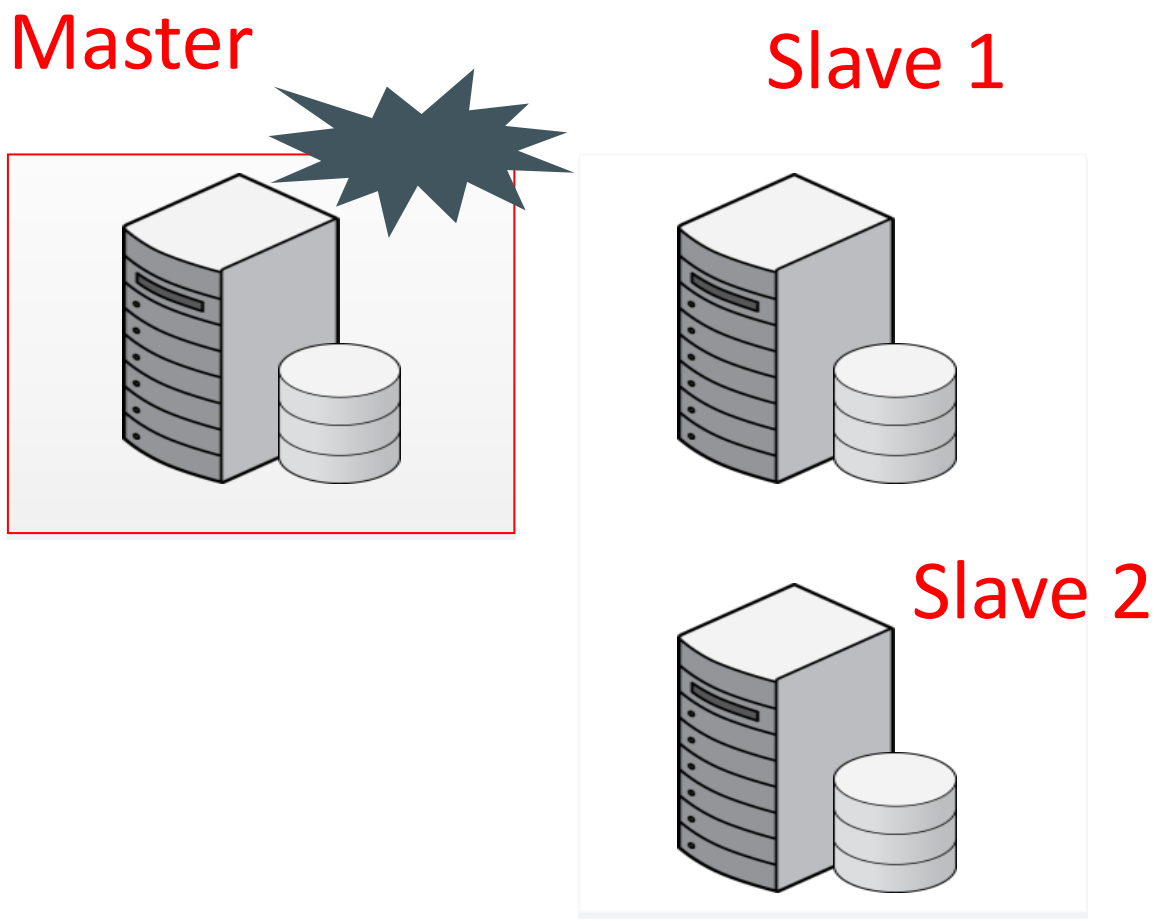
# Failover

- One Master, Two Slaves
  - Crash

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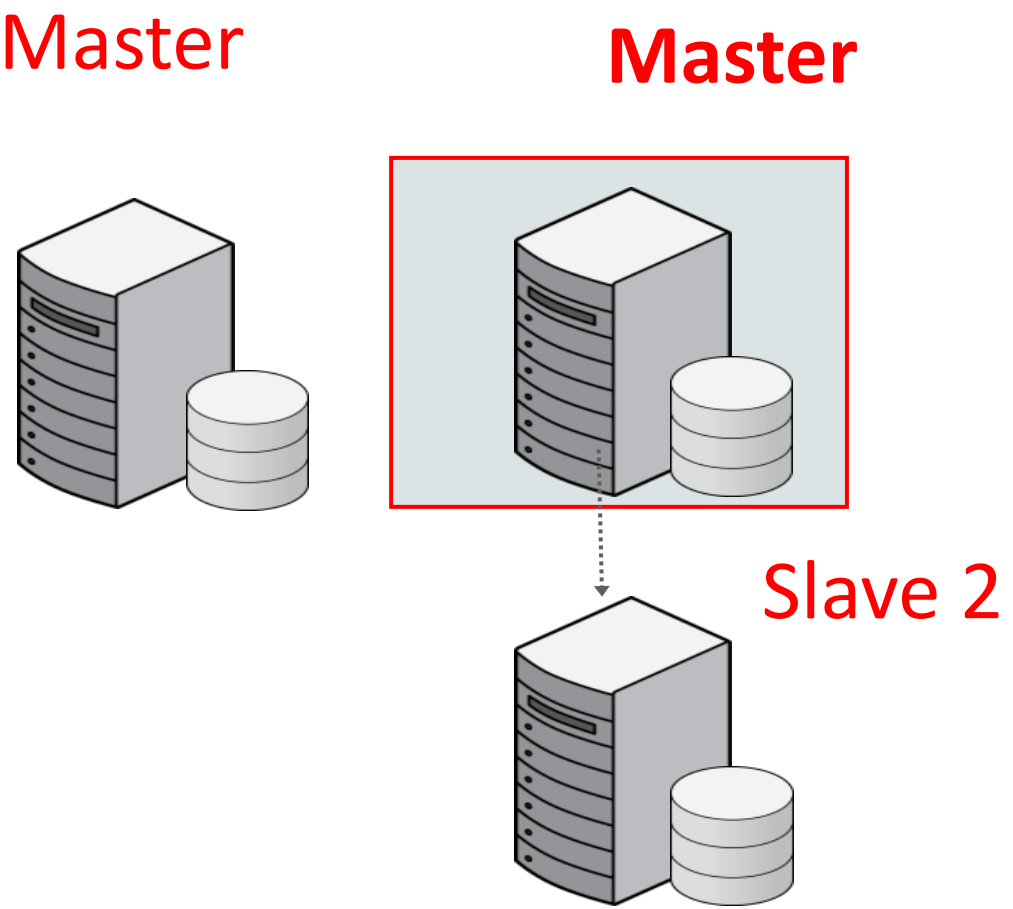
# Failover

