MySQL Enterprise Edition
Product Guide

A MySQL® White Paper

ORACLE

Table of Contents

1 Introduction

Whether you are building high volume websites, enterprise and departmental applications, or advanced communications networks, your organization needs the tools to build and manage these business-critical database applications. This paper explores how you can confidently deploy MySQL, on-premises and in the Cloud, as part of a cost-effective cross-platform solution for delivering high-performing, highly available, reliable and scalable applications. It examines some of the challenges associated with building and supporting scalable, data-driven applications using open source technologies and provides a detailed overview of how MySQL Enterprise Edition can address these challenges. MySQL Enterprise Edition, combines the most secure, scalable, "always on" version of the MySQL database with online backup, monitoring, management and visual database design and SQL development tools, all backed by Oracle Premier Support, 24x7 global enterprise-class support services. Further, MySQL Enterprise Edition supports your use of MySQL in conjunction with many of the Oracle products and tools you may already be familiar with or are currently using. MySQL Enterprise Edition is specifically designed to help you bring secure, high performing and scalable MySQL applications to market faster, mitigate risk, and ensure you meet customer and end-user Service Level Agreements (SLAs).

2 MySQL Enterprise Edition

MySQL is the world's most popular open source database. Whether you are a fast growing web property, software vendor, a large organization or an SMB MySQL can cost-effectively help you deliver high performance, scalable database applications. If you are currently using MySQL, you probably started with MySQL Community Edition. In fact, in many instances MySQL enters an organization via an application development project and makes its way into the data center when the application is promoted for production use. Challenges arise when these applications become vital to business revenues or key business functions. The most common challenges around running MySQL and other open source technologies are revealed by a simple line of questioning:

- How will you ensure you are using the most reliable, secure, scalable, up-to-date version?
- How will you know:
  - If a server or applications is down?

  - If there is a replication master/slave synchronization or latency issue?
  - If something else is affecting the performance of a server?
- Will you know:
  - If MySQL is configured to scale-out as your application data and customer base grows?
  - How to configure MySQL variables to ensure your applications run at their peak performance?
- How will you:
  - Identify security loopholes in MySQL servers?
  - Know when there have been security alterations on a MySQL server?
  - Seamlessly add auditing compliance to your new and existing MySQL applications?
- How will you:
  - Optimize your database designs and queries before they are migrated into your production environments or included in your products?
  - Ensure replicated servers are configured correctly for performance and scalability?
  - Monitor and tune poorly performing user/application SQL code?
- How will you integrate MySQL with your existing security standards and infrastructure?
- If you or your customers also use the Oracle Database, how can you:
  - Manage MySQL high availability using existing Oracle solutions?

To help you answer these questions with confidence MySQL provides MySQL Enterprise Edition. MySQL Enterprise Edition is a commercial offering comprised of the MySQL database with security, encryption, auditing, high availability and scalability extensions, online backup, monitoring, management, and visual database design and SQL development tools. MySQL Enterprise Edition is backed by Oracle Premier support for organizations delivering highly available, business critical applications and services.

For MySQL deployments in the cloud, Oracle provides Oracle MySQL Cloud Service.

3 Oracle MySQL Cloud Service

Oracle MySQL Service Cloud delivers a secure, cost-effective and enterprise-grade MySQL database service. Built on MySQL Enterprise Edition and powered by the Oracle Cloud, it provides the best in class management tools to automate administrative tasks such as provisioning, patching, backup & recovery, monitoring & tuning. Multi-layered security protects your data against external attacks while helping you achieve

regulatory compliance. Self-service provisioning creates pre-configured MySQL databases optimized for performance and automated scaling enables users to elastically scale compute resources, storage resources and MySQL replicas.

The Oracle MySQL Cloud Service video will provide you a rapid overview:
https://www.youtube.com/embed/xXUlHvAYtiE?autoplay=1

Oracle MySQL Cloud Service makes it extremely easy to rely on MySQL either to migrate existing on-premises applications to the cloud or deliver new ones. You can:

- **Increase Business Agility**: Focusing your resources on innovation, not on infrastructure management.
- **Ensure Security, Performance & Uptime**: relying on the most comprehensive MySQL cloud platform – straight from the source.
- **Reduce Total Cost of Ownership**: Saving on infrastructure and database management operations costs while improving uptime.

Get our eBook "Oracle MySQL Cloud Service; Propel innovation and time-to-market":
https://cloud.oracle.com/opc/paas/ebooks/Oracle_MySQL_Cloud_Service.pdf

Learn more about Oracle MySQL Cloud Service and sign up for a free trial:
https://cloud.oracle.com/mysql

We shall now review the various components included in MySQL Enterprise Edition:

4 MySQL Database

The MySQL Database is a fully integrated transaction-safe, ACID compliant database with full commit, rollback, crash-recovery and row level locking capabilities. The MySQL Database is a cost-effective solution for:

- High-performance, scalable Web/Cloud/SaaS and E-commerce applications
- Corporate Departmental OLTP and Data Mart applications
- Operational data store integrated with Big Data repositories (Hadoop)
- Low administration, high performance, reliable embedded database applications

- And more

The MySQL Database provides the following features:

- **Native HA** to ensure that your database is always available.
- **Self-healing Replication Clusters** to improve scalability, performance and availability of high-volume applications.
- **Performance/Scalability** to meet the demands of ever growing data loads and user concurrency.
- **NoSQL Document Store** gives developers the flexibility of developing traditional SQL relational applications and NoSQL, schema-free document database applications.
- **Native JSON Support** for efficient and flexible storage, search and manipulation of schema-less data.
- **Online DDL/Schema Changes** for dynamic applications that must remain available for updates at all times.
- **Performance Schema** for monitoring user/application level performance and resource consumption.
- **Platform Interoperability** that allows MySQL to run across operating systems and to be used as the operational data store for Hadoop and other Big Data platform deployments.

You can learn more about what's new in MySQL 8.0 for DBAs and Developers here:
https://www.mysql.com/why-mysql/white-papers/whats-new-mysql-8-0/

MySQL Enterprise Edition builds on the above feature set by providing a set of commercial extensions around the MySQL Database that meet the advanced security, performance, scale and availability requirements of the most demanding applications, web and online environments. These extended features are exclusive to MySQL Enterprise Edition and are described below.

5 MySQL Enterprise Authentication

MySQL Database 5.5 and higher also supports an open, pluggable authentication interface that enables users to develop plug-ins to authenticate MySQL client connections against external resource such as LDAP, Windows Active Directory, PAM, etc. This enables MySQL to easily integrate with existing security standards and infrastructure.

MySQL External Authentication

MySQL Enterprise Edition provides ready to use external authentication modules for users who authenticate users via Pluggable Authentication Modules ("PAM") or native Windows OS services. Each is described below:

- MySQL External Authentication for PAM - Enables you to configure MySQL to use PAM to authenticate users on LDAP, Unix/Linux, and other systems.

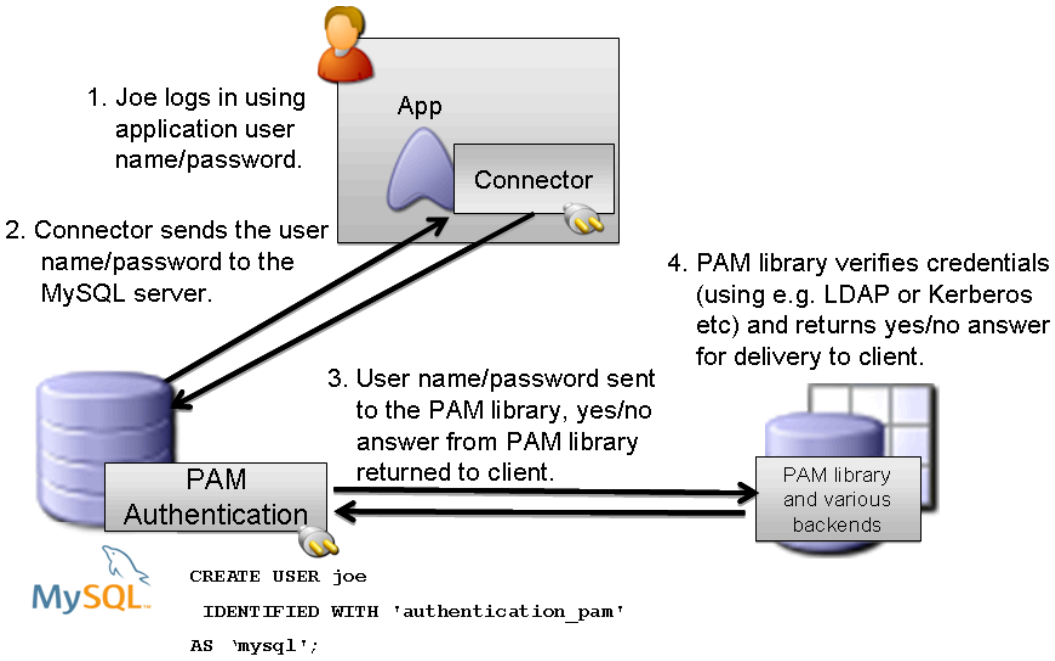


Figure 2: MySQL External Authentication for PAM

- MySQL External Authentication for Windows – Enables you to configure MySQL to use native Windows services to authenticate client connections. Users who have logged in to Windows can connect from MySQL client programs to the server based on the token information in their environment (via Active Directory) without specifying an additional password.

