MySQL Technical Overview

Oracle Corporation MySQL Engineering
Vice President Tomas Ulin,
April, 3rd, 2012
Safe Harbor Statement

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The development, release, and timing of any features or functionality described for Oracle’s products remains at the sole discretion of Oracle.
Agenda

• Oracle’s Strategy and Investment in MySQL
• What’s New in MySQL 5.6
• MySQL Cluster 7.2
• MySQL Enterprise Edition
• Q&A
ORACLE DRIVES MySQL INNOVATION

UNMATCHED INVESTMENT
PERFORMANCE IMPROVEMENTS
HUNDREDS OF EXPERTS
LARGEST MySQL ENGINEERING & SUPPORT ORGANIZATION

InnoDB
REPLICATION
EMBEDDED
CLOUD
WINDOwS
HUNDREDS OF EXPERTS
WEB

STRAteGIC

WORLD-CLASS SUPPORT
MySQL CLUSTER
MySQL ENTERPRISE EDITION

NoSQL
LINUX
More Product Releases Than Ever Before

Driving MySQL Innovation

- MySQL Enterprise Monitor 2.2  
- MySQL Cluster 7.1  
- MySQL Cluster Manager 1.0  
- MySQL Workbench 5.2  
- MySQL Database 5.5  
- MySQL Enterprise Backup 3.5  
- MySQL Enterprise Monitor 2.3  
- MySQL Cluster Manager 1.1  
  All GA!

- MySQL Enterprise Backup 3.7  
- Oracle VM Template for MySQL Enterprise Edition  
- MySQL Enterprise Oracle Certifications  
- MySQL Windows Installer  
- New MySQL Enterprise Commercial Extensions  
  All GA!

- MySQL Database 5.6 DMR*  
- MySQL Cluster 7.2 DMR  

A Better MySQL

and MySQL Labs! *Development Milestone Release ("early and often")

CY2010  |  CY2011  |  Q1 CY2012
MySQL “Early Access” Release Model

• Development Milestone Releases (“DMR”)
  • New DMR every 3-6 months
  • Accumulating features for next GA (5.6)
  • New features integrated on stable trunk
  • Features signed off by QA and tested together
  • Close to Release Candidate quality
  • Next GA cut from one upcoming DMR

• MySQL Labs “Early Access” features: Previews, not on trunk
MySQL 5.5, Best Release Ever!

Improved Performance
• Enhancements in MySQL DB
• Enhancements in InnoDB
• + 360% over 5.1 on Linux
• + 1500% over 5.1 on Windows

Improved Availability
• Semi-synchronous Replication
• Replication Heartbeat

Improved Usability
• SIGNAL/RESIGNAL
• More Partitioning Options
• New PERFORMANCE_SCHEMA

InnoDB is Default Storage Engine

> 95% of all MySQL apps run on InnoDB
MySQL 5.5
APAC Specific Enhancements

• Support for 4-byte UTF8, 16, 32
• Improved performance for Japanese characters translations
• Standardized upper/lower case character conversion across Chinese, Korean, Japanese (consistent with Latin characters)
• Upgraded to Unicode 5.2
• MySQL Enterprise Monitor & Documentation in Japanese
• More general globalization improvements
MySQL 5.6, a Better MySQL.

• MySQL 5.6 builds on MySQL 5.5 by improving:
  • **Optimizer** for better performance, scalability
  • **Performance Schema** for better instrumentation
  • **InnoDB** for better transactional throughput
  • **Replication** for higher availability, data integrity
  • “**NotOnlySQL” options** for more flexibility
  • MySQL 5.6.4 DMR – available now
  • MySQL 5.6.5 DMR – coming soon!

  dev.mysql.com/downloads/downloads/mysql/
MySQL 5.6.4 - Optimizer

- File sort optimizations with small limit
  - 3X better execution time – 40s to 10s
- Index Condition Pushdown
  - Better execution time – 15s to 90ms
- Batched Key Access and Multi Range Read
  - Better execution time – 2000s to 10s
- Postpone Materialization of views/subqueries in FROM
  - 240X better execution time for EXPLAIN - 8m to 2s
- EXPLAIN for INSERT, UPDATE, and DELETE
- Persistent Optimizer Statistics - InnoDB
- Optimizer Traces
MySQL 5.6.4 – Optimizer

