What's New in MySQL 5.7

ORACLE

MySQL

Safe Harbor Statement

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MySQL 5.7 Is Now Generally Available!

Performance & Scalability

- 2 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

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

And many more new features and enhancements... http://mysqlserverteam.com/the-mysql-5-7-8-release-candidate-is-available/

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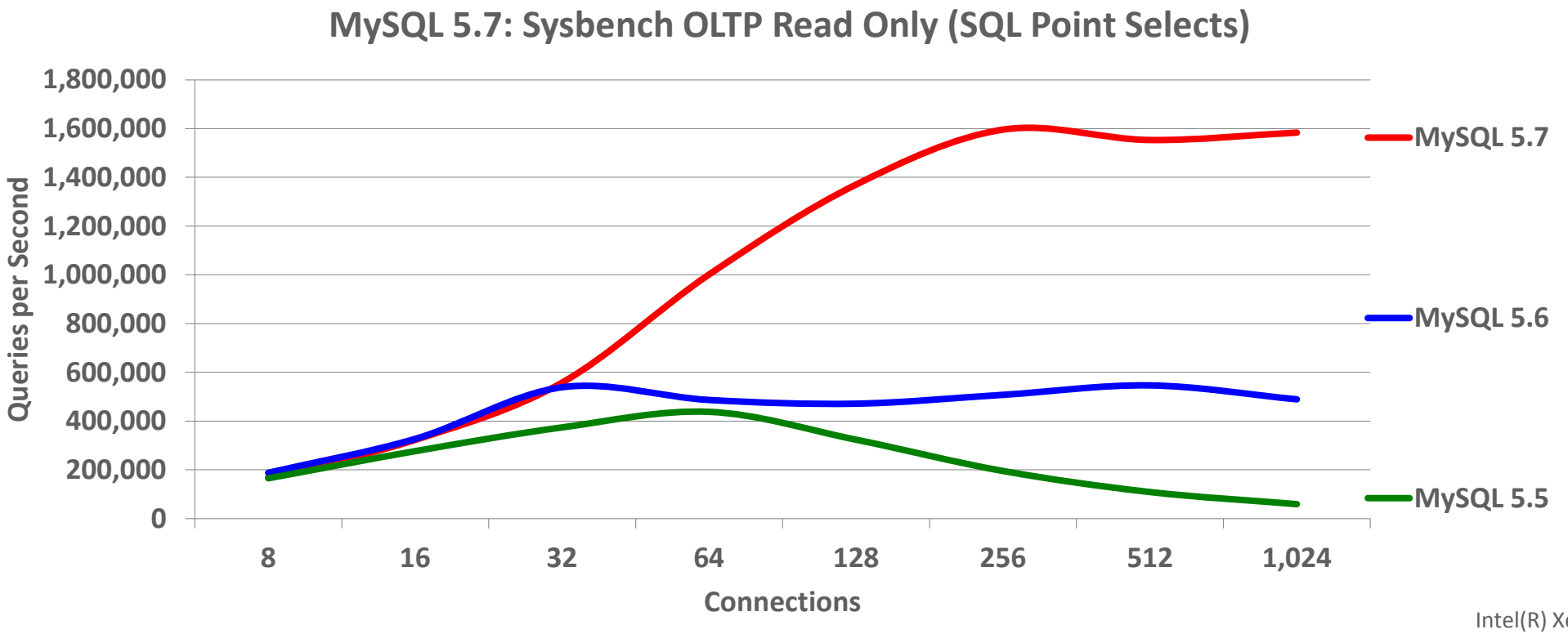
MySQL 5.7 Sysbench Benchmark: SQL Point Selects

3x Faster than MySQL 5.6

4x Faster than MySQL 5.5

1,600,000 QPS



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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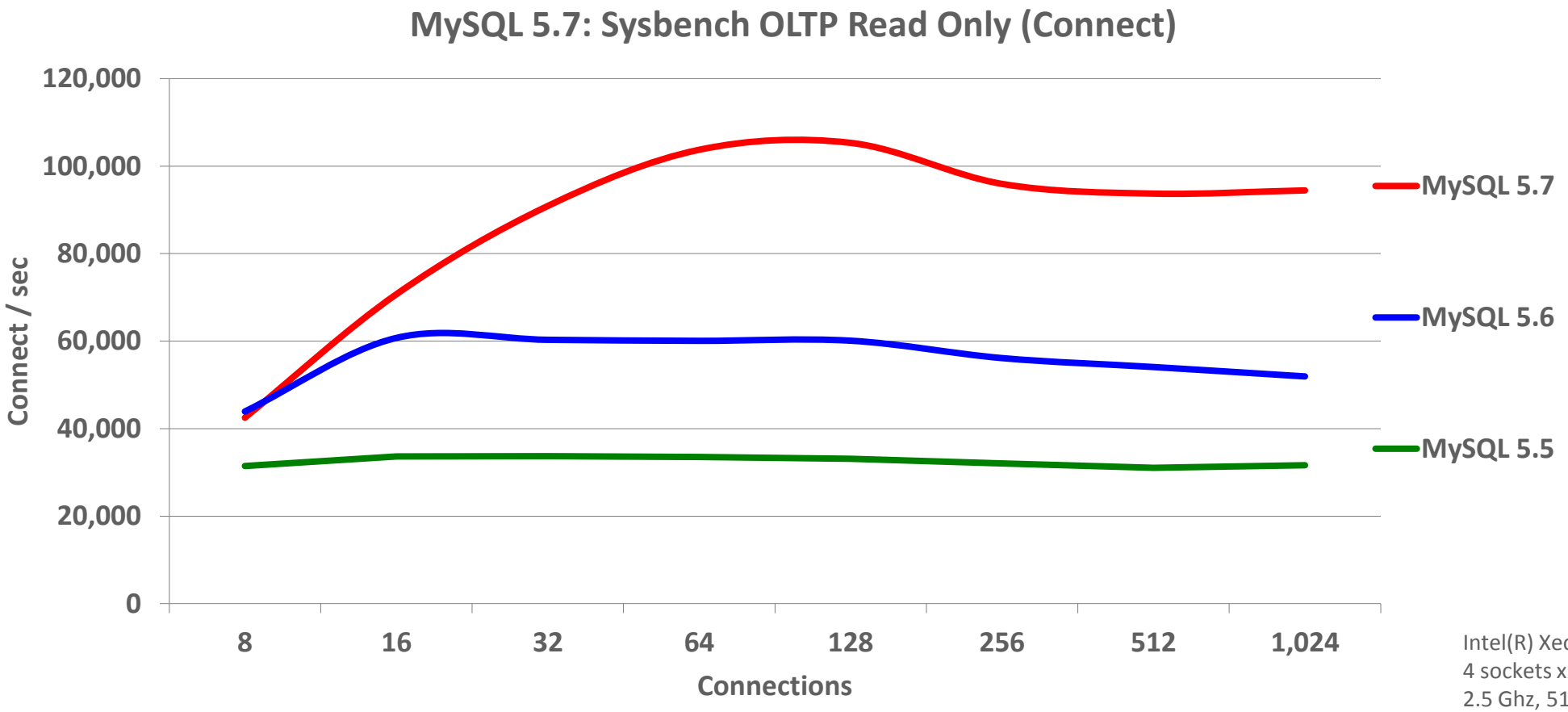
MySQL 5.7 Sysbench Benchmark: Connection Requests