- Promote Slave 1 to Master

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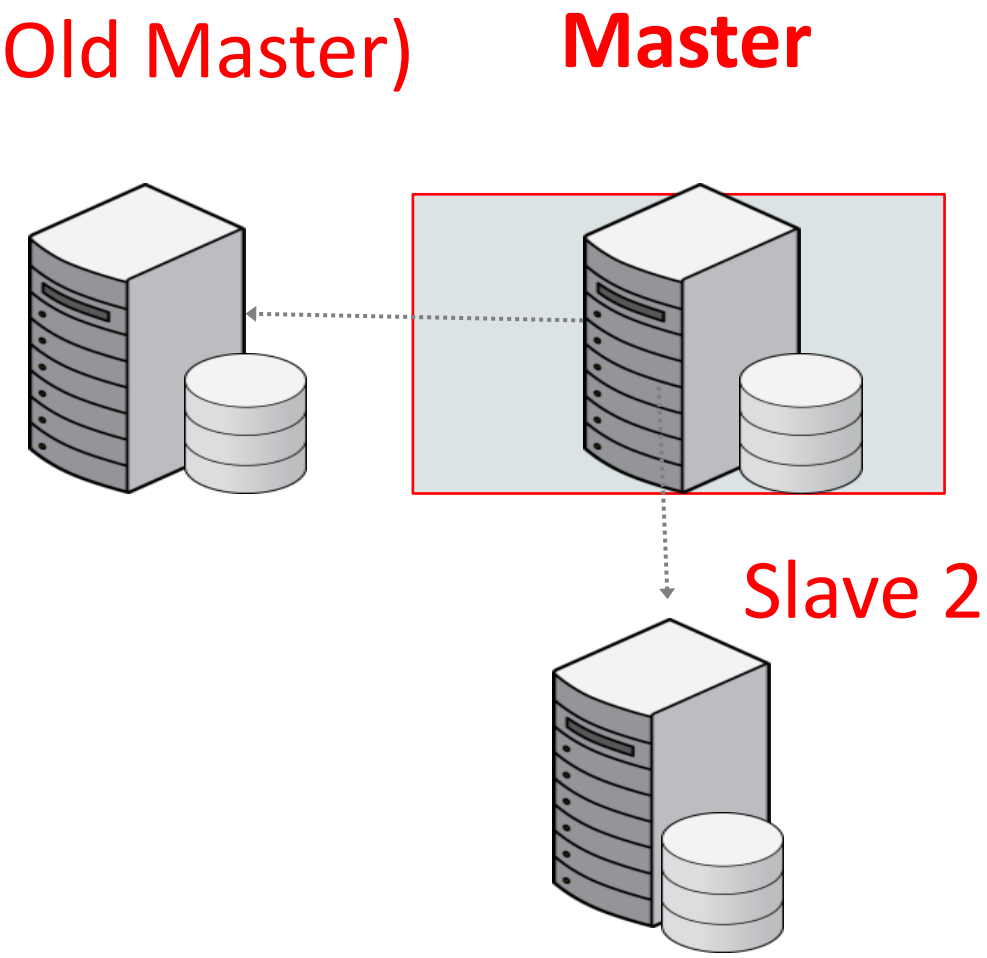
# Failover

- Fix problem with  Old Master

  - becomes Slave 1

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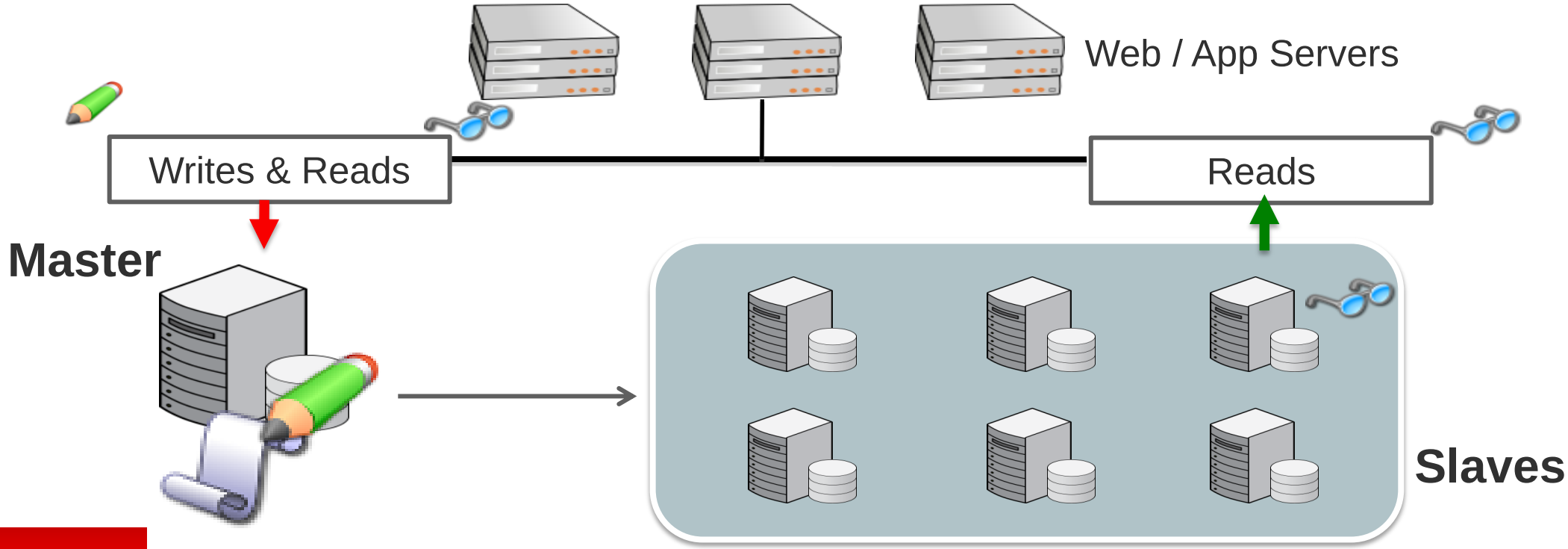
# Faster queries

– Not only HA but scale out by distributing queries across the servers





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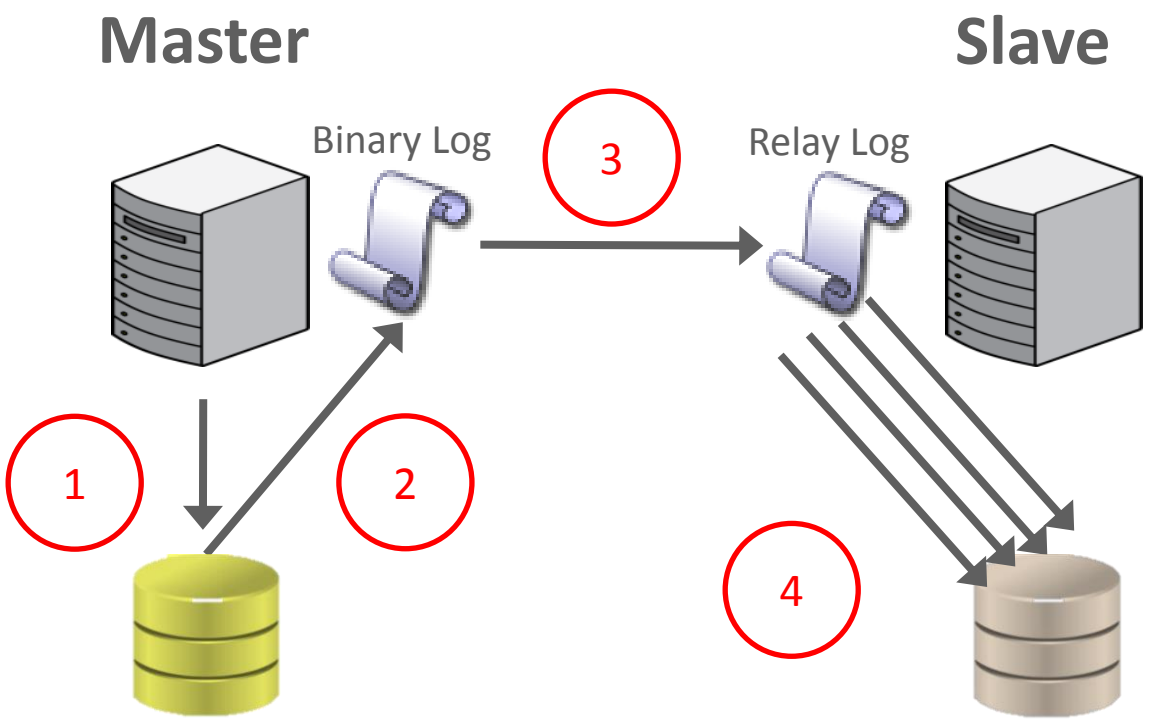
# Asynchronous Replication Internals: Workflow - Multi-Threaded Slaves (MTS)