File sort optimization with small LIMIT

CREATE TABLE products(
  productid int auto_increment PRIMARY KEY,
  productname varchar(200)
);

SELECT * FROM products ORDER BY productname LIMIT 100;

• Web use case – list first 100 products sorted by name
• Avoid creating intermediate sorted files
• Produce ordered result set using a single table scan
• Example above: 20 million rows, default sort buffer

=> 3X better execution time (drops from 40s to 10s)
MySQL 5.6.4 – Optimizer
Index Condition Pushdown (ICP)

CREATE TABLE person (  
    personid INTEGER PRIMARY KEY,  
    firstname CHAR(20),  
    lastname CHAR(20),  
    postalcode INTEGER,  
    age INTEGER,  
    address CHAR(50),  
    KEY k1 (postalcode,age)  
) ENGINE=InnoDB;

SELECT lastname, firstname FROM person  
WHERE postalcode BETWEEN 5000 AND 5500 AND age BETWEEN 21 AND 22;

• With ICP Disabled  
  • 15 s (buffer pool 128 Mb)  
  • 1.4 s (buffer pool 1.5 Gb)  

• With ICP Enabled  
  ⇒ Execution time drops to 90 ms for both
MySQL 5.6.4 – Optimizer

Batched Key Access (BKA) and Multi Range Read

Improves performance of disk-bound join queries

Execution time without BKA + MRR

Execution time with BKA + MRR

DBT3 Q3: “Customer Distribution Query”
MySQL 5.6.4 – Optimizer
Postpone materialization of views/subqueries in FROM

Late materialization
• Allows fast EXPLAINs for views/subqueries
• Avoid materialization when possible, faster bail out

A key can be generated for derived tables

=> 240X better execution time (drops from ~8 min to ~2 sec)

EXPLAIN SELECT * FROM (SELECT * FROM a_big_table);
SELECT ... FROM derived_table AS dt
    join table AS t WHERE dt.fld = t.dlf
MySQL 5.6.4 – Optimizer
Add EXPLAIN for INSERT/UPDATE/DELETE

• Long standing feature request from customers and users

```
CREATE TABLE t1(c1 INT, c2 INT, KEY(c2), KEY(c2, c1));
EXPLAIN UPDATE t1 SET c1 = 10 WHERE c2 = 1;
```

```
mysql> EXPLAIN UPDATE t1 SET c1 = 10 WHERE c2 = 1;
+----+------------+-------+-------+---------------+------+-----+---------+-------+
<table>
<thead>
<tr>
<th>id</th>
<th>select_type</th>
<th>table</th>
<th>type</th>
<th>possible_keys</th>
<th>key</th>
<th>key_len</th>
<th>ref</th>
<th>rows</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SIMPLE</td>
<td>t1</td>
<td>range</td>
<td>c2,c2_2</td>
<td>c2</td>
<td>5</td>
<td>NULL</td>
<td>1</td>
<td>Using where</td>
</tr>
</tbody>
</table>
+----+------------+-------+-------+---------------+------+-----+---------+-------+
1 row in set (0.00 sec)
```
MySQL 5.6.4 – Optimizer Traces

SET SESSION.OPTIMIZER_TRACE='enabled=on';
SELECT (SELECT 1 FROM t6 WHERE d = c) AS RESULT FROM t5;
select * from information_schema.OPTIMIZER_TRACE;

- EXPLAIN shows the generated plan
- TRACE shows how the plan was generated, decision points etc.
- Developers, support, advanced customers
- First step in 5.6.3, more tracing to come
MySQL 5.6.4 – Optimizer
Persistent Optimizer Statistics (InnoDB)

• More Accurate Statistics
• More Stable Statistics
• Run ANALYZE
• mysql.innodb_table_stats and mysql.innodb_index_stats
• Can be manually updated
MySQL 5.6.4 – Performance Schema Instrumentation
Improved Database Profiling/Application Tuning