82% Faster than MySQL 5.6

100K Connect / Sec



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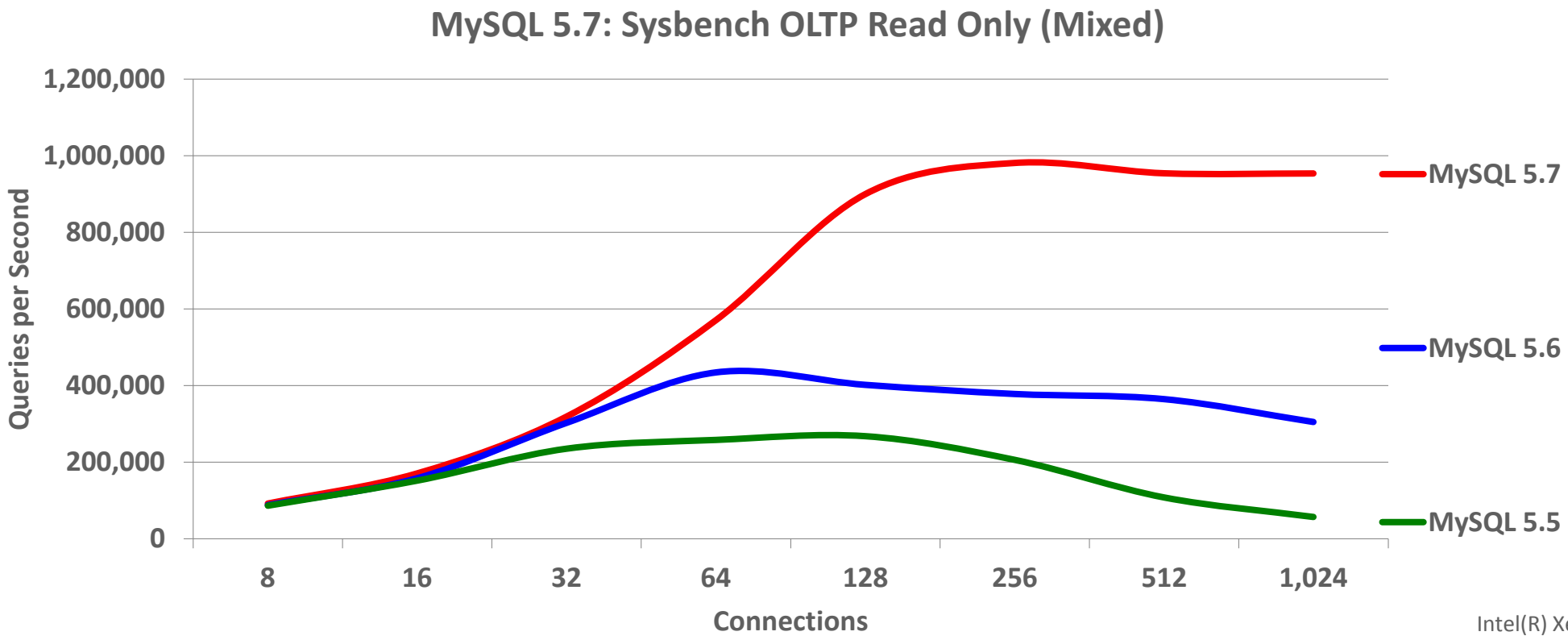
MySQL 5.7 Sysbench Benchmark: OLTP Read Only