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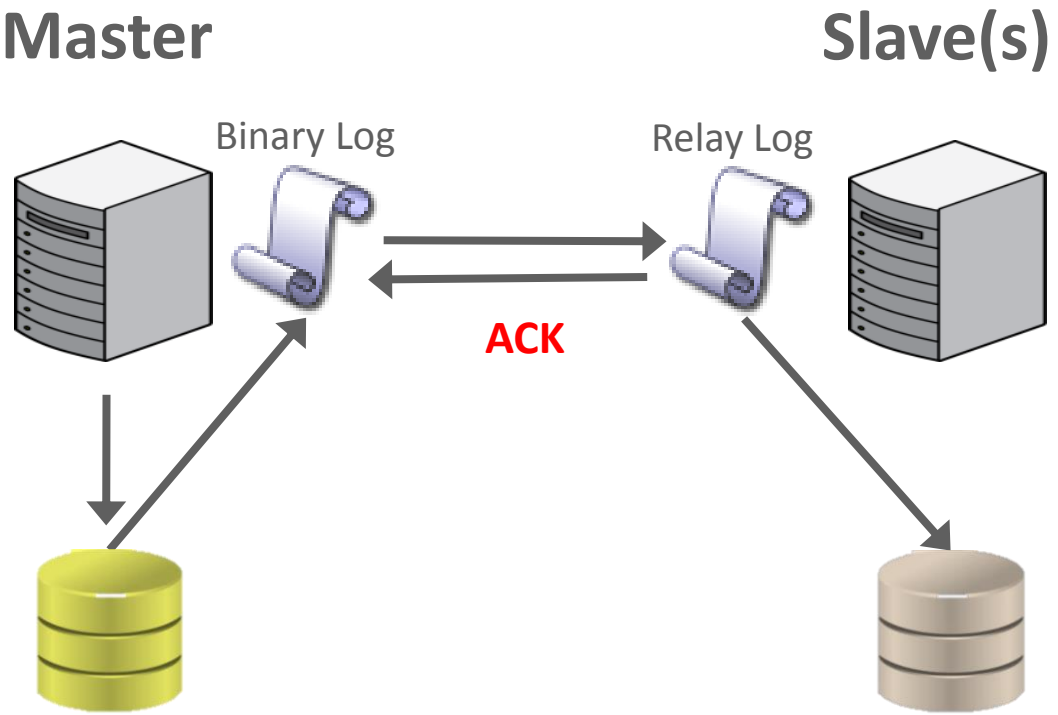
# Semi-synchronous Replication Internals: Workflow

Updates are:

1. Saved to database
2. Saved to Binary log
3. Transmitted to Relay log
4. Replayed on database




One or more slaves says, ‘Yes, got data’

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# Facebook Messenger Mobile App – MySQL Semi-Synchronous Replication

| Requirements | Solution |
| --- | --- |
| ▪ Infrastructure for Messaging<br>  ▪ Multiple devices<br>  ▪ Faster responses<br>  ▪ Short connections<br>  ▪ Millions of messages | ▪ **New IRIS application**<br>▪ **Millions messages/sec**<br>▪ **"No Data Loss" system and 10X improvement in write scalability.**<br>▪ **Highly Available**<br><br>**"Semi-Synchronous Replication is one of the best kept secrets of MySQL"**<br>**Harrison Fisk, Data Performance Engineer at Facebook, Sept 24, 2014**<br>**https://youtube.com/watch?v=eADBCKKf8PA** |

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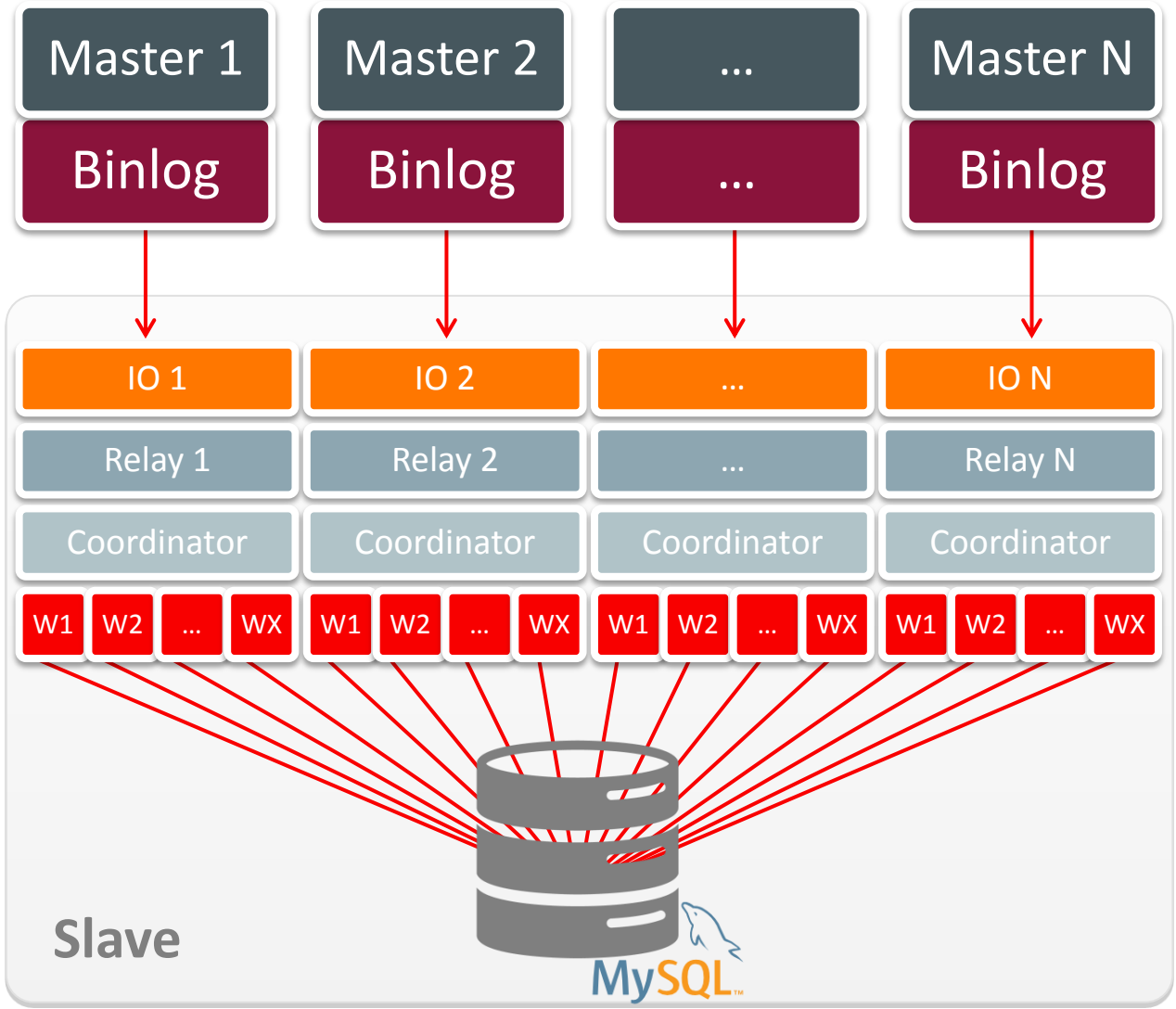
# MySQL 5.7: Replication Improvements