• Statements/Stages
  • What are my most resource intensive queries? Where do they spend time?
• Table/Index I/O, Table Locks
  • Which application tables/indexes cause the most load or contention?
• Network I/O
  • What is the network load like? How long do sessions idle?
• Users/Hosts/Accounts
  • Which application users, hosts, accounts are consuming the most resources?
• Summaries
  • Aggregated statistics grouped by thread, user, host, account or object
MySQL 5.6.4 - InnoDB

- Better Performance, Scale
  - Improved thread scheduling
  - Reduced contention during file extension
  - Deadlock detection now non-recursive
  - Improve LRU flushing
  - Increase max redo log size
  - Separate tablespaces for undo log
  - Fast checksum
MySQL 5.6.4 - InnoDB

• Better Recovery
  • Dump and restore buffer pool
• Better Usability
  • Full-text Search
  • Variable page sizes – 4k, 8k
  • Larger limit of index key prefixes (3072 bytes)
• New INFORMATION_SCHEMA tables
  • Metrics table, System tables, Buffer pool info table
MySQL 5.6.4 - Replication

- Better Data Integrity
  - Crash-Safe Slaves, Replication Checksums, Crash-Safe Binlog
- Better Performance, Scale
  - Multi-threaded slaves
  - Reduced Binlog size for RBR
- Extra Flexibility
  - Time-delayed replication
- Simpler Troubleshooting
  - Row-based repl. logging of original query
- Enhanced Monitoring/Management

MySQL Masters

Slave 1 Slave 2 Slave 3 Slave 4 Slave 5
Slave 6 Slave 7 Slave 8 Slave 9 Slave 10
MySQL 5.6.4 - General Improvements

- TIME/TIMESTAMP/DATETIME – fractional second precision
- Ipv6 improvements
- Support Unicode for Windows command client
- Import/export tables to/from partitioned tables
- Explicit partition selection
- GIS/MyISAM: Precise spatial operations
- And more...

5.6.4 DMR – Available now!

dev.mysql.com/downloads/mysql/
MySQL 5.6.5: Coming Soon!

- Global Transaction Ids (WL#3584)
- Replication Failover Utility (WL#6143)
- Better Optimizer
  - Subquery optimizations (WL#5729)
  - Filesort optimizations (WL#6160)
  - Statistics-based Range optimization for many ranges (WL#5957)
  - More efficient ORDER BY (WL#5558)
  - Structured EXPLAIN (WL#855)
- And more...
MySQL 5.6.5 - Global Transaction Ids

- Foundation for reliable, automatic failover & recovery
  - Unique identifier for each replication event written to the Binlog
- Simple to track & compare replication across the cluster
- Automatically identify the most up-to-date slave for failover
- Deploy complex replication topologies
- Eliminates Dev/Ops overhead
MySQL 5.6.5 – Replication Failover Utility

- Leverages GTIDs to provide Automatic failover & recovery
- Manual switchover for maintenance
- Delivers HA within the base MySQL distribution
- Eliminates cost & complexity of integrating 3rd party components to achieve HA
MySQL 5.6.5 – Replication Failover Utility

- Default is to promote most up-to-date slave, based on GTID
- Slave promotion policies are fully configurable
- Monitors slave lag

Auto-Failover & Slave Promotion

Failover Utility

Master

Slaves
MySQL Database - Under Development

Early Access Features

- Replication
  - Binlog Group Commit
  - Binlog API

- InnoDB
  - “NotOnlySQL” options for accessing InnoDB data
  - Online operations (INDEX add, rebuild) – coming soon!
  - SSD/Flash Optimizations – coming soon!

- And More...

labs.mysql.com/
MySQL Database, Key-value access for InnoDB

NotOnlySQL: Memcached API

- Fast, simple access to InnoDB
  - Accessed via Memcached API
  - Use existing Memcached clients
  - Bypasses SQL transformations
- NotOnlySQL access
  - For key-value operations
  - SQL for rich queries, JOINs, FKs, etc.
- Implementation
  - Memcached daemon plug-in to mysql
  - Memcached protocol mapped to the native InnoDB API
  - Shared process space for ultra-low latency

SQL (MySQL Client)

NoSQL (Memcached Protocol)

Application

MySQL Server

Memcached plugin

InnoDB Storage Engine

MySQL™ labs.mysql.com

labs.mysql.com/
MySQL Cluster
## MySQL Cluster

- Read AND Write Scalability
- 99.999% Availability
- Very Low Latency
- SQL and NoSQL Access Flexibility & Schema Agility