3x Faster than MySQL 5.6

6x Faster than MySQL 5.5

~ 1,000,000 QPS



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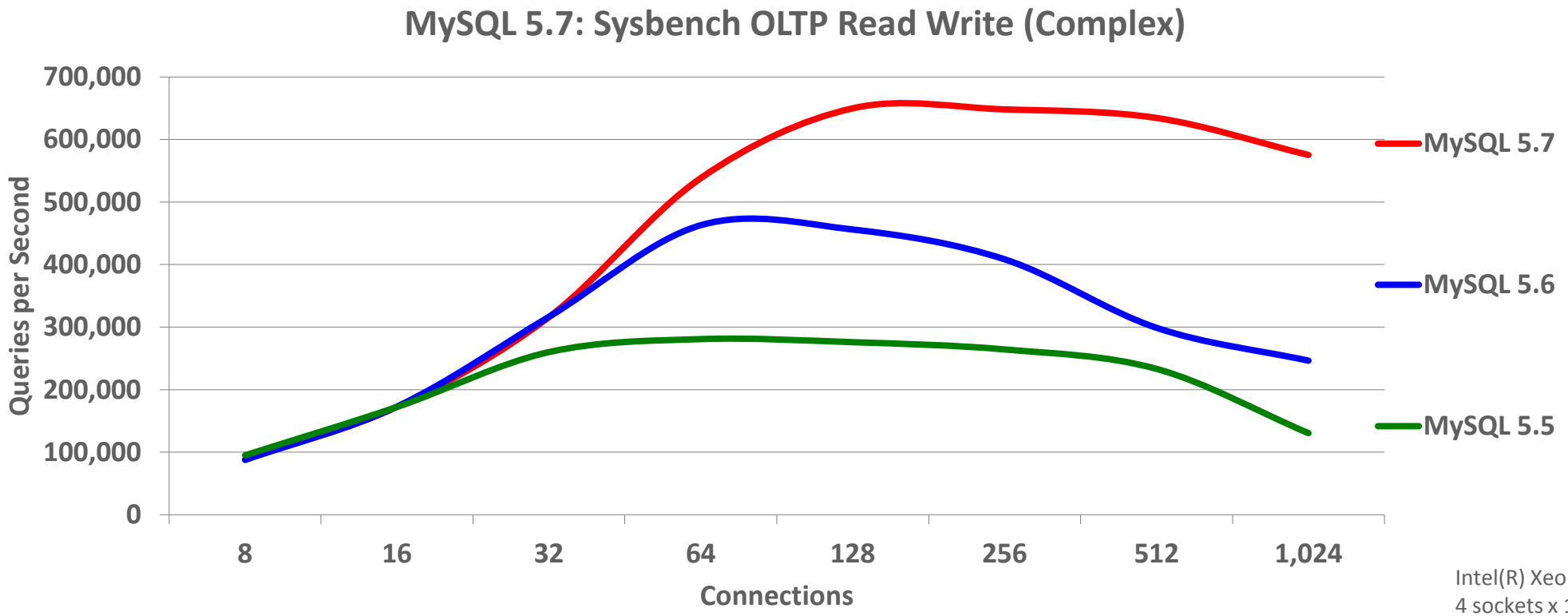
MySQL 5.7 Sysbench Benchmark: OLTP Read Write

1.5x Faster than MySQL 5.6

3x Faster than MySQL 5.5



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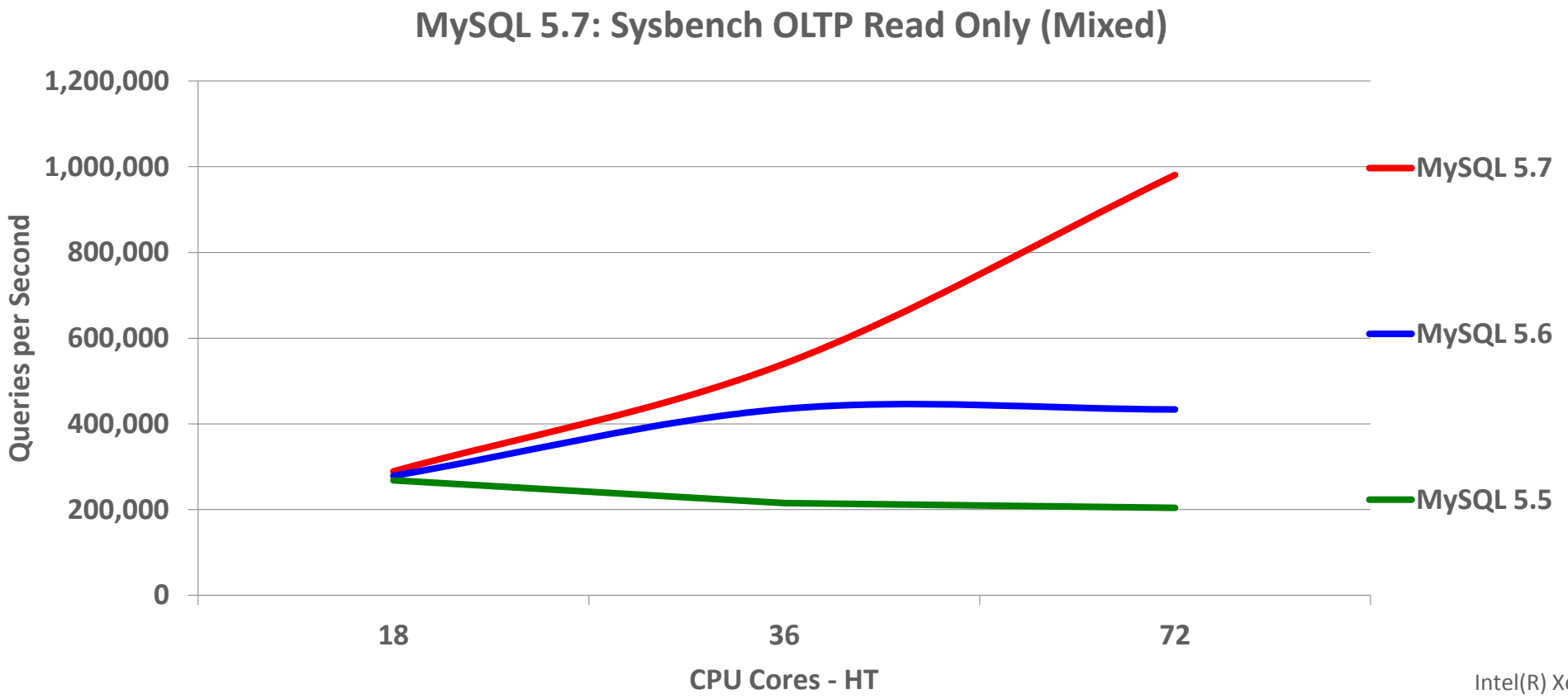
MySQL 5.7 Sysbench Benchmark: OLTP Read Only