- Multi-Source Replication
  - Consolidate updates from multiple Masters Slave (geographically distributed locations) into one Slave
  - Consolidated view of all shards
    - More flexible topologies
    - Centralized point for backups
  - Compatible with Semi-Sync Replication & enhanced MTS
- Performance Schema tables for monitoring slave
- Online Operations: Dynamic Replication Filters, switch master

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# Program Agenda

Complete range of options to make your MySQL application deployments Highly Available

1. HA with Master-Slave Replication
2. **HA with MySQL Fabric (enhanced Master-Slave Replication)**
3. HA with MySQL Group Replication
4. HA with MySQL Cluster Replication

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# MySQL Fabric

A framework for managing a group of MySQL servers supporting high-availability, automatic failover and sharding

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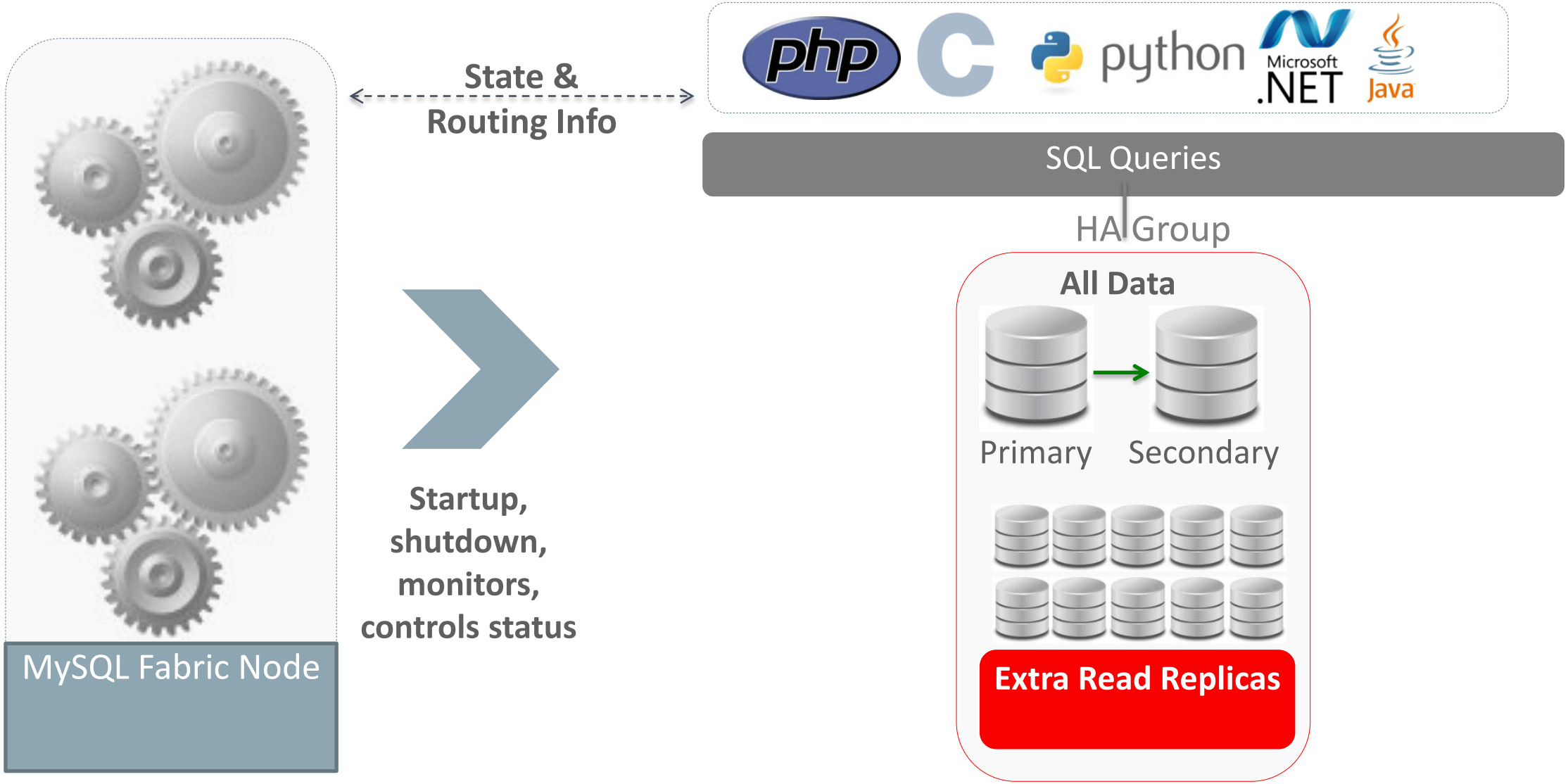
# MySQL Fabric Framework (HA)

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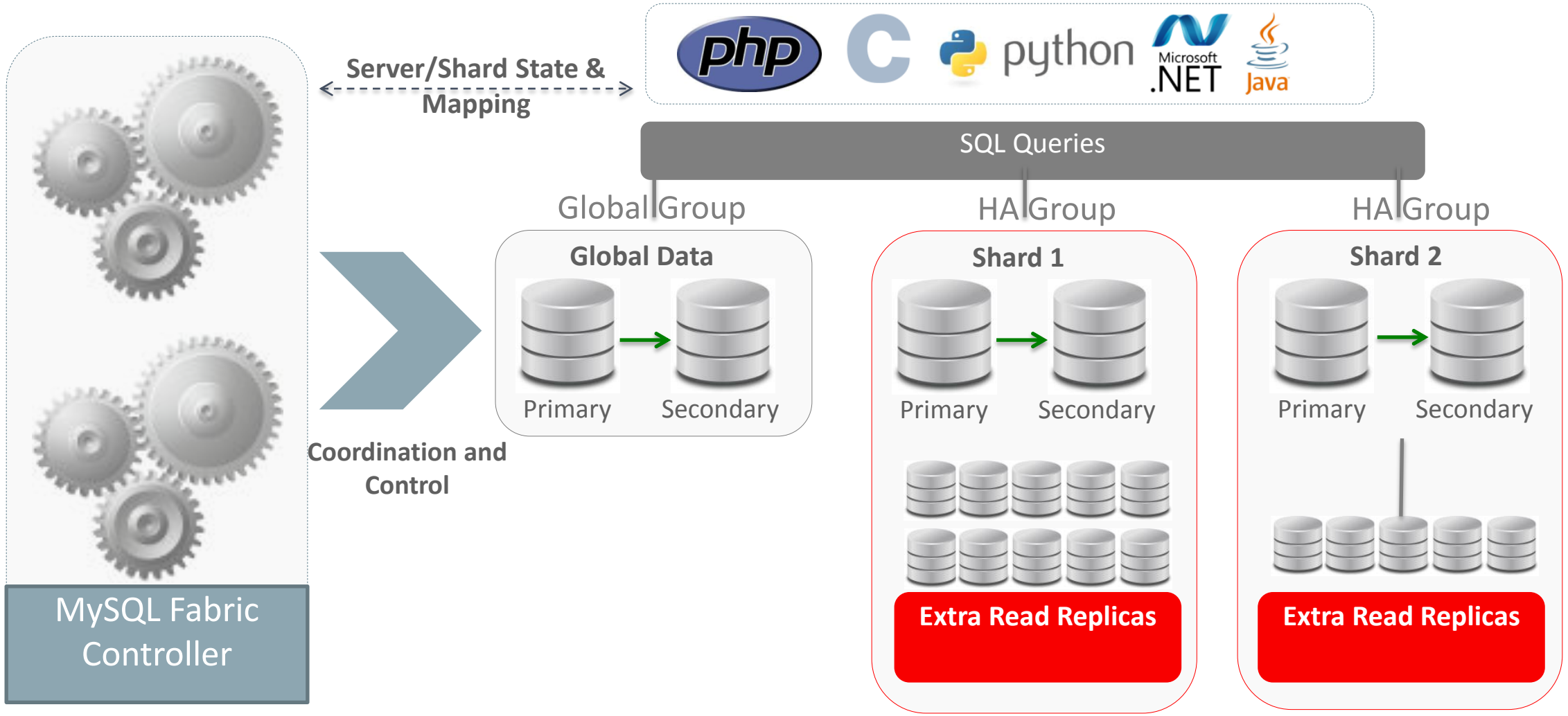
# MySQL Fabric (HA + Sharding)