<table>
<thead>
<tr>
<th>Web</th>
<th>Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High volume OLTP</td>
<td>• Subscriber Databases (HLR / HSS)</td>
</tr>
<tr>
<td>• eCommerce</td>
<td>• Service Delivery Platforms</td>
</tr>
<tr>
<td>• User Profile Management</td>
<td>• VAS: VoIP, IPTV &amp; VoD</td>
</tr>
<tr>
<td>• Session Management &amp; Caching</td>
<td>• Mobile Content Delivery</td>
</tr>
<tr>
<td>• Content Management</td>
<td>• Mobile Payments</td>
</tr>
<tr>
<td>• On-Line Gaming</td>
<td>• LTE Access</td>
</tr>
</tbody>
</table>
MySQL Cluster 7.2: GA February 15<sup>th</sup> 2012

Enabling Next Generation Web Services
- 70x Higher Complex Query Performance: Adaptive Query Localization
- New Native NoSQL memcached API
- MySQL 5.5 Server Integration
- Oracle VM Support

Enhancing Cross Data Center Scaling
- Multi-Site Clustering
- Simplified Active / Active Replication

Simplifying Provisioning & Administration
- MySQL Cluster Manager 1.1.4
- Consolidated Privileges
Adaptive Query Localization
Scaling Distributed Joins

• Perform Complex Queries across Shards
  • JOINs pushed down to data nodes
  • Executed in parallel
  • Returns single result set to MySQL

• Opens Up New Use-Cases
  • Real-time analytics
  • Recommendations engines
  • Analyze click-streams

DON’T COMPROMISE FUNCTIONALITY TO SCALE-OUT !!
The Best of Both Worlds
SQL & NoSQL Combined

- **SQL:** Complex, relational queries
- **HTTP / memcached:** Key-Value web services
- **Java:** Enterprise Apps
- **NDB API:** Real-time services

**Mix & Match**

**Clients**

- Native
- memcached
- HTTP/REST
- Java
- MySQL

**NDB API**

<table>
<thead>
<tr>
<th>Scalability</th>
<th>✓</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>✓</td>
</tr>
<tr>
<td>HA</td>
<td>✓</td>
</tr>
<tr>
<td>Ease of use</td>
<td>✓</td>
</tr>
<tr>
<td>SQL/Joins</td>
<td>✓</td>
</tr>
<tr>
<td>ACID Transactions</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Data Nodes**

- JDBC / ODBC
- PHP / PERL
- Python / Ruby
- 8 x Commodity Intel Servers
  - 2 x 6-core processors 2.93GHz
  - x5670 processors (24 threads per total)
  - 48GB RAM
  - Linux
- Infiniband networking
- flexAsynch benchmark
  - C++ NoSQL API (NDB API)
MySQL & MySQL Cluster

- MySQL Storage Engine Strategy
- Select on a per-table, providing broadest application functionality
  - InnoDB: Foreign Keys, XA Transactions, Large Rows
  - MySQL Cluster: HA, High Write Rates, Real-Time
- Choose the right tool for the job - Example: On-Line Retail Service
  - User profiles & session management
  - Content management
  - eCommerce
  - Analytics
- Reduces Complexity, Simplifies DevOps
MySQL Enterprise Edition
MySQL Enterprise Edition

Highest levels of MySQL Scalability, Security & Uptime
MySQL Enterprise Monitor

- Global view of MySQL environment
- Automated, rules-based monitoring and alerts (SMTP, SNMP enabled)
- Query capture, monitoring, analysis and tuning, correlated with Monitor graphs
- Visual monitoring of “hot” applications and servers
- Real-time Replication Monitor with auto-discovery of master-slave topologies
- Integrated with MySQL Support

A Virtual MySQL Tuning Assistant!
MySQL Enterprise Backup

- Online Backup for InnoDB
- Full, Incremental, Partial Backups (scriptable interface)
- Compression
- Point in Time, Full, Partial Recovery options
- Metadata on status, progress, history
- Unlimited Database Size
- Cross-Platform
  - Windows, Linux, Unix
- Certified with Oracle Secure Backup