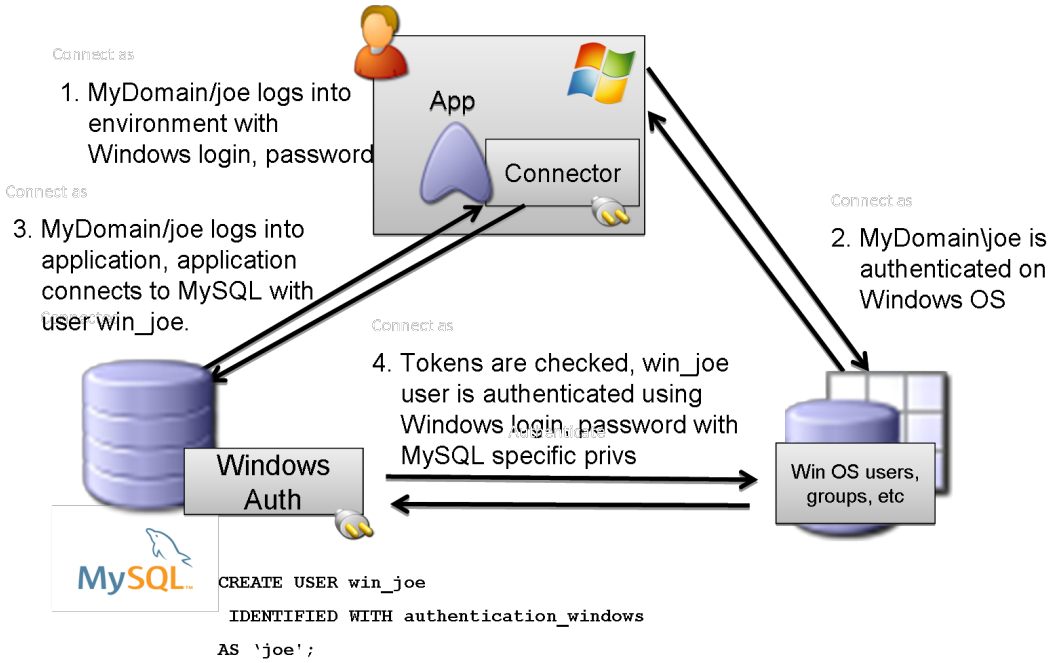


Figure 3: MySQL External Authentication for Windows

To learn more about MySQL Enterprise Authentication visit: http://www.mysql.com/products/enterprise/security.html.

6 MySQL Enterprise Encryption

To protect sensitive data throughout its lifecycle, MySQL Enterprise Encryption provides industry standard functionality for asymmetric encryption (Public Key Cryptography). MySQL Enterprise Encryption provides encryption, key generation, digital signatures and other cryptographic features to help organizations protect confidential data and comply with regulatory requirements including HIPAA, Sarbanes-Oxley, and the PCI Data Security Standard.

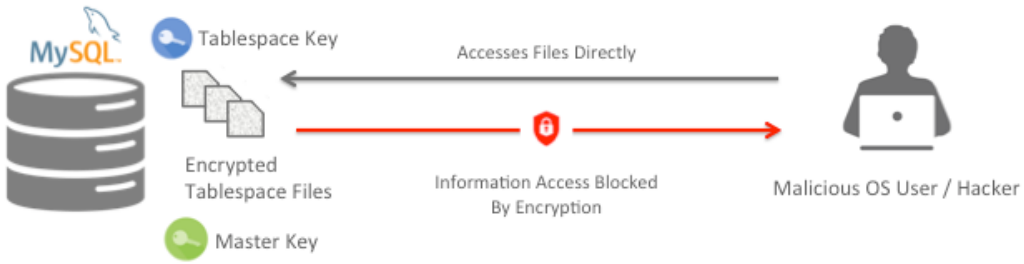
MySQL Enterprise Encryption gives DBAs and Developers the tools they need for:

- Asymmetric Public Key Encryption (RSA)
- Asymmetric Private Key Decryption (RSA)
- Generate Public/Private Key (RSA, DSA, DH)
- Derive Symmetric Keys from Public and Private Key pairs (DH)
- Digitally Sign Data (RSA, DSA)
- Verify Data Signature (RSA, DSA)
- Validation Data Authenticity (RSA, DSA)

This enables software developers to encrypt data by using RDS, DHS and DH encryption algorithms without changing existing applications.

7 MySQL Enterprise Transparent Data Encryption (TDE)

MySQL Enterprise Transparent Data Encryption (TDE) protects your critical data by enabling data-at-rest encryption in the database. It protects the privacy of your information, prevents data breaches and helps meet regulatory requirements including the Payment Card Industry Data Security Standard (PCI DSS), Health Insurance Portability and Accountability Act (HIPAA) and numerous others.



MySQL Enterprise TDE enables data-at-rest encryption by encrypting the physical files of the database. Data is encrypted automatically, in real time, prior to writing to storage and decrypted when read from storage. As a result, hackers and malicious users are unable to read sensitive data from tablespace files, database backups or disks.

MySQL Enterprise TDE uses a two-tier encryption key architecture, consisting of a master encryption key and tablespace keys which provides easy key management and rotation. Tablespace keys are managed automatically behind the scenes while the master encryption key is stored in a centralized key management solution such as Oracle Key Vault, which enforces clear separation of keys from encrypted data.

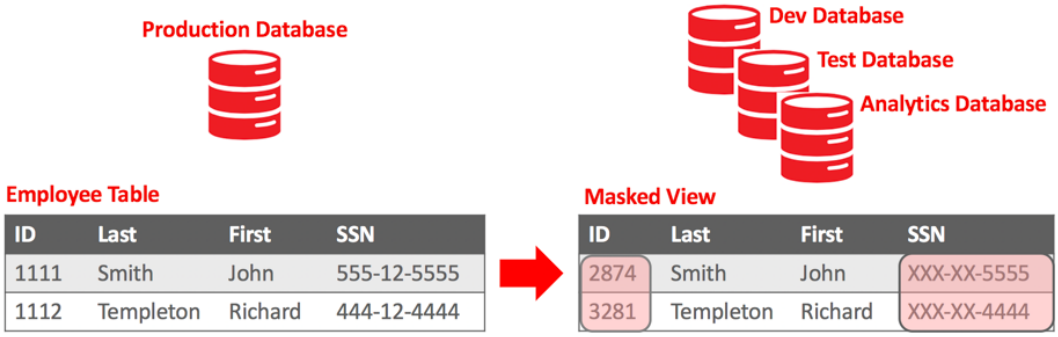
8 MySQL Enterprise Masking and De-identificaiton

MySQL Enterprise Masking and De-identification provides an easy to use, built-in database solution to help organizations protect sensitive data from unauthorized uses by hiding and replacing real values with substitutes.

MySQL Enterprise Masking and De-identification enables organization to:

- **Meet regulatory requirements and data privacy laws** such GDPR, PCI DSS and HIPPA that require data de-identification.
- **Significantly reduce the risk of a data breach** by preventing unauthorized access to confidential data.

- **Protect confidential information** while improving development, test and analytics environments.



MySQL Enterprise Masking and De-identificaiton protects sensitive data from unauthorized users.

Meet Industry Regulation Requirements and Data Privacy Mandates
All major industry regulations require data masking of PII (personally identifiable information), PANs (Primary Account Number) and other confidential data so that only authorized personnel can access the data. MySQL Enterprise Masking and De-identification provides specific functions to mask and de-identify confidential data so your IT organization can comply with privacy regulations, including:

- **GDPR:** General Data Protection Directive
- **PCI DSS:** Payment Card Industry Data Security Standard
- **HIPAA:** Health Insurance Portability and Accountability Act
- **HITECH:** Health Information Technology for Economic and Clinical Health Act
- **Data Protection Act:** United Kingdom
- **SOX:** Sarbanes Oxley
- **FERPA:** Family Educational Rights and Privacy Act
- And many more

Improve the Security of Dev, Test and Analytics Environments
Organizations can reduce the risk of a data breach by masking sensitive or confidential application data so it can be used in non-production systems. Real values are replaced with realistic but fictitious values, allowing production data to be safely used for development, testing, analytics or sharing with 3rd party partners for non-production purposes.

Built-in & Easy to Use
MySQL Enterprise Data Masking is implemented in the MySQL Server itself, so the masking logic is centralized. Its simple to implement masking functions on sensitive fields, which can be done on an existing database without affecting database operations, requiring changes in application code

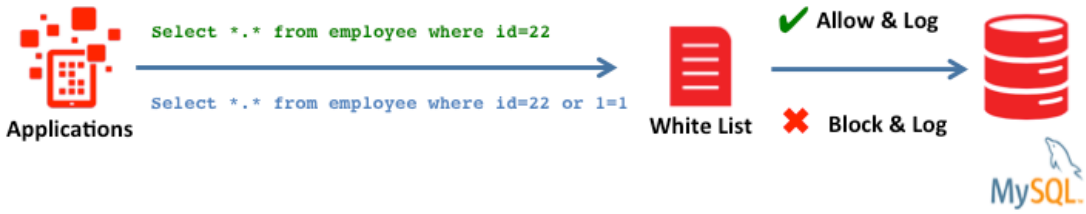
or changes to the production data itself. MySQL Enterprise Data Masking operates in memory with minimal performance impact.