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4. HA with MySQL Cluster Replication

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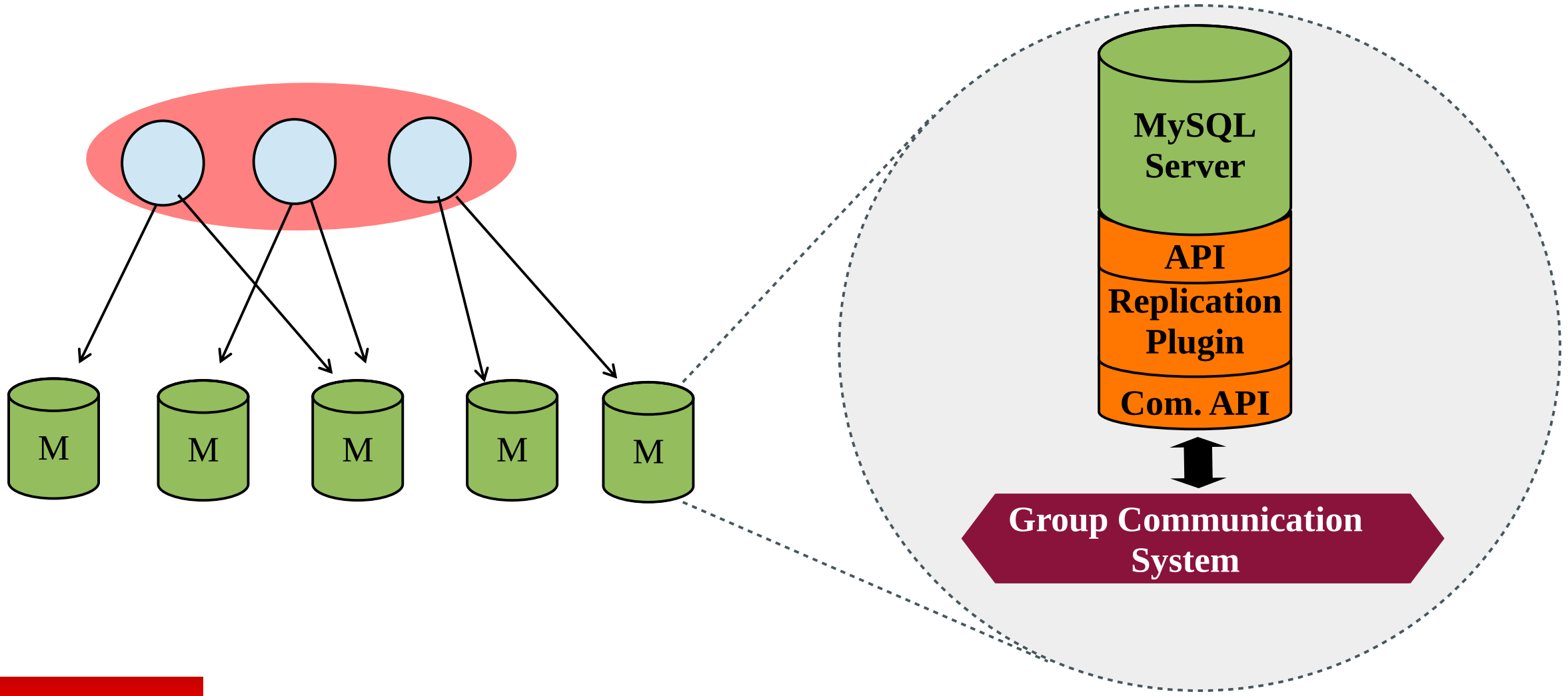
labs.mysql.com

# MySQL Group Replication

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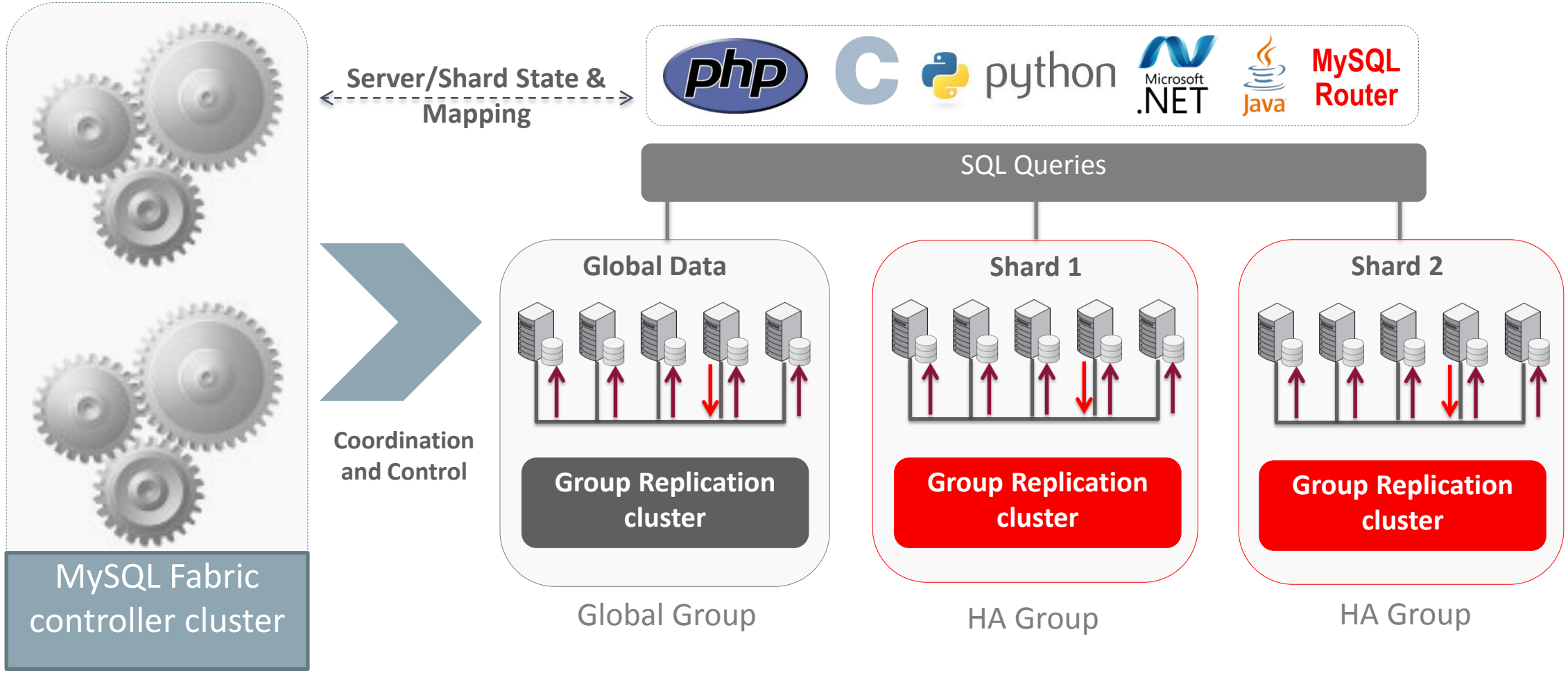
# The Future of MySQL Scaling (HA + Sharding)