MySQL Scales Beyond 72 CPU Cores-HT



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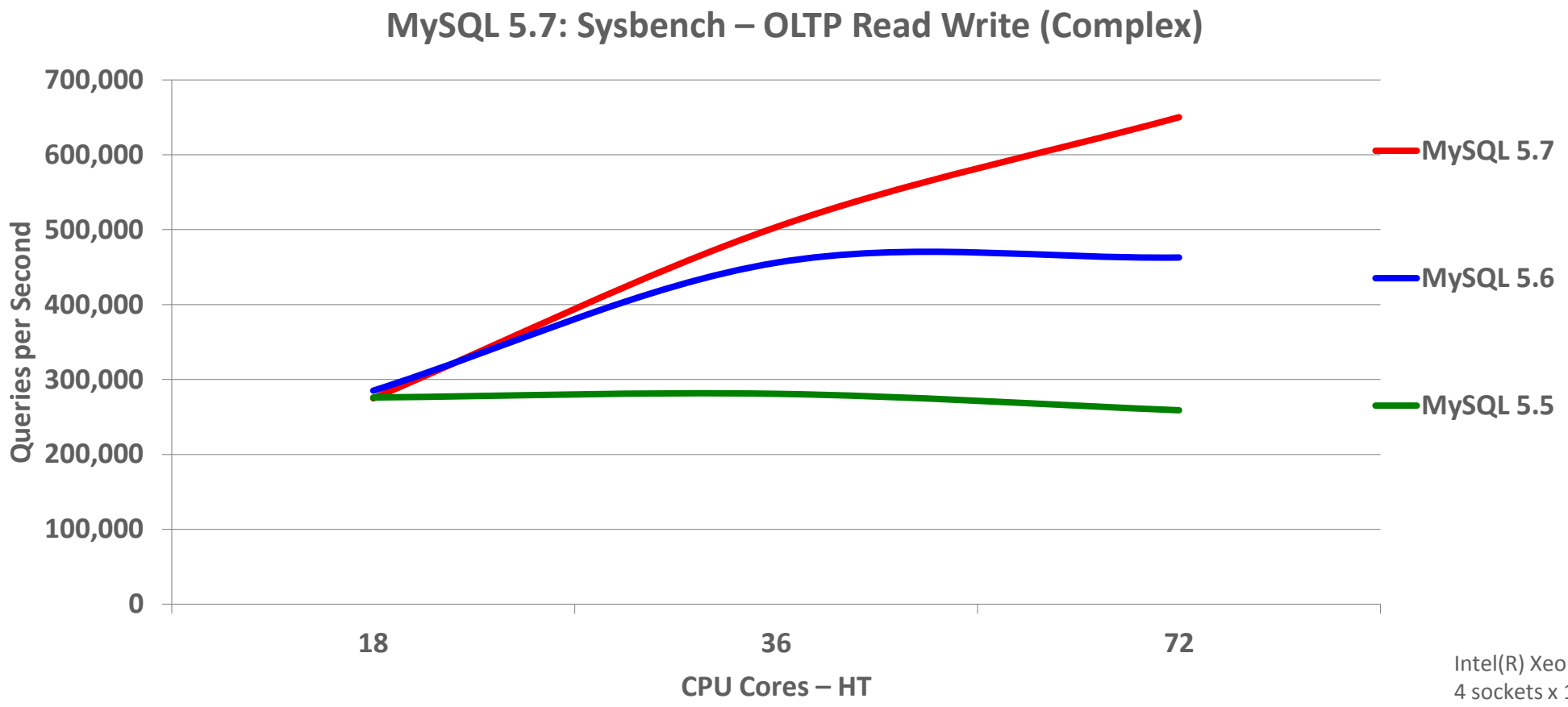

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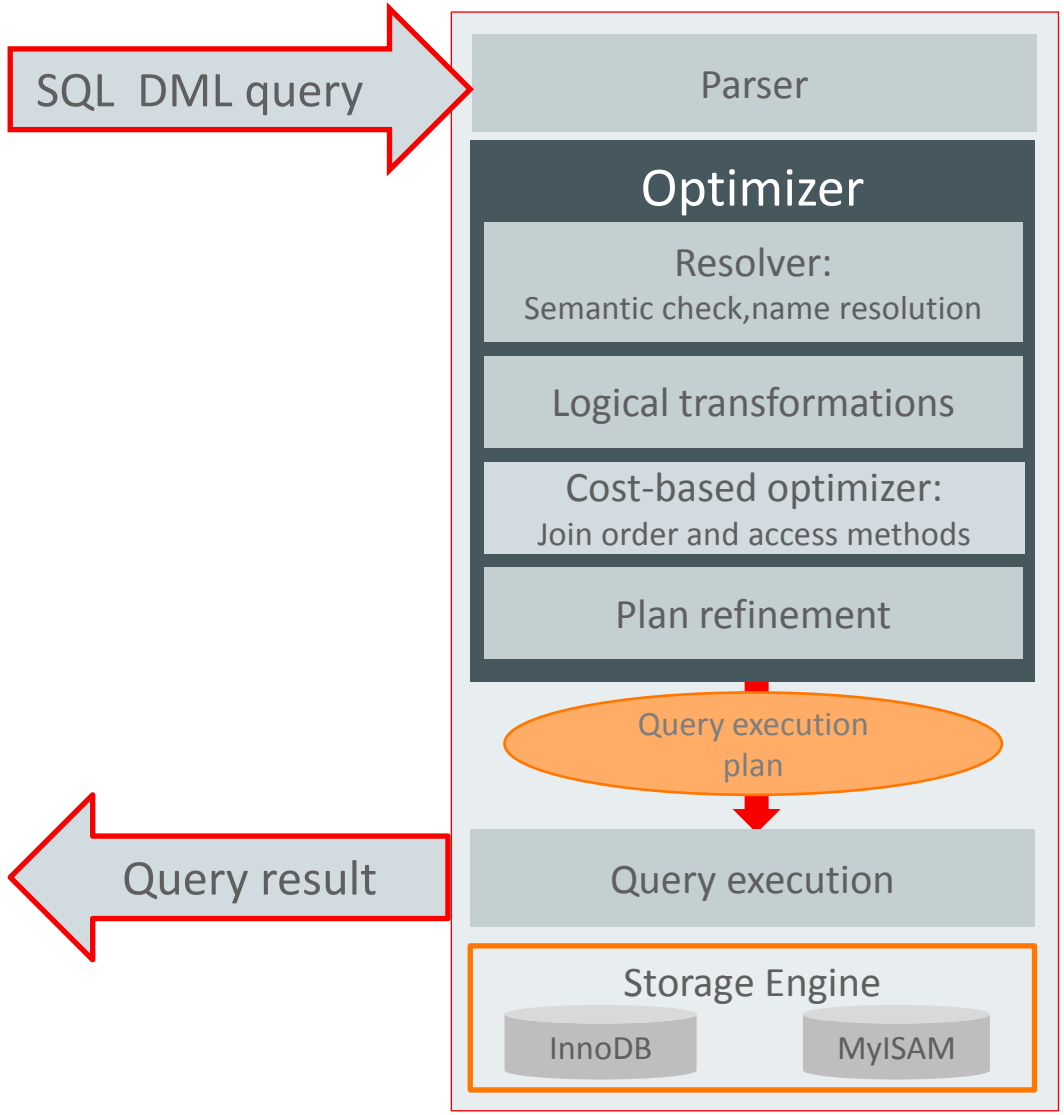
MySQL 5.7: Parser & Optimizer Refactoring

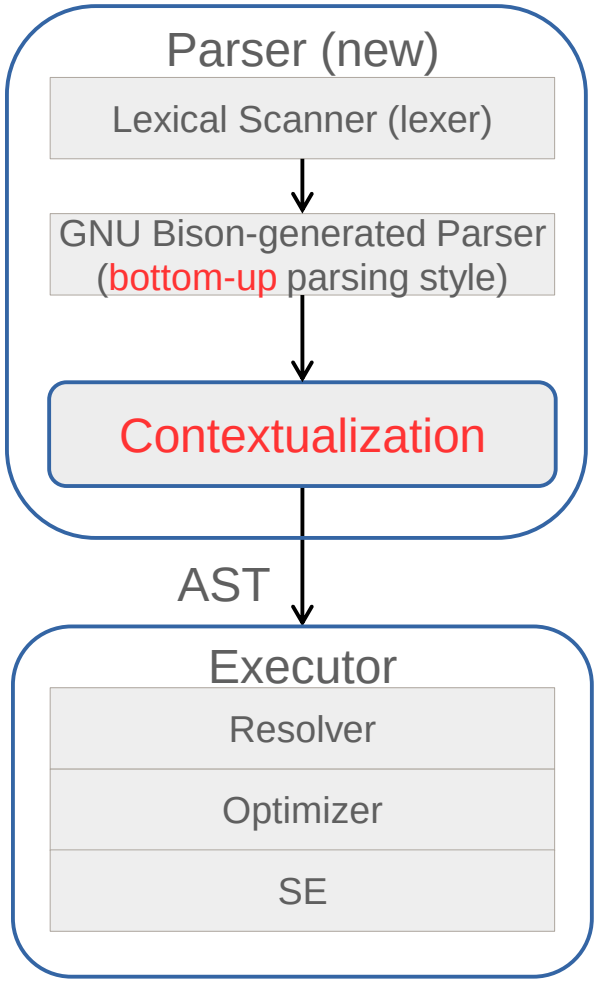
Improves readability, maintainability and stability

- Cleanly separate the parsing, optimizing, and execution stages
- Allows for easier feature additions, with lessened risk



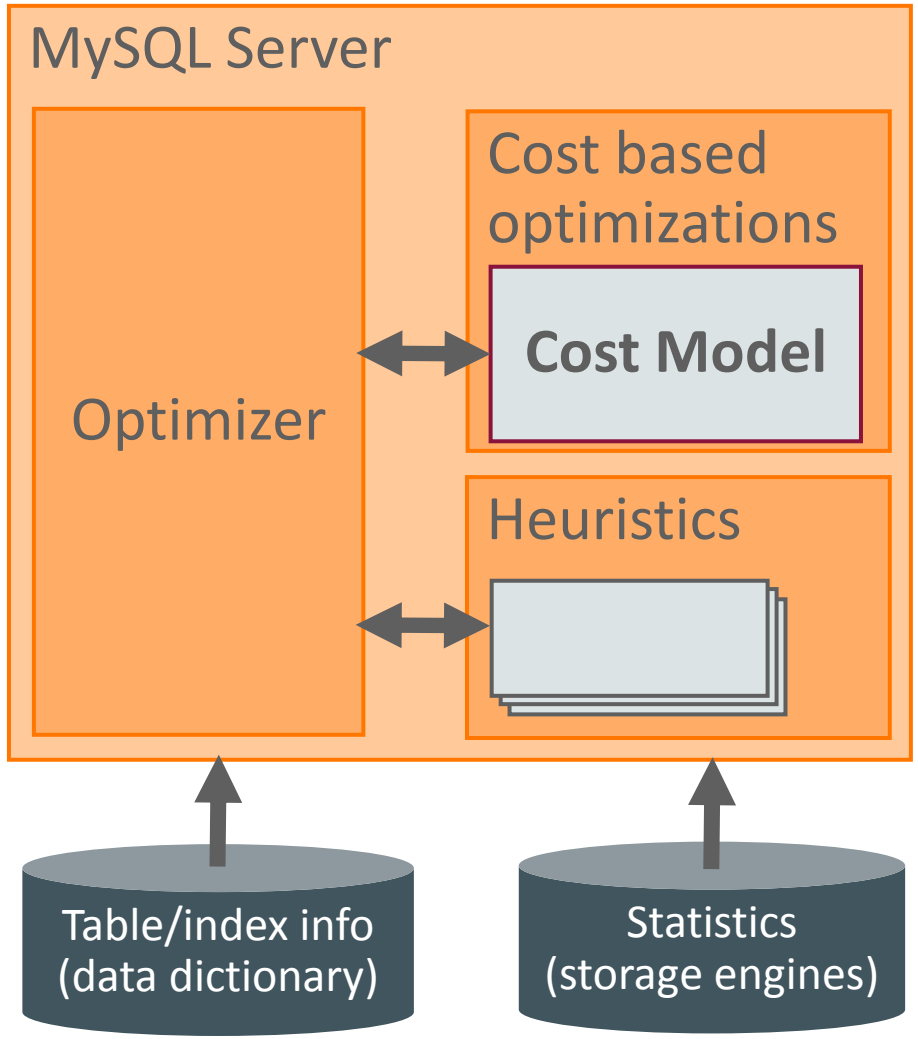
MySQL 5.7: Parser Refactoring

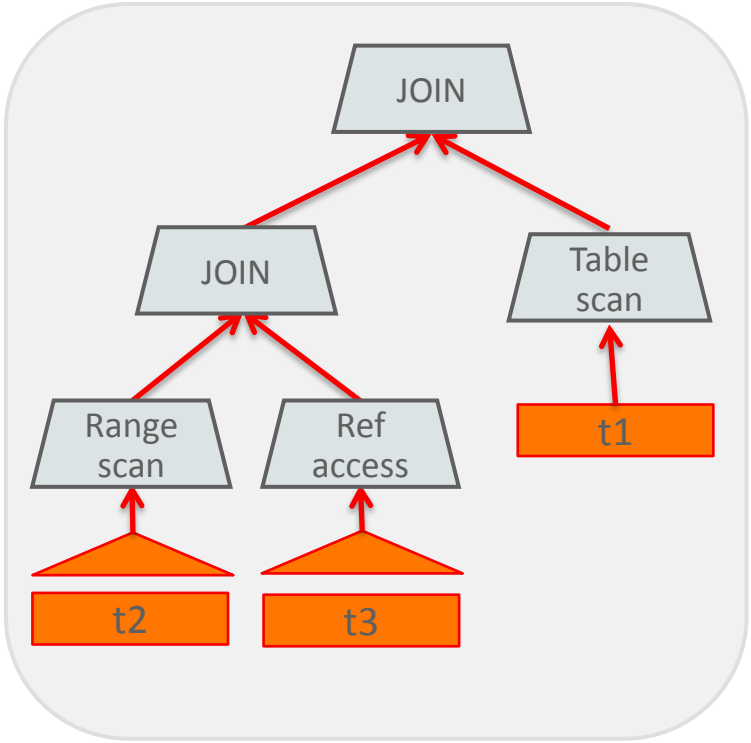
- Challenge:
  - Overly complex, hard to add new syntax
- Solution:
  - Create an internal parse tree bottom-up
  - Create an AST (Abstract Syntax Tree) from the parse tree and the user's context.
  - Have syntax rules that are more precisely defined and are closer to the SQL standard.
  - More precise error messages
  - Better support for larger syntax rules in the future



MySQL 5.7: Optimizer Overview

```
SELECT a, b
FROM t1, t2, t3
WHERE t1.a = t2.b
    AND t2.b = t3.c
    AND t2.d > 20
    AND t2.d < 30;
```





MySQL 5.7: Optimizer Improvements

- Optimizer and Parser refactoring
  - Improves readability, maintainability and stability
  - Cleanly separate the parsing, optimizing, and execution stages
  - Allows for 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
- Generated Columns
- Support for InnoDB based internal temp tables
- Better ONLY_FULL_GROUP_BY mode
- Better support for InnoDB & GIS
- Many specific new optimizations

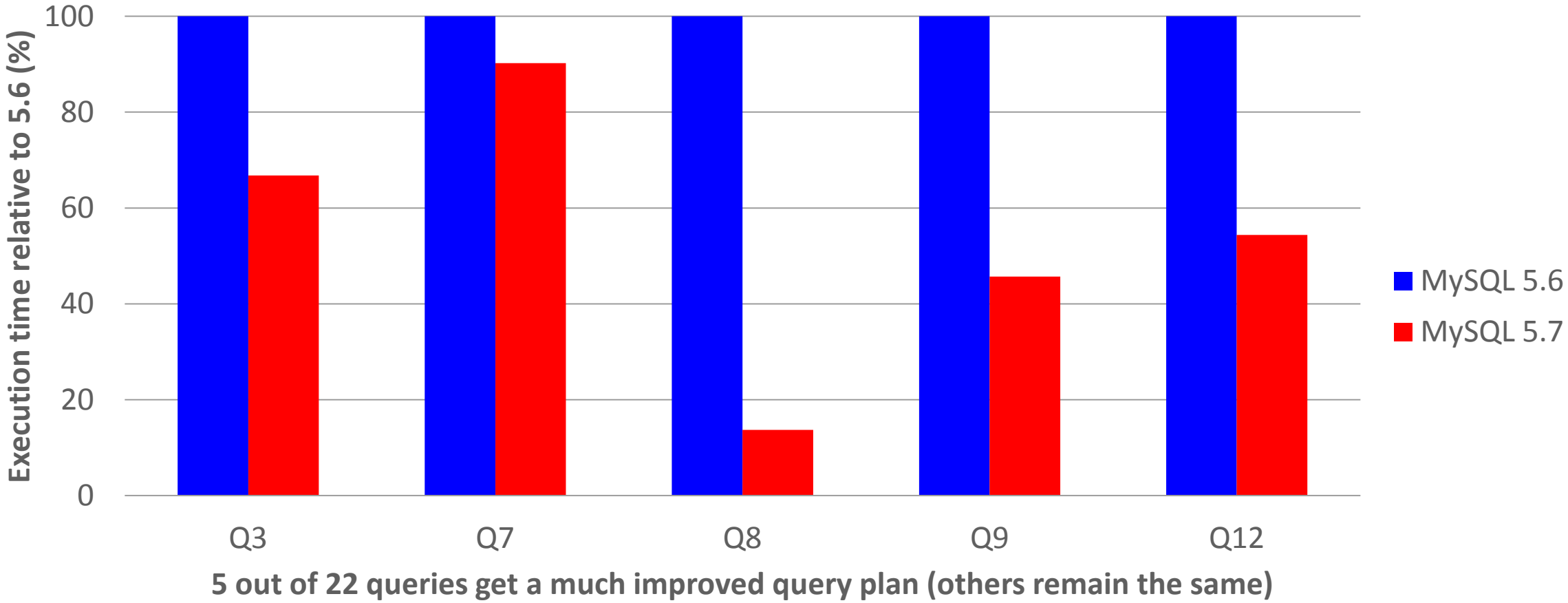
Queries execute faster, while using less CPU and disk space!

MySQL 5.7: New Optimizer Cost Model

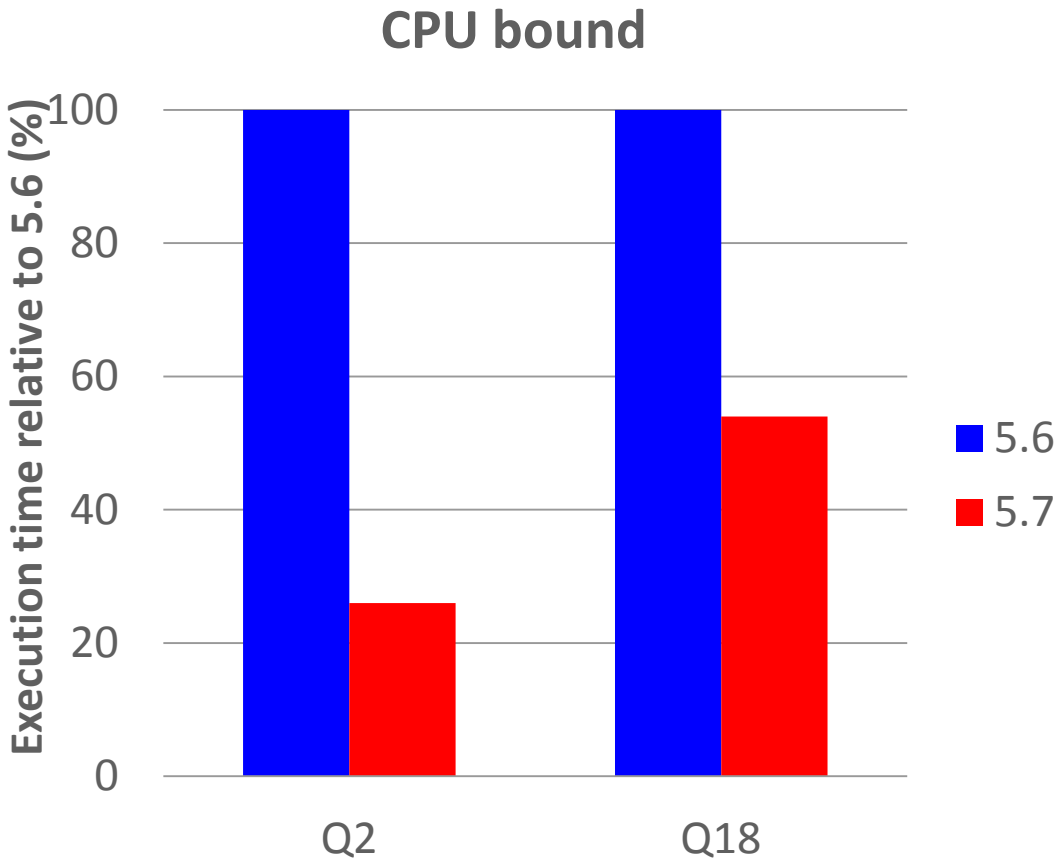
- More accurate cost estimates
  - Better decisions by the optimizer should improve query performance
- Adapt to new hardware architectures
  - SSDs, larger memory sizes, improved caches
- More maintainable cost model implementation
  - Avoid hard coded “cost constants”
  - Refactoring of existing cost model code
- Configurable and tunable
  - mysql.server_cost and mysql.engine_cost tables
  - API for determining where data resides: on disk or in cache

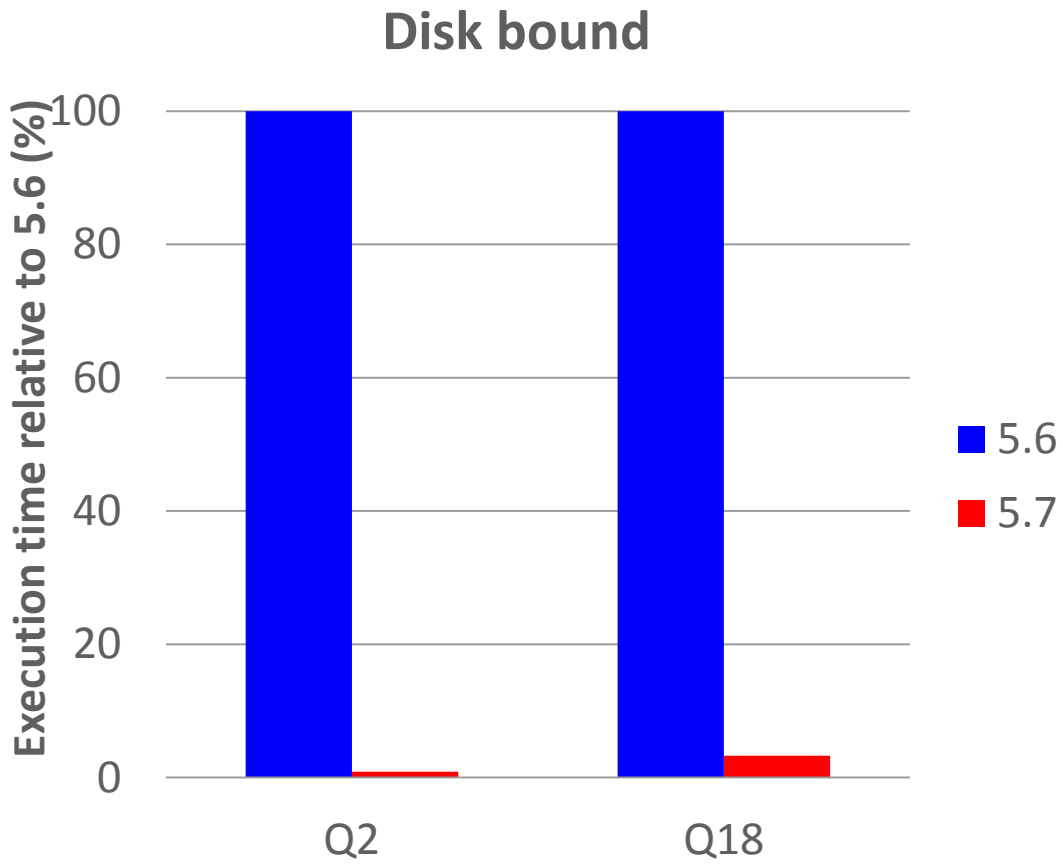
Optimizer Cost Model: Performance Improvements

DBT-3 (Size Factor 10, CPU bound)



Optimizer Cost Model: Performance Improvements
DBT-3 (Size Factor 10)





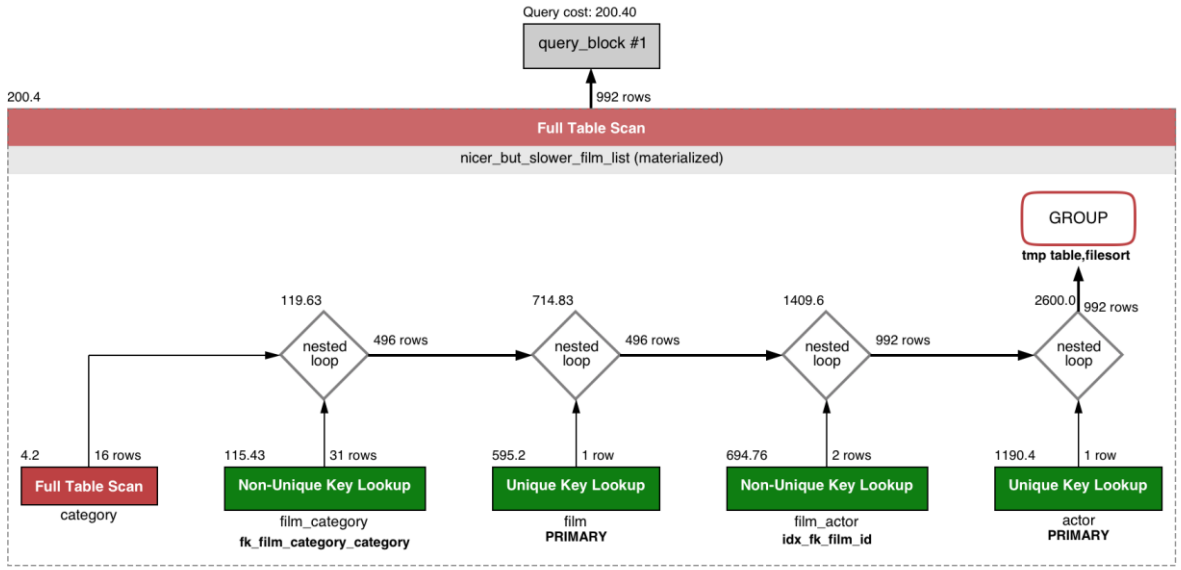
2 out of 22 queries get a significantly improved query plan (others remain the same)

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

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"
      ],
...
```

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

MySQL 5.7: JSON Data Type

- utf8mb4 character set
- Optimized for read intensive workload
- Parse and validation on INSERT only
- Dictionary
  - Sorted objects' keys
  - Fast access to array cells by index
- Internal binary format
  - Efficient storage, retrieval and manipulation

- Supports all native JSON types
- Numbers, strings, bool
- Objects, arrays
- Extended
  - Date, time, datetime, timestamp
  - Other

MySQL 5.7: JSON Functions

- 5.7 supports functions to CREATE, SEARCH, MODIFY and RETURN JSON values:

JSON_ARRAY_APPEND()
JSON_ARRAY_INSERT()
JSON_ARRAY()
JSON_CONTAINS_PATH()
JSON_CONTAINS()
JSON_DEPTH()
JSON_EXTRACT()
JSON_INSERT()
JSON_KEYS()
JSON_LENGTH()
JSON_MERGE()
JSON_OBJECT()
JSON_QUOTE()
JSON_REMOVE()
JSON_REPLACE()
JSON_SEARCH()
JSON_SET()
JSON_TYPE()
JSON_UNQUOTE()
JSON_VALID()

https://dev.mysql.com/doc/refman/5.7/en/json-functions.html

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.

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 (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
```

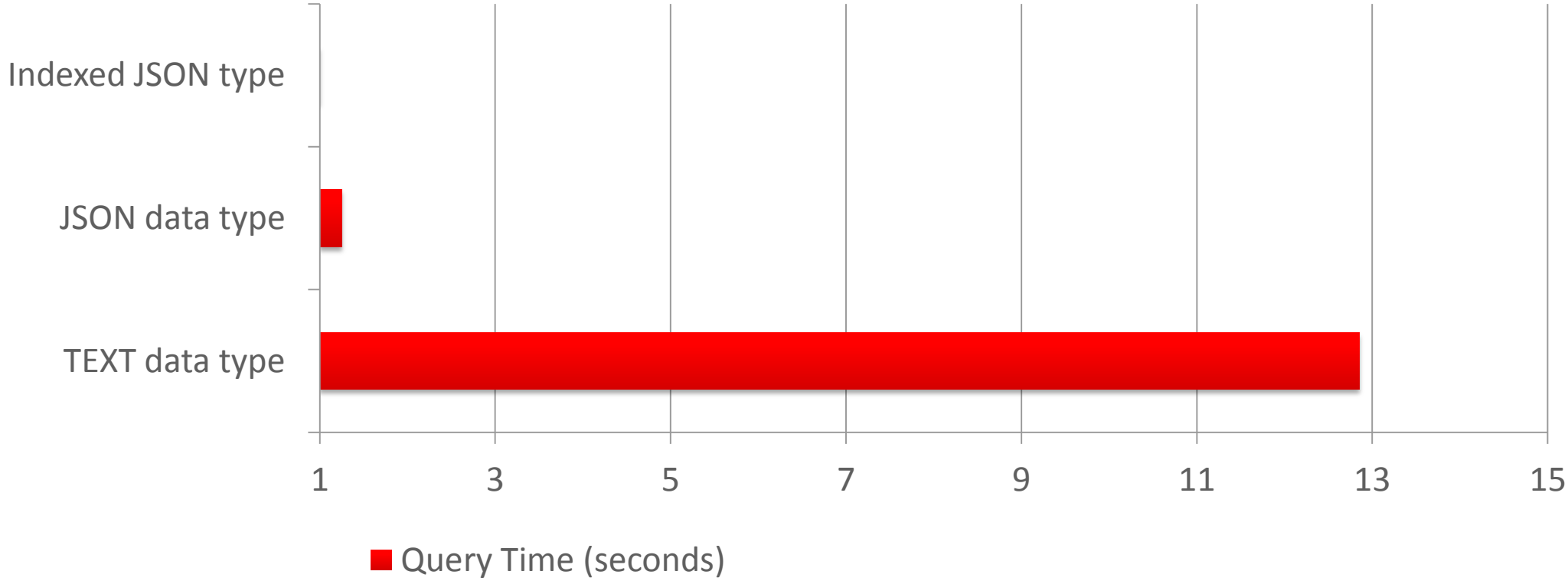
Creates index only, does not touch row data.

```
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

MySQL 5.7: Searching JSON Documents

200x Improvement



Using 206K JSON documents containing City lot parcels from SF OpenData.