Robust Data Masking Functions
MySQL Enterprise Masking and De-identification can hide or obfuscate sensitive data, by controlling how the data appears. It features robust masking algorithms including selective masking, blurring, random data substitution and other special techniques for credit card numbers, account numbers and other personally identifiable information, enabling IT departments to maintain structural rules to de-identify values. MySQL Enterprise Masking and De-identification functions include:

- **Selective Masking** - Obscures a particular portion of numbers or strings such as phone numbers, and payment card numbers.
- **Strict or Relaxed Masking** – Implement strict or relaxed masking to obfuscate data
- **Random Data Substitution** – Replace real values with random values while maintaining format consistency.
- **Blurring** – Add a random variance to existing values such as randomized numeric ranges for salaries.
- **Dictionary substitution** – Randomly replace values from task specific dictionaries.
- **Blacklisting and substitution** – Replace specifically blacklisted data, but leave non-blacklisted in place.

9 MySQL Enterprise Firewall

MySQL Enterprise Firewall guards against cyber security threats by providing real-time protection against database specific attacks, such as an SQL Injection. MySQL Enterprise Firewall monitors for database threats, automatically creates a whitelist of approved SQL statements and blocks unauthorized database activity.



- Real-time Threat Monitoring - All incoming queries pass through a SQL analysis engine and are matched against an approved Whitelist of expected SQL statements.

- Block Suspicious Traffic - Statements that do not match the approved whitelist are blocked, logged and can be analyzed to help block a potential SQL injection attack.
- Learn and Build Whitelists - Automatically create user specific whitelists of pre-approved SQL statements using a self-learning system.
- Transparent Protection - MySQL Enterprise Firewall requires no changes to your application regardless of development language, framework or 3rd party application.
- High Performance - MySQL Enterprise Firewall runs within each MySQL instance and provides scale-out performance.
- Logging - MySQL Enterprise Firewall tracks and provides metrics on both allowed and blocked SQL statements. Blocked statements are logged for inspection and alerting.

10 MySQL Enterprise Audit

Today's web-based applications have evolved from nice-to-have enablers to the mission-critical revenue generating mechanisms that characterize the modern business model. In this virtual marketplace, PCI compliance guidelines ensure credit card data is secure within e-commerce apps. From a corporate standpoint, Sarbanes-Oxley, HIPAA and other government imposed mandates guard the medical, financial, public sector and other personal data centric industries with required logging, archiving and "upon request" access to audit trails that reveal the eyes and hands that have viewed and acted upon the most sensitive of data. In all use cases, requirements for capturing application level user activity are most commonly implemented on the back-end database.

With this in mind, MySQL 5.5 and higher provides an open pluggable audit interface that enables all MySQL users to write their own auditing solutions based on application specific requirements. To help users quickly and seamlessly add auditing compliance to their existing applications MySQL Enterprise Edition includes MySQL Enterprise Audit, an easy to use policy-based auditing solution that enables users to:

- **Powerful Filtering to Protect Sensitive Data -** Define what you audit using templates or design highly custom filters using simple JSON filter definition. Filter on connections, users, table access, access type, statement status (success/failure), query content, and more.

- **Meet Regulatory Compliance Standards -** Provide the data your organization and auditors need to be in compliance with requirements including PCI, HIPAA, FERPA, SOX and more

- **Achieve Security Goals through Comprehensive Auditing -** Trust but verify DBA activity, prove your data's validity and perform forensic analysis to investigate or discover data breaches.

- **Easy Integration with Audit Vaults and Stores -** Externally archive and analyze XML-based audit logs with ease using Oracle Audit Vault and other third party solutions including Splunk.

- **Dynamic and Easy to Manage -** Dynamically enable/disable audit stream, change filtering, and more with no downtime. Automatically rotate audit log files based on size.

- **Low Overhead -** Collects critical audit data with minimal performance impact. Use fine grain filtering to minimize audit log size and IO impact.

A common set up and use case scenario is depicted here:

Figure 1: MySQL Enterprise Audit Set Up and Use Case

To learn more about MySQL Enterprise Audit visit:
http://www.mysql.com/products/enterprise/audit.html.

11 MySQL Enterprise Scalability

By default the MySQL Database provides a complex thread-handling model that provides excellent throughput and performance for online and web-based applications. User connections are mapped to execution threads on a one-to-one basis with each connection/thread assignment remaining intact until the connection is terminated by the client. Under this model the

MySQL Database provides scalable concurrency of both user connections and query executions.

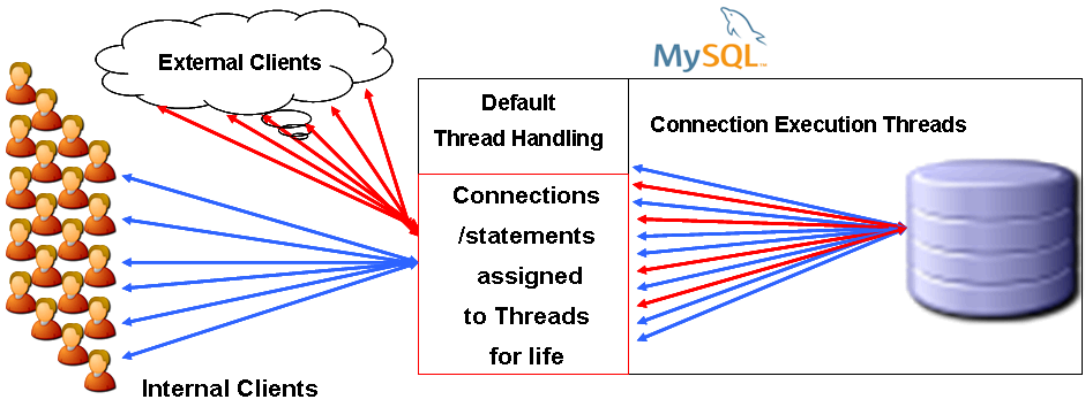


Figure 4: Default Thread Handling Model

While this model serves and scales most web deployment use cases very well it does have the potential to limit scalability as connection and query loads increase at an increasing rate. This use case is becoming more common as application clients now extend far beyond the keyboard to mobile and other web-enabled devices. For the most highly-trafficked applications when concurrent connections grow from hundreds to thousands and associated query executions grow proportionally scalability challenges and limitations with the default model are potentially exposed:

- Current model does not prioritize connection queries for execution, regardless of the number that have been submitted or that are in a "wait" status. No prioritization of queries means that all attempt to execute in parallel with no regard for server resource limitations.
- More concurrency of query executions requires significantly more server memory. In an extreme case if the amount of memory needed by all active connections exceeds server memory, the MySQL server may revert to memory/disk swapping, which will greatly impact user response times.
- More query executions also leads to more cache flushing, which leads to more cache misses and disk I/O requests. More disk I/O leads to longer query execution and user response times.
- Write intensive applications are impacted significantly as concurrent DML statement execution times can degrade exponentially as disk I/O increases.

The MySQL Thread Pool

To meet these challenges around the most demanding "mobilized" application user and workloads MySQL Enterprise Edition provides the MySQL Thread Pool. The Thread Pool is a user configurable option that

provides an efficient, alternate thread-handling model designed to sustain performance and scalability as concurrent user loads continue to grow. In these use cases the Thread Pool addresses the limitations to scalability by:

- Managing/controlling query execution until the MySQL server has the resources to execute it.
- Splitting threads into managed Thread Groups. Inbound connections are assigned to a group via a round-robin algorithm and the number of concurrent connections/threads per group is limited based on queue prioritization and nature of queries awaiting execution. Transactional queries are given a higher priority in queue than non-transactional, but queue prioritization can be overridden at the user level as needed.
- Avoiding deadlocks when queries are stalled or executing for long period of time.

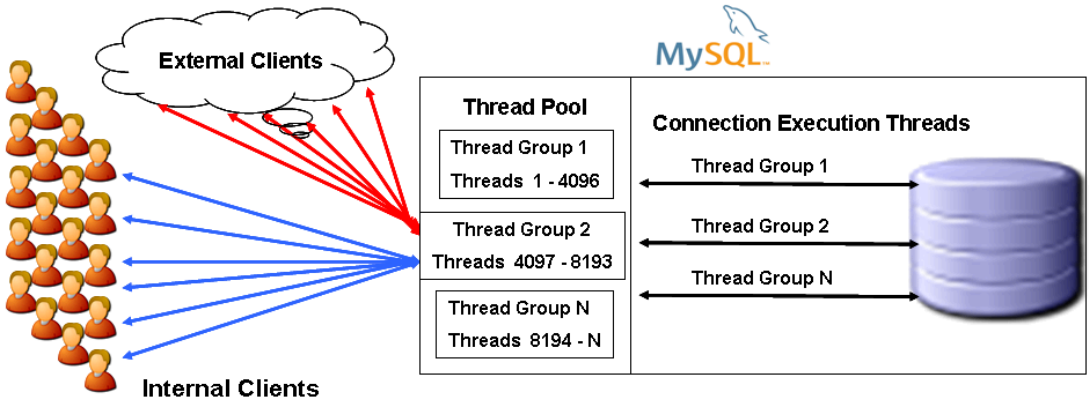


Figure 5: MySQL Thread Pool

The result is sustained performance and scalability as concurrent user connections and work loads grow as shown here in a benchmark conducted using MySQL 5.6:

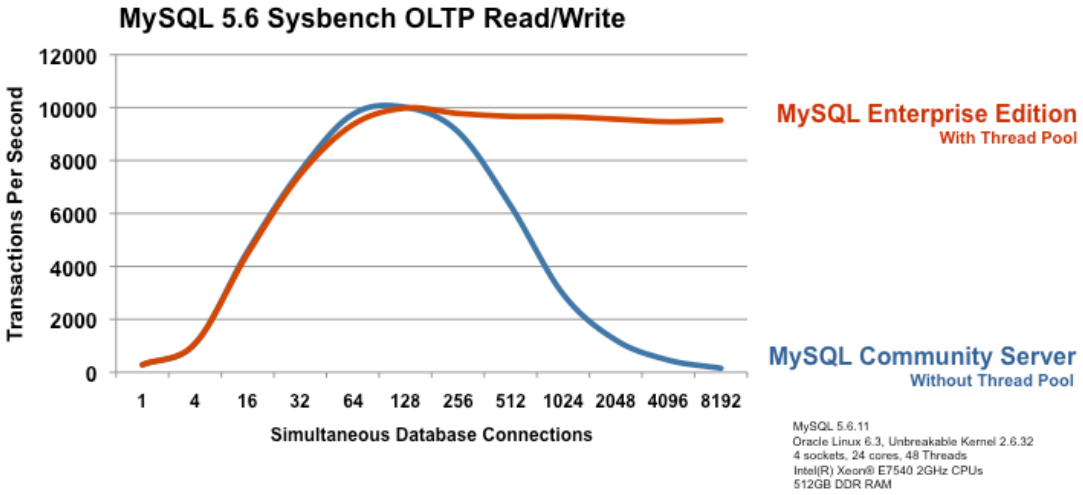


Figure 6: MySQL Enterprise Edition provides 60x better scalability for OLTP Read/Write activity with Thread Pool

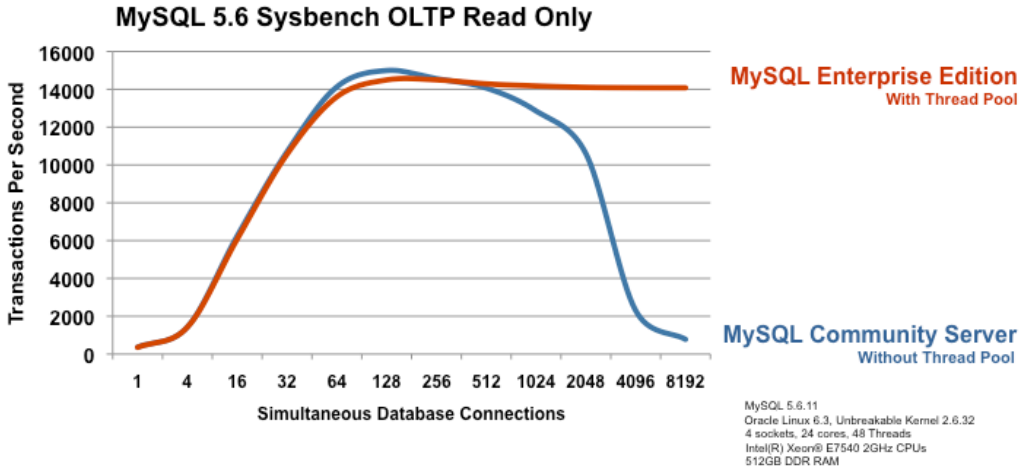


Figure 7: MySQL Enterprise Edition provides 18x better scalability for OLTP Read activity with Thread Pool

SysBench OLTP benchmarks show that the MySQL Thread Pool provides a significant improvement in sustained performance and scalability for applications that service a growing number of concurrent user connections and query executions. The graphs above show read/write activity improves by a factor of 60 while read only activity improves by a factor of 18, both at 8,192 concurrent connections, with the Thread Pool enabled.

To learn more about MySQL Enterprise Scalability visit: http://www.mysql.com/products/enterprise/scalability.html.

12 MySQL Enterprise High Availability

MySQL has always been famous for its very flexible Master/Slave replication. However, MySQL users have been looking for a high availability solution built into the MySQL Server. Unlike other products, MySQL Group Replication delivers native, built-in HA for your MySQL databases:

- **Core part of the standard MySQL Server**
- **Leverages proven MySQL features:** InnoDB, GTIDs, binary logs, multi-threaded slave execution, multi-source replication, Performance Schema
- **Supported on all MySQL platforms**

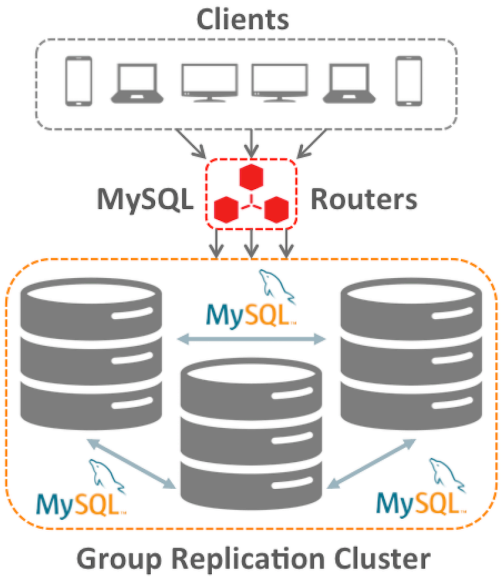


Figure 8: MySQL Group Replication delivers native, built-in HA for MySQL

Group Replication implements both a single-primary mode with automatic leader election and a multi-master update everywhere mode. By using a powerful new group communication system, which provides an in-house implementation of the popular Paxos algorithm, the group automatically coordinates on data replication, consistency, and membership. This provides all of the built-in mechanisms necessary for making your MySQL databases highly available.

Elasticity

With Group Replication, a set of servers coordinate together to form a group. The group membership is dynamic and servers can leave, either voluntarily or involuntarily, and join at any time. The group will automatically reconfigure itself as needed and ensure that any joining member is synchronized with the group. This makes it easy to quickly scale your total database capacity up and down as needed.

Failure Detection
Group Replication implements a distributed failure detector to find and report servers that have failed or are no longer participating in the group and the remaining members in the group coordinate to reconfigure the membership.

Fault Tolerance
Group Replication builds on an in-house implementation of the popular Paxos distributed algorithm to provide distributed coordination between servers. In order for a group to continue to function, it requires a majority of the members to be online and for them to form an agreement on every change. This allows your MySQL databases to safely continue to operate without manual intervention when failures occur, without the risk of data loss or data corruption.

Self-Healing
If a server joins the group, it will automatically bring itself up to date by synchronizing its state from an existing member. In the event that a server leaves the group, for instance it was taken down for maintenance, the remaining servers will see that it has left and will reconfigure the group automatically. When that server later rejoins the group, it will automatically re-synchronize with the group again.

Monitoring
Performance Schema tables provide clear and detailed information and statistics on individual members and for the group as a whole.

13 MySQL Enterprise Backup

Backup

MySQL Enterprise Backup performs online "Hot", non-blocking backups of MySQL databases. Full backups can be performed on all InnoDB data while MySQL is online, without interrupting queries or updates. In addition, incremental backups are supported so that only data that has changed from a previous backup are backed up. Also partial backups are supported when only certain tables or tablespaces need to be backed up.

Restore

MySQL Enterprise Backup restores data from a full backup with full backward compatibility. Consistent Point-in-Time Recovery (PITR) enables restoration to a specific point in time. Using MySQL backups and binlog, you can also perform fine-grained roll forward recovery to a specific transaction. A partial restore allows recovery of targeted tables or tablespaces. In addition, you can restore backups to a separate location, or create clones for fast replication setup or administration.

Compression

MySQL Enterprise Backup supports creating compressed backup files, typically reducing backup size from 70% to over 90% when compared to the size of actual database files, reducing storage and other costs.

Direct to Cloud Storage

Support for Oracle Storage Cloud, AWS S3 (Simple Storage Service) API to backup and restore direct to inexpensive Cloud Storage (S3, Swift, and more)

14 MySQL Enterprise Monitor

MySQL developers, DBAs and SysAdmins often find themselves having to manage dynamic, high growth applications that require continuous uptime. The MySQL Enterprise Monitor helps them automate the management of their MySQL infrastructure and improve the performance and availability of their applications.

The MySQL Enterprise Monitor is a web-based application that can manage MySQL within the safety of a corporate firewall or remotely in a public cloud. MySQL Enterprise Monitor provides:

- **Performance & Availability Monitoring -** Continuously monitor MySQL queries and performance related server metrics
- **Visual Query Analysis –** Monitor query performance and pinpoint SQL code that is causing a slow-down
- **InnoDB Monitoring -** Monitor key InnoDB metrics that impact MySQL performance
- **MySQL Cluster Monitoring -** Monitor and manage your MySQL NDB Cluster installations
- **Replication Monitoring –** Gain visibility into the performance, and health of all MySQL Masters and Slaves

- **Group Replication and InnoDB Cluster Monitoring –** Monitor and manage your distributed and highly available MySQL setups with ease
- **Backup Monitoring –** Ensure your online, hot backups are running as expected
- **Firewall Monitoring -** monitor MySQL Enterprise Firewall activity and protect your MySQL servers against database attacks
- **Audit Monitoring** – enforce MySQL Enterprise Audit usage across all of your MySQL servers
- **Disk Monitoring –** Forecast future capacity requirements using trend analysis and projections.
- **Security Monitoring -** Identify and resolve security vulnerabilities across all MySQL servers
- **Operating System Monitoring -** Monitor operating system level performance metrics such as load average, CPU usage, RAM usage and swap usage
- **Access Control Lists (ACLs) -** Role and group based access controls provide an easy way for MySQL DBAs to define fine-grained security policies for their MySQL servers

Enterprise Dashboard for Monitoring all MySQL Servers

The Enterprise Dashboard provides real-time visibility into the performance and availability of all your MySQL installations. You can monitor MySQL related metrics for a single server or groups of servers, and manage all forms of replication and clustered topologies. The Enterprise Dashboard is designed to give you an overall view of the health of your MySQL installations and point you to potentially critical issues that may impact the performance and availability of your applications. A rich set of real time and historical graphs allow you to drill down into relevant statistics and details.