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Complete range of options to make your MySQL application deployments Highly Available

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2. HA with MySQL Fabric (enhanced Master-Slave Replication)
3. HA with MySQL Group Replication
4. **HA with MySQL Cluster Replication**

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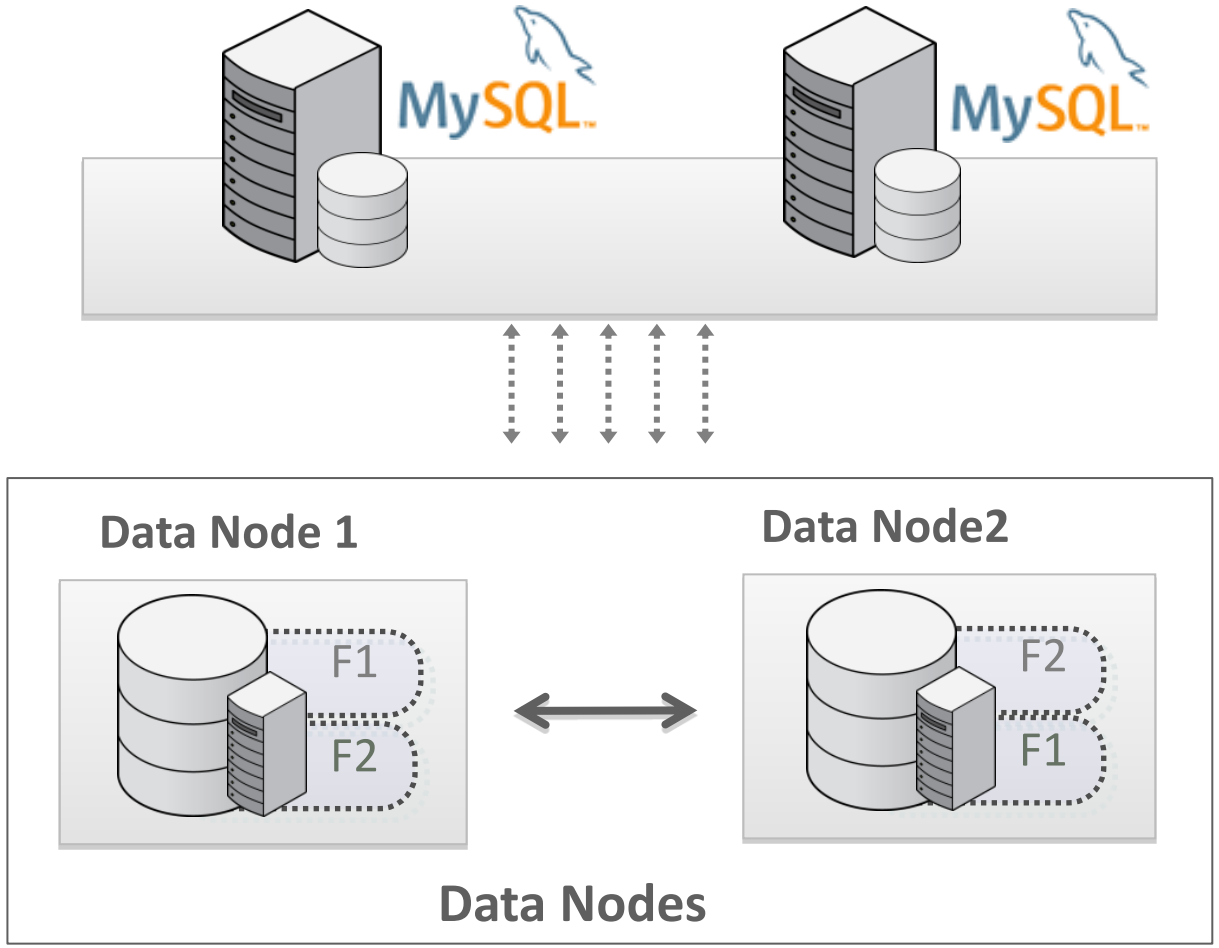
# MySQL Cluster – Basic Architecture

- Master-Master
- 99.999% Availability
- No Single Point of Failure
- 200 million reads per minute (in memory)

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# Big Fish Games – MySQL Cluster

| Requirements | Solution |
| --- | --- |
| ▪ Support the ramp in demand when new games gain traction<br>▪ Produce personalized recommendations to their gamers in near real-time<br>▪ Reduce IT involvement | ▪ MySQL Cluster<br>▪ On-demand scalability of both read and write operations and elasticity of the cluster<br>▪ In-memory tables<br>▪ Continuous availability through the redundancy of the data |