Ensures quick, online backup and recovery of your MySQL apps.
MySQL Enterprise Scalability

Thread Pool

- MySQL default thread-handling – excellent performance, can limit scalability as connections grow
- MySQL Thread Pool improves sustained performance/scale as user connections grow
- Thread Pool API
Default Thread Handling

- Connections assigned to 1 thread for life, same thread used for all statements
- No prioritization of threads, statement executions
- Many concurrent connections = many concurrent execution threads to consume server memory, limit scalability
With Thread Pool Enabled

- Configurable number of thread groups (default = 16), 4096 threads
- Each connection assigned to thread group via round robin
- Threads are prioritized, statements queued to limit concurrent executions, load on server, improve scalability as connections grow
MySQL Enterprise Edition

MySQL 5.5 Sysbench OLTP Read/Write

MySQL Enterprise Edition
With Thread Pool

MySQL Community Edition
Without Thread Pool

20x Better Scalability with Thread Pool

MySQL 5.5.16
Oracle Linux 6.1, Unbreakable Kernel 2.6.32
2 sockets, 24 cores, 2 x 12-core
Intel(R) Xeon(R) X5670 2.93GHz CPUs
72GB DDR3 RAM
2 x LSI SCSI Disk (MR9261-8i) (597GB)
MySQL Enterprise Security
MySQL External Authentication

- PAM (Pluggable Authentication Modules)
  - Access external authentication methods
  - Standard interface (Unix, LDAP, Kerberos, others)
  - proxied and non-proxied users
- Windows
  - Access native Windows services (WAD)
  - Authenticate users already logged into Windows
- Pluggable Authentication API

*Integrates MySQL apps with existing security infrastructures/SOPs*
MySQL Enterprise High Availability

Oracle VM Template for MySQL

- Oracle Linux with the Unbreakable Enterprise Kernel
- Oracle VM & Oracle VM Manager
- Oracle Cluster File System 2 (OCFS2)
- MySQL Database (Enterprise Edition)
  - Pre-Installed & Pre-Configured
  - Full Integration & QA Testing
  - Single Point of Support*

Windows Server Failover Clustering

- Failures of MySQL or underlying server detected; MySQL restarted on standby node
- Proactive failover for maintenance operations
  - Business Critical Applications using native Windows Clustering services
  - Expanded HA solutions range on Windows

*Technical support for Oracle Linux and Oracle Virtual Machine requires Unbreakable Linux Network subscription.
MySQL Workbench SE

Database Design
- Visual Design, modeling
- Forward/Reverse Engineer
- Schema validation, Schema doc

SQL Development
- SQL Editor - Color Syntax Highlighting
- Objects - Import/Export, Browse/Edit
- Connections - Wizard, SSH Tunnel

Database Administration
- Status, Configuration, Start/Stop
- Users, Security, Sessions
- Import/Export Dump Files

Scripting & Plug-in Support
UI Designed to match VS 2010

*Saves you time* developing and managing your MySQL apps.
MySQL Enterprise Oracle Certifications
Completed

• Oracle Fusion Middleware
  • WebLogic Server
  • Database Adapter for Oracle SOA Suite
  • Oracle Business Process Management
  • Oracle Virtual Directory
  • Oracle Data Integrator
  • Oracle Enterprise Performance Management
  • Oracle Identity Analytics
  • Open SSO STS, Open SSO Fedlet

• Oracle Linux
• Oracle VM
• Oracle VM Template for MySQL Enterprise Edition
• Oracle GoldenGate
• Oracle Secure Backup
• Oracle Database Firewall
• MyOracle Online Support
MySQL Enterprise Oracle Certifications

In Progress

- Oracle Fusion MiddleWare
  - WebCenter Suite
  - Enterprise Content Management
  - Oracle Business Intelligence Suite
- Oracle Clusterware
- Oracle Audit Vault
- Oracle Enterprise Manager
- And More…
ORACLE DRIVES MySQL INNOVATION

BEST OF BREED SOLUTIONS FOR NEXT GENERATION WEB APPLICATIONS
Than you!

“Thank you MySQL users in Japan for your feedback and contributions to MySQL!
Hardware and Software

Engineered to Work Together