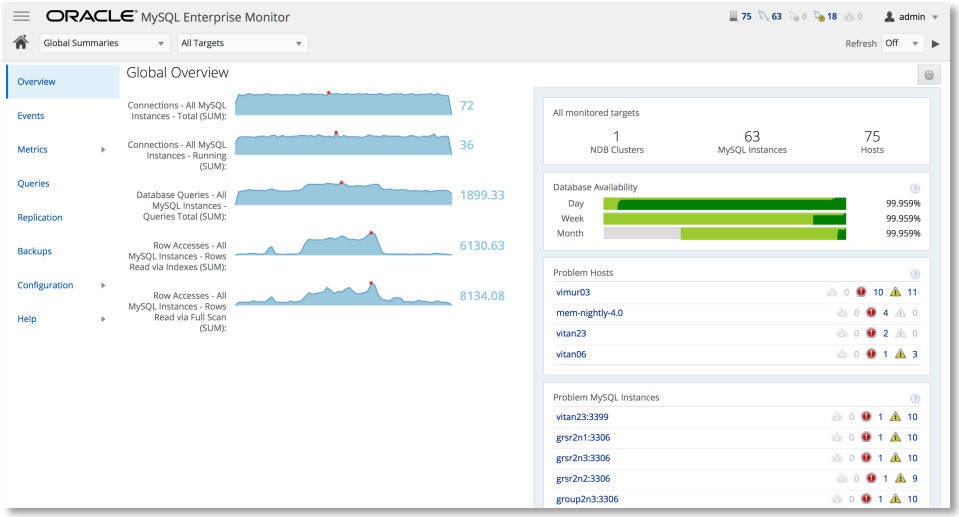


Figure 10: MySQL Enterprise Overview Dashboard

Monitoring of Replication/Scale-Out/Clustered Topologies

The Replication and Topology Dashboards make it easier to scale out using MySQL replication and clustering by providing industry-leading auto detection, grouping, documenting and monitoring of all combinations of MySQL master/slave Replication, Group Replication, InnoDB clusters, and NDB Clusters. Changes and additions to existing topologies are also auto detected and maintained providing you instant visibility into changes. This helps reduce the learning curve for anyone new to MySQL Replication, Group Replication, InnoDB Cluster, and NDB Cluster or to scale-out and high availability environments in general.

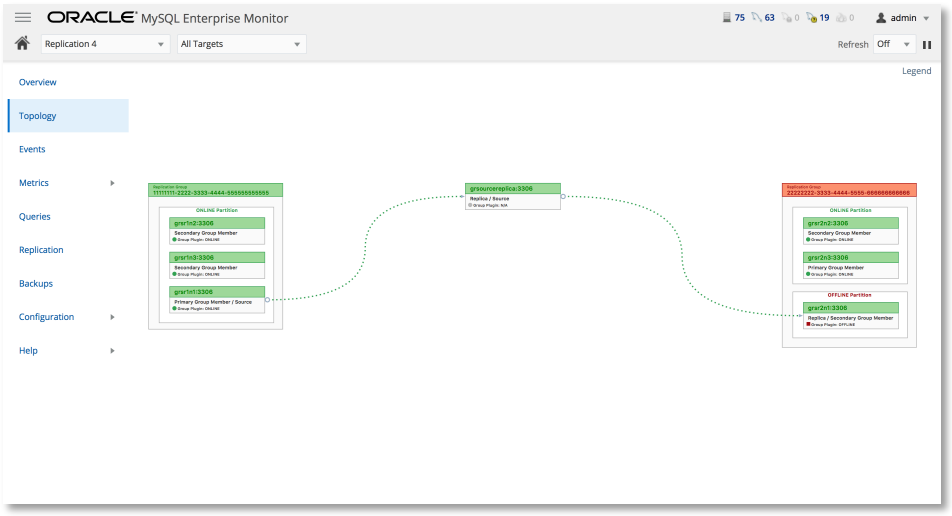


Figure 11: MySQL Enterprise Replication Topology view

Whether you use a single-source tree hierarchy, circular replication, Group Replication, NDB Cluster, or a complex, multi-level, multi-source hierarchy that mixes all of the above, the Topology view shows how your MySQL Topology is currently operating.

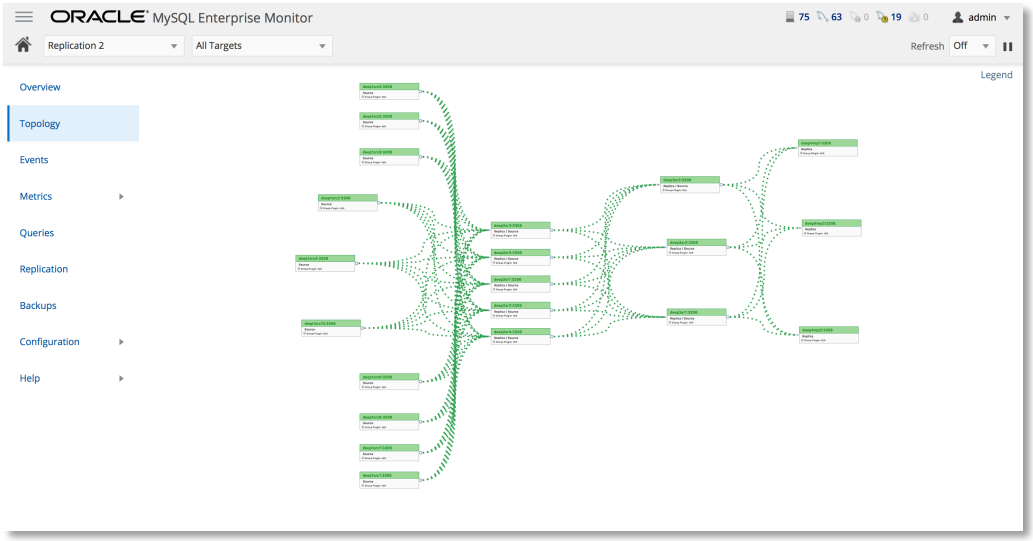


Figure 12: Multi-source Replication topology view

The Topology and Replication Dashboards show context-sensitive information for each node and node type, as well as Group Replication and NDB clusters as a whole. High-level identity and throughput metrics are always displayed. For each Replication Source, you'll see Binary Logging and GTID status, or, if enabled, statistics on Semi-Sync Replication or Group Replication performance. For each Replica, you'll see the status of each Replication Channel, statistics on Relay Logging, Multi-Threaded Replication and other source configuration details.

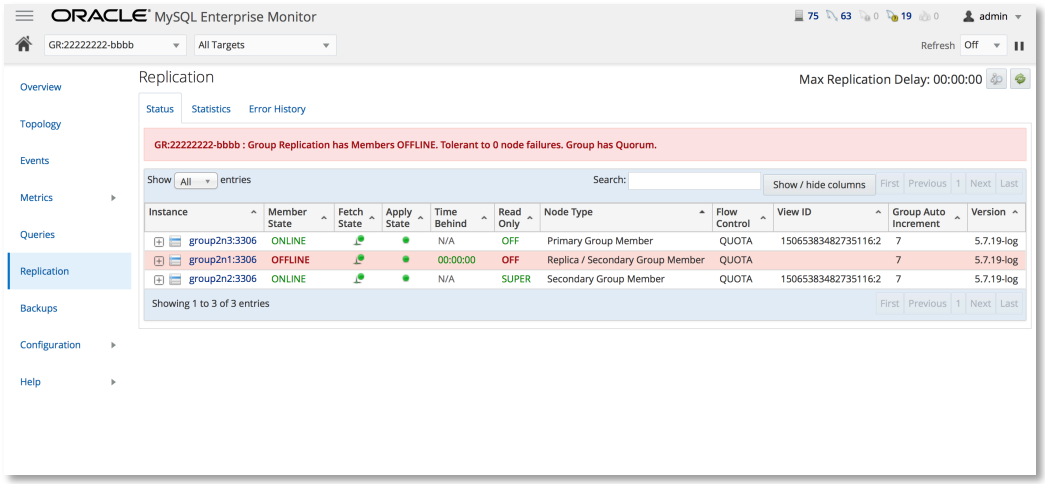


Figure 13: MySQL Replication Dashboard Status View

Monitoring MySQL Enterprise Backup

The Backups Dashboard brings deeper integration with MySQL Enterprise Backup and provides key visibility into critical backup activities, allowing you to easily ensure that your most valuable assets are protected against data

loss. Visually monitor high level backup metrics for your entire MySQL topology or individual groups, and drill in to view all key metrics and details for individual backups of specific instances. Best Practice Advisors also help you ensure that your backup jobs are running as expected by proactively alerting you when potential problems are detected.

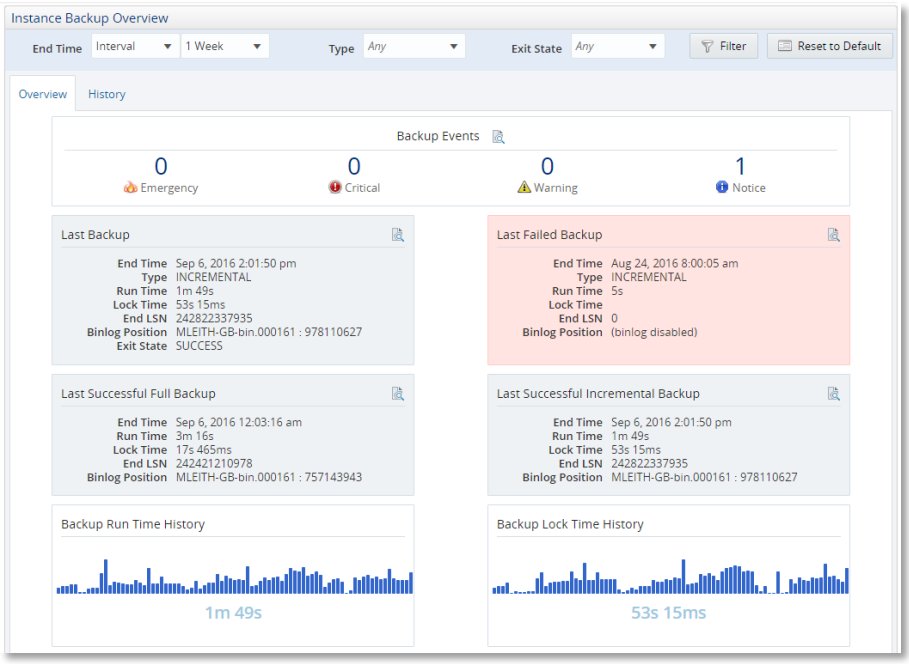


Figure 14: MySQL Enterprise Backup Dashboard Instance View

After selecting a Group or drilling in to a specific MySQL Instance, users can see all known backups should you need to perform a restore operation. Each row in the backup history table shows the backup type, status, completion timestamp and the log coordinates when the consistent snapshot was taken.

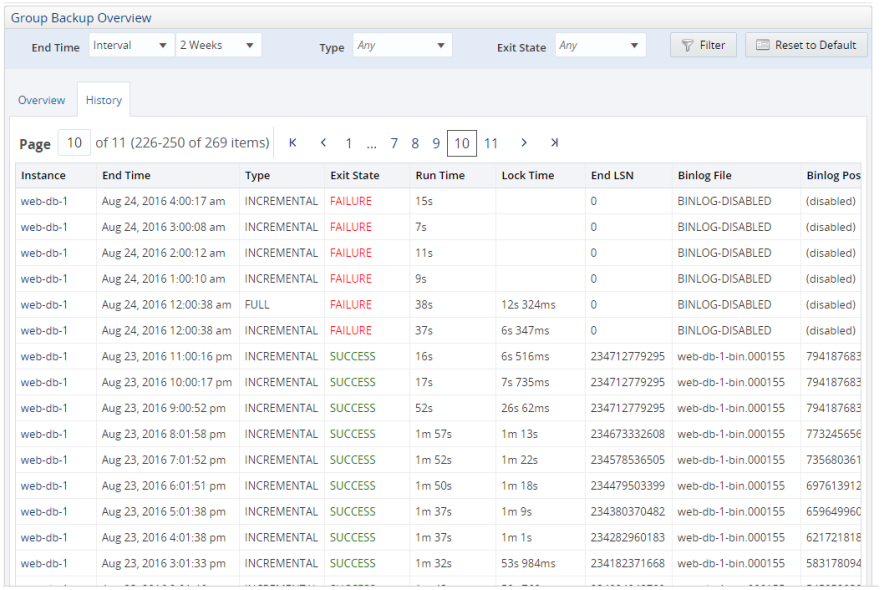


Figure 15: MySQL Enterprise Backup Dashboard History View

MySQL Query Analyzer

The MySQL Query Analyzer helps developers and DBAs improve application performance by monitoring queries and accurately pinpointing SQL code that is causing a slowdown. Using the Performance Schema with MySQL Server 5.6 and later, data is gathered directly from the MySQL server without the need for any additional software or configuration.

Queries are presented in an aggregated view across all MySQL servers so DBAs and developers can filter for specific query problems and identify the code that consumes the most resources. With the MySQL Query Analyzer, DBAs can improve the SQL code during active development and continuously monitor and tune the queries in production.

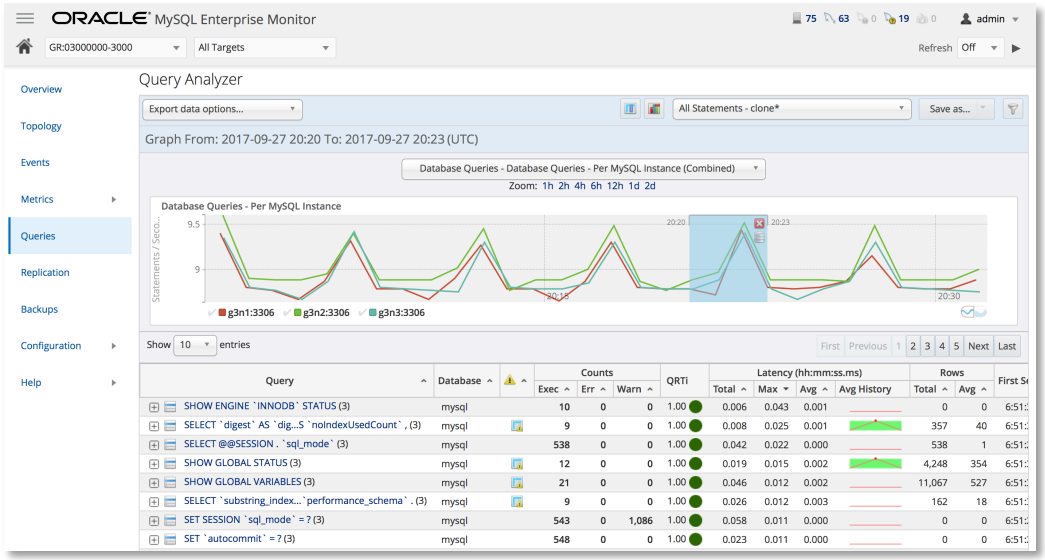


Figure 16: MySQL Query Analyzer

The MySQL Query Analyzer saves you time and effort in monitoring MySQL servers for problem queries by providing:

- An integrated monitoring solution for all supported versions of MySQL (5.5 and higher).
- Aggregated query content and performance stats in real time with no reliance on MySQL logs or SHOW PROCESSLIST.
- Visual “grab and go” correlation of query activity with Monitor graphs.
- A consolidated view into query activity across all MySQL servers, no user parsing required.
- Historical browsing/analysis of queries across all MySQL servers.
- Aggregated, searchable roll ups of all queries in canonical form (no variables) with total number of executions, total execution time, total data size and date/time of when query was “first seen”:
    - **Total Executions** helps you see when queries are running too often or in error. Even properly tuned queries cause performance problems when they run excessively.
    - **SQL Warning and Error counts** help you see queries that did not finish or that returned incorrect result sets. These executions may never be found using other query monitoring options.
    - **Total Execution Time** helps you see the most “expensive” queries across all of the servers. This value helps you see where systems are spending the most time and resources and where you should focus your tuning efforts.
    - **Total Data Size (Rows and Bytes)** helps you analyze if queries are returning more data than your application is using. Sorting on this value, examining the underlying queries and comparing the returned rows and columns with your

application requirements will help you tune your applications and schema for better performance.
    - **"First Seen"** allows you to easily monitor when queries attributed to new application deployments are affecting the performance of your production systems.
- Drill downs into query details, number of executions, execution stats, visual EXPLAIN plan, and query specific execution graphs.
- Drill downs that allow developers to trace query execution back to the originating source code.

To learn more, visit: http://www.mysql.com/products/enterprise/query.html

MySQL Reports

The MySQL Enterprise Monitor also helps developers and DBAs understand the real-time behavior and performance of a MySQL installation, offering unprecedented insights into the current state of the system.

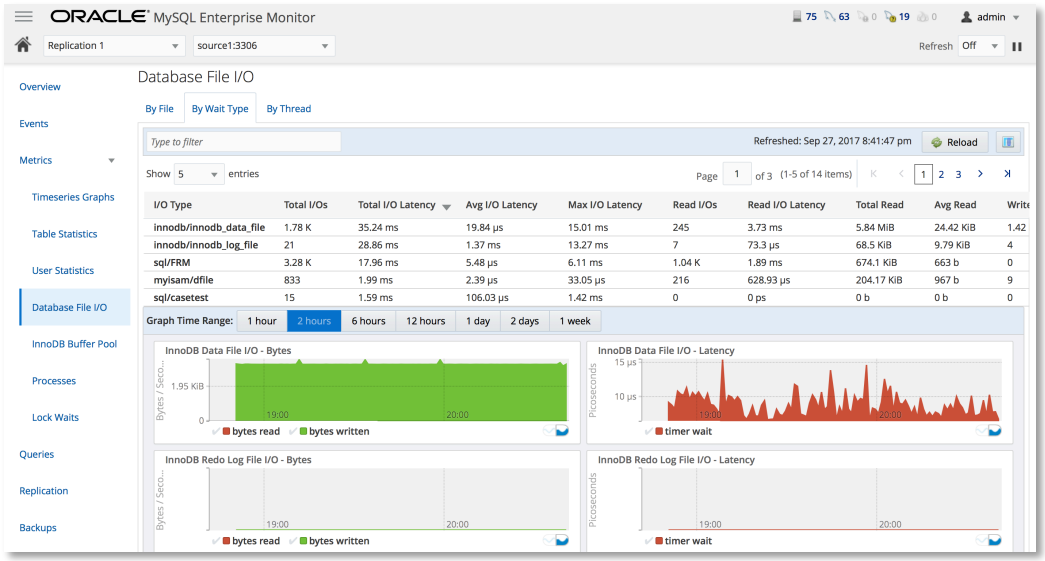


Figure 17: MySQL Database File I/O – By Wait Type

These reports include:

- **Database File I/O** report allows you to easily see exactly where your disk I/O hotspots are.
- **Lock Waits** report provides an incredibly powerful and easy to understand breakdown of the lock waits (row and metadata locks) within the system.
- **Process** report provides invaluable insights into exactly what the threads/connections are doing within the system.
- **User Statistics** report provides a breakdown of resource utilization and activity per user.

- **InnoDB Buffer Pool Usage** report allows you to quickly and easily determine the breakdown of your primary caching layer by database object.
- **NDB Cluster Memory** report allows you to easily see how your data is distributed across the data nodes.

The total of these reports gives MySQL developers and DBAs insights into MySQL that were simply impossible in the past. This makes MySQL Enterprise Monitor the best in class solution for real-time debugging of MySQL.

To learn more, visit:
https://dev.mysql.com/doc/mysql-monitor/en/mem-reports-and-graphs.html

15 Oracle Enterprise Manager for MySQL

Oracle Enterprise Manager for MySQL provides Oracle developers and DBAs with real-time monitoring and delivers comprehensive performance, availability and configuration information for your MySQL databases. Enterprise Manager collects more than 500 metrics covering various MySQL components. Custom critical and warning thresholds can then be set for each of the collected metrics. Plus, DBAs can track configuration details over time to easily keep track of configuration changes.

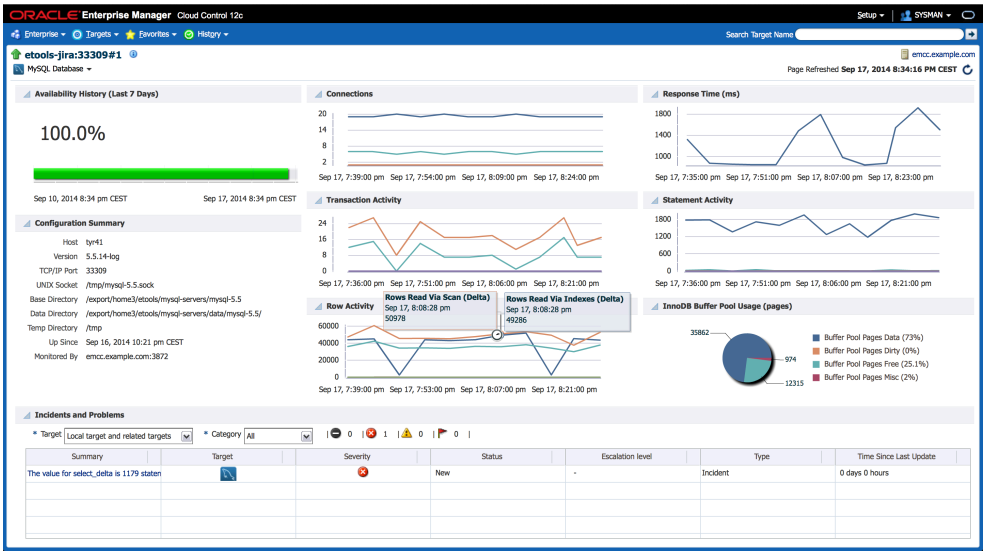


Figure 18: Oracle Enterprise Manager for MySQL allows Oracle developers and DBAs manage MySQL databases.

More information about Oracle Enterprise Manager for MySQL is available at: http://www.mysql.com/products/enterprise/em.html

16 MySQL Workbench Enterprise Edition

MySQL Workbench is a unified visual development tool that includes advanced data modeling capabilities, a visual SQL editor and comprehensive administration tools for database design, query development, server configuration, user administration, and wizard-driven database migrations.

Design

MySQL Workbench enables a DBA, developer, or data architect to visually design, model, generate, and manage databases. It includes everything a data modeler needs for creating complex ER models, forward and reverse engineering, and also delivers key features for performing difficult change management and documentation tasks that normally require much time and effort.

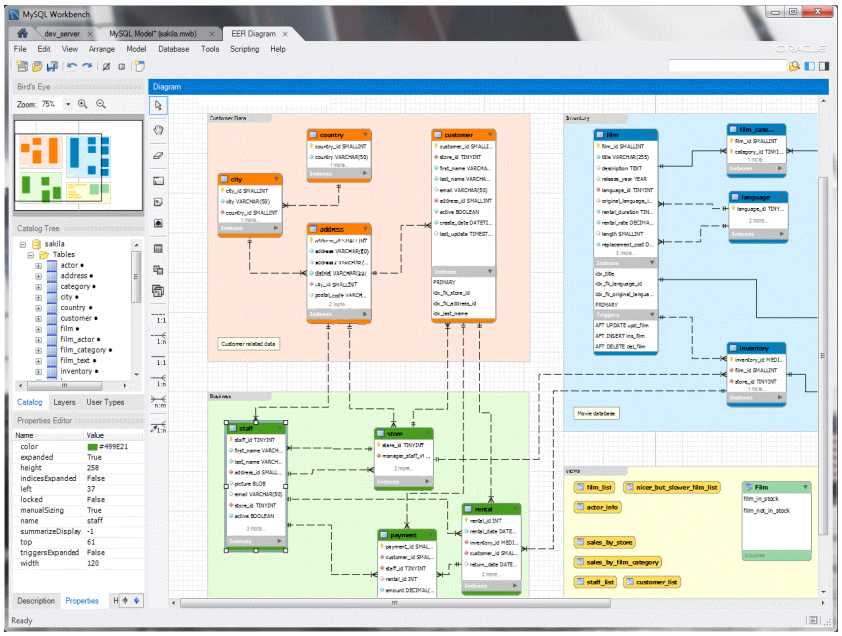


Figure 19: MySQL Workbench – Visual Database Design

Develop

MySQL Workbench delivers visual tools for creating, executing, and optimizing SQL queries. The SQL Editor provides color syntax highlighting, reuse of SQL snippets, and execution history of SQL. The Database Connections Panel enables developers to easily manage database connections. The Object Browser provides instant access to database schema and objects.

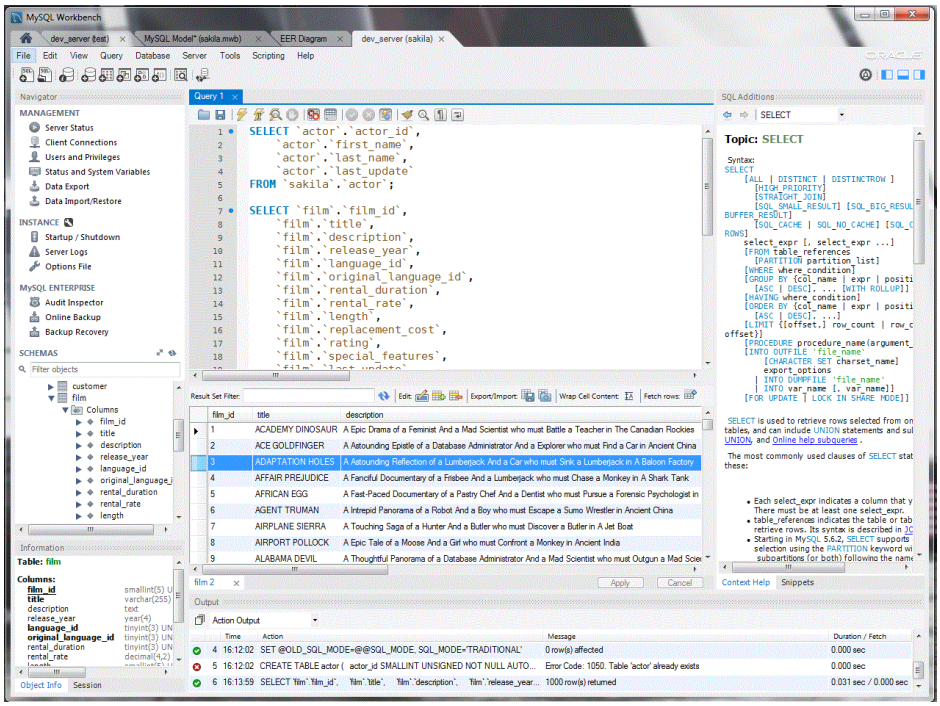


Figure 20: MySQL Workbench – SQL Development, Execution, Tuning

Administer

MySQL Workbench provides a visual console to easily administer MySQL environments and gain better visibility into databases. Developers and DBAs can use the visual tools for configuring servers, administering users, and viewing database health.

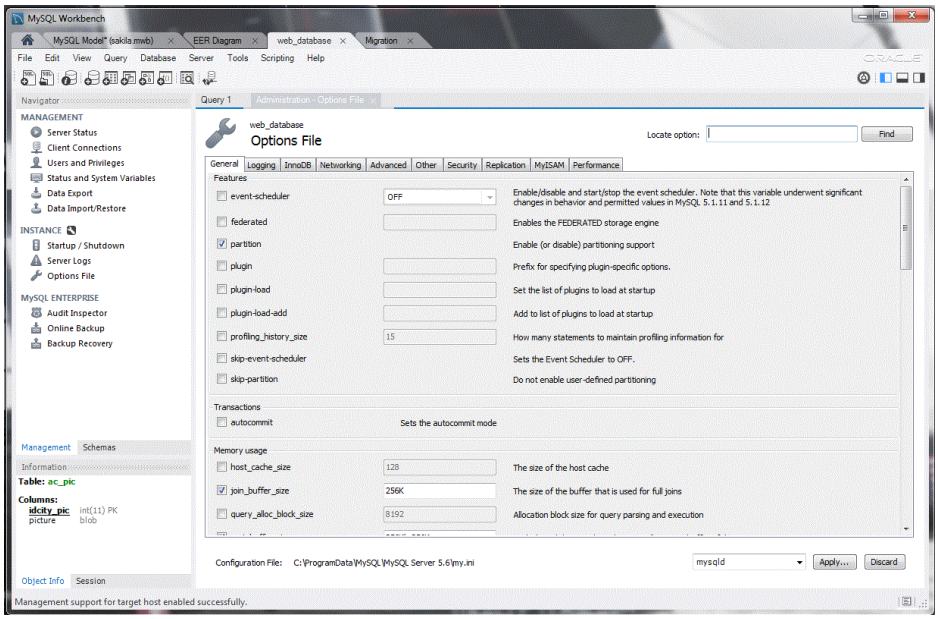


Figure 21: MySQL Workbench – Server Administration, Monitoring

Migrate

MySQL Workbench provides a visual console to easily administer MySQL environments and gain better visibility into databases. Developers and DBAs can use the visual tools for configuring servers, administering users, and viewing database health.

MySQL Workbench provides a visual Migration Wizard that enables quick migration of tables, objects and data from Microsoft SQL Server, Microsoft Access, Sybase and other RDBMS platforms to MySQL. The MySQL Workbench Migration Wizard is designed to save DBA and developer time by providing visual, point and click ease of use around all phases of configuring and managing a complex migration process:

- **Migration project management** - allows migrations to be configured, copied, edited, executed and scheduled.
- **Source and Target selection** - allows users to define specific data sources and to analyze source data in advance of the migration.
- **Object migration** - allows users to select objects to migrate, assign source to target mappings where needed, edit migration scripts and create the target schema.
- **Data migration** - allows users to map source and target data and data types, set up data transfer and assign post data transfer events where needed.

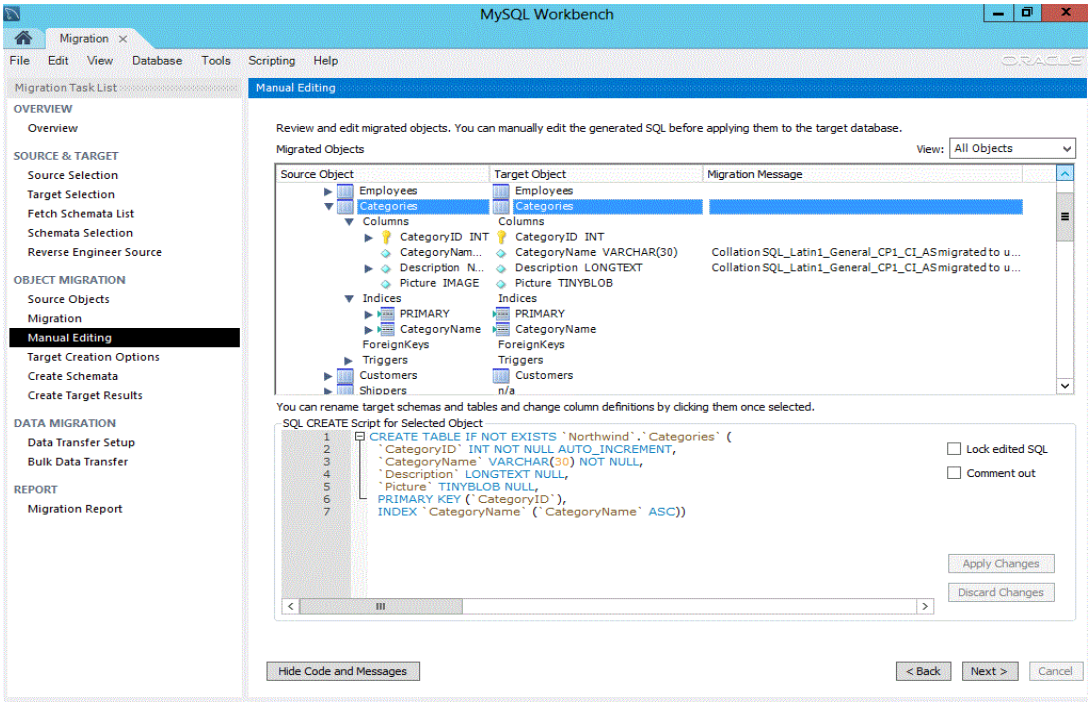


Figure 22: MySQL Workbench – Database Migration Wizard

To learn more, download the whitepaper:
http://mysql.com/why-mysql/white-papers/mysql-wp-workbench.php

17 Oracle Product Certifications/Integrations

An estimated 70% of Oracle's customers also use MySQL. MySQL Enterprise Edition makes managing MySQL easier in these environments by certifying and supporting the use of the MySQL Database in conjunction with many Oracle products. These include:

- Oracle Linux
- Oracle VM
- Oracle Fusion Middleware
- Oracle Secure Backup
- Oracle Golden Gate
- Oracle Audit Vault and Database Firewall
- Oracle Enterprise Manager
- Oracle OpenStack for Oracle Linux
- Oracle Clusterware

Learn more about Oracle products certified with MySQL Enterprise Edition:
http://www.mysql.com/why-mysql/white-papers/spotlight-on-mysql-enterprise-oracle-certifications/

18 Oracle Premier Support

Oracle offers 24x7, global support for MySQL. The MySQL Support team is composed of seasoned MySQL developers, who are database experts and understand the issues and challenges you face. With Oracle Premier Support, you can lower the total cost and risk of owning your MySQL databases, improve the return from your IT investment, and optimize the business value of your IT solutions. MySQL support is included in the subscription for end users, and available separately from commercial licenses for ISVs and OEMs. Oracle Premier Support for MySQL includes the following features:

- 24 X 7 production support
- Unlimited support incidents
- Knowledge Base
- Maintenance releases, bug fixes, patches and updates
- MySQL Consultative support
- Staffed by the most experienced MySQL Engineers in the industry
- The ability to get MySQL support in 29 languages

MySQL Consultative Support service is included in Premier Support. MySQL Consultative Support is a proactive approach that is designed to help you avoid critical outages. MySQL Support Engineers advise you on how to properly setup and tune your MySQL servers, schema, queries, and replication set-up to maximize performance and availability. Also, by taking the initiative to properly design and tune your MySQL database applications you can avoid having to purchase expensive hardware for your IT infrastructure.

Learn more about Oracle Premier Support:
http://mysql.com/support/

19 Conclusion

In this paper we explored the components that are included in MySQL Enterprise Edition. These components are designed to help you mitigate risk and meet Service Level Agreements (SLAs) as you implement applications built on the lower costs and licensing freedom that comes with standardizing on MySQL and other open source technologies. MySQL Enterprise Edition extends the MySQL Database to include advanced Auditing, Security, Encryption, Performance/Scale and High Availability features. The MySQL Enterprise Backup performs online "Hot", non-blocking backups of your MySQL databases. The Enterprise Monitor, Advisors and Query Analyzer proactively notify you of problems and tuning opportunities before they turn into customer facing issues. MySQL Workbench enables developers, DBAs, and data architects to design, develop, migrate, and administer database applications. For managing Oracle and MySQL databases, there are supported integrations and certifications that allow you to manage MySQL using many Oracle products. Finally, the Oracle Premier Support provides you with quick answers and resolutions when you need help, so your systems provide uninterrupted availability to your customers.

Built on the proven MySQL Enterprise Edition and powered by the Oracle Cloud, Oracle MySQL Cloud Service provides a simple, automated, integrated and enterprise-ready cloud service that enables organizations to deliver MySQL-based applications globally at scale.

20 Additional Resources

http://www.mysql.com/

https://cloud.oracle.com/mysql

MySQL Enterprise Edition Demo:
https://www.youtube.com/watch?v=ypQh9H9Rf9w

To contact an Oracle MySQL Representative:
http://www.mysql.com/about/contact/