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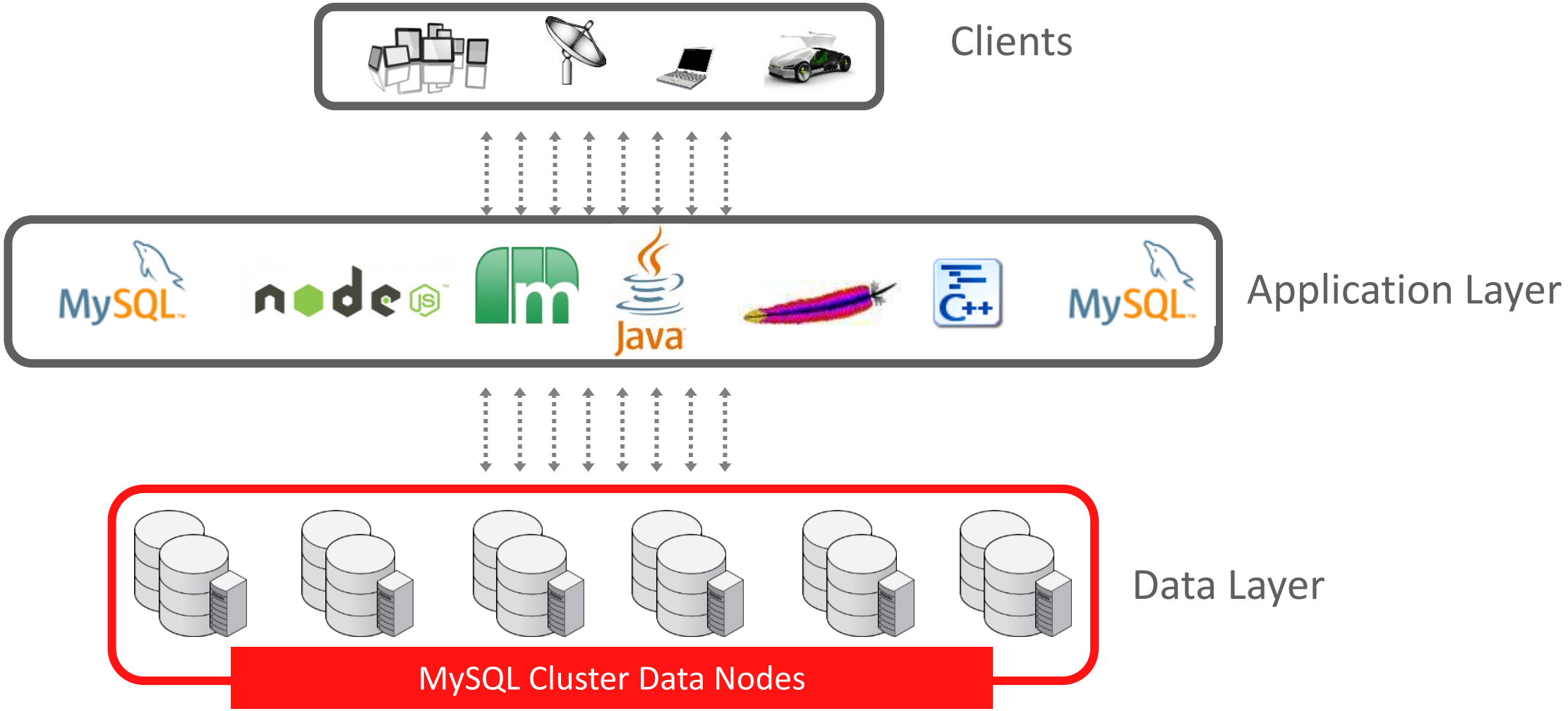
# MySQL Cluster Scaling





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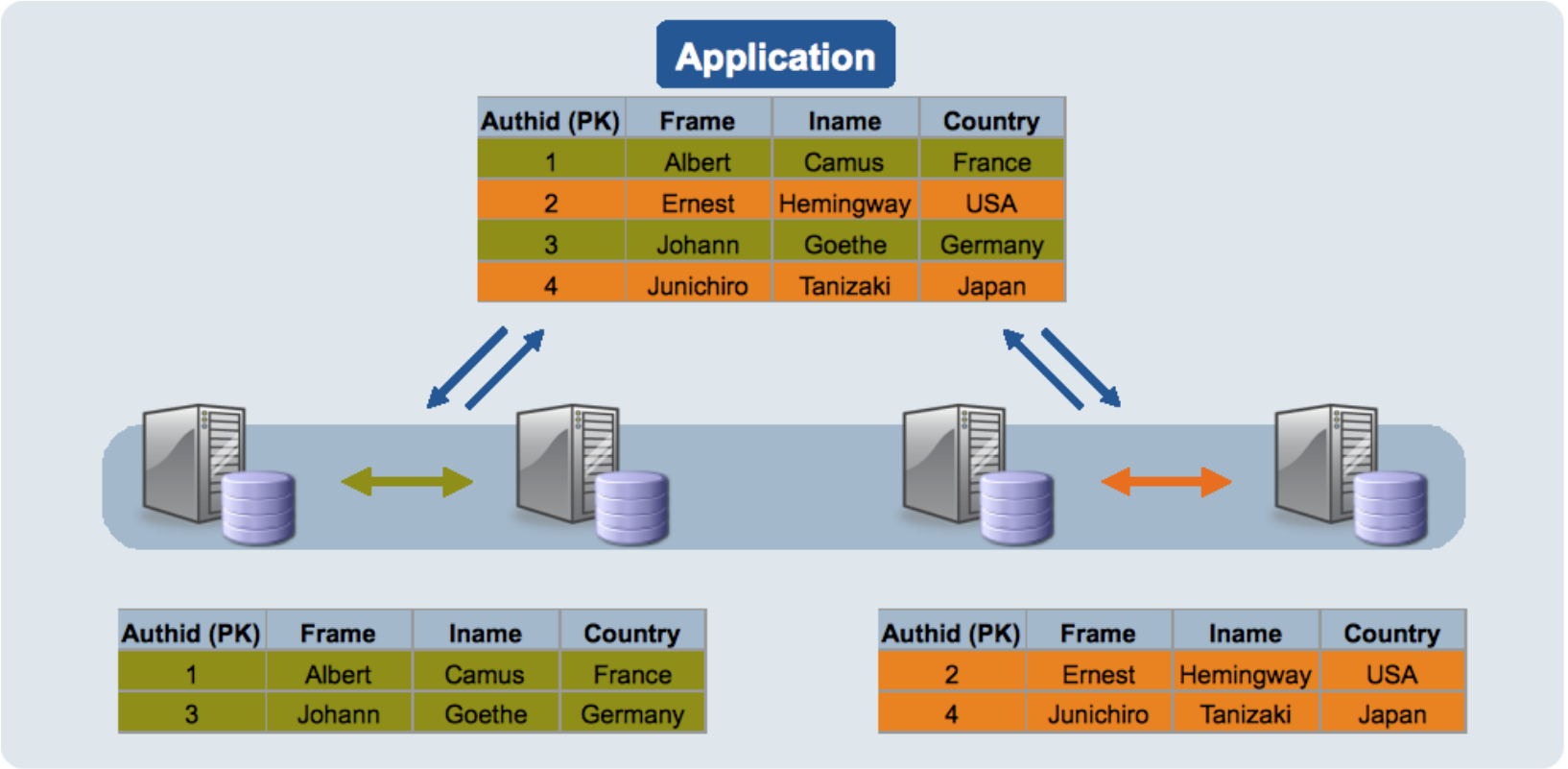
# Transparent

- Application
- Transparency
- Sharding

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# When to Consider MySQL Cluster

- Usage:
  - Short OLTP transactions
  - Many parallel transactions
- Scalability demands:
  - Sharding for write performance?
- Latency demands:
  - Cost of each millisecond?
- Uptime requirements:
  - Cost per minute of downtime?
  - Failure versus maintenance?

MySQL Cluster Evaluation Guide
*http://mysql.com/why-mysql/white-papers/mysql_cluster_eval_guide.php*

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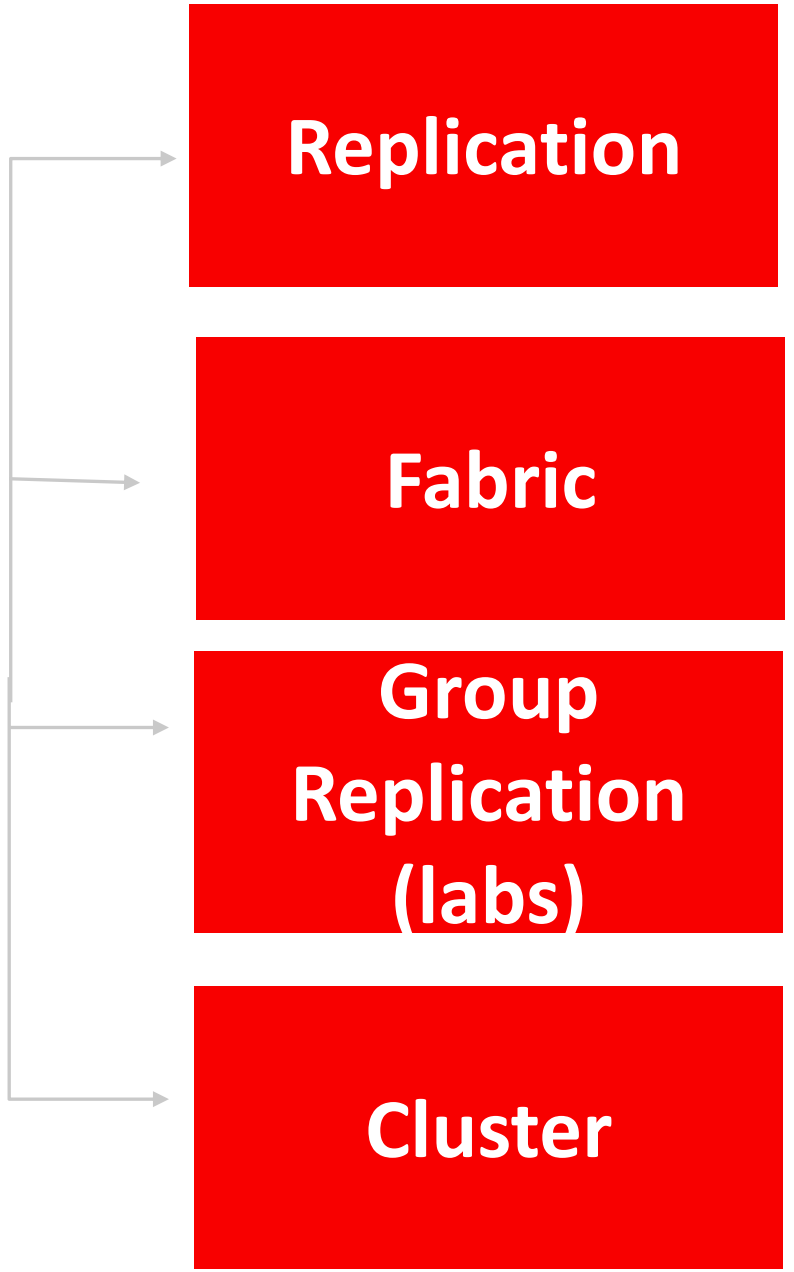
# MySQL High Availability

- Replication
- Fabric for Easy High Availability
- Group Replication
- Network Database (NDB) Cluster
  - High performance (in memory)
  - No single point of failure
  - Synchronous replication

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# Trade-offs

- MySQL Master-Slave Replication- Writes separated from reads – very common in applications where reporting occurs on the replica such as in a business that does analytics on data that doesn't have to be in real-time.
- MySQL Semi-Synchronous Replication - Great where you want to make sure the data is perfectly in sync on a least one master and one slave (Facebook).

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# Trade-offs

- MySQL Fabric – For a business that requires high availability (automatic failover and capability of some redundancy (sharding)). Applications can be ignorant of IP addresses (Fabric manages data location).
- MySQL Cluster - Good for a geographically distributed database where everyone is updating from every location and data must be in sync. Consider an online gaming company with users all over the world (Big Fish Games).

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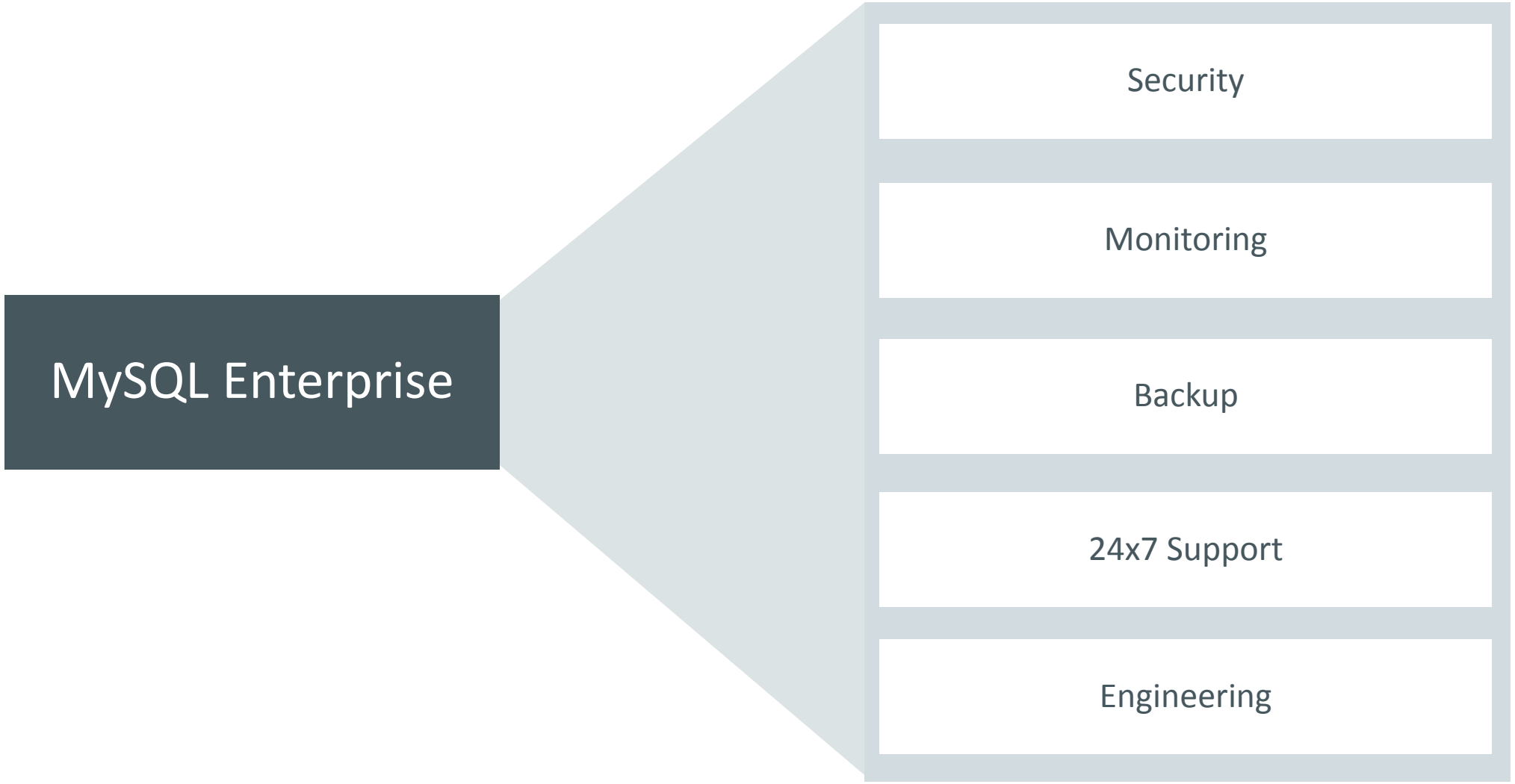
# High availability starts with a well-managed server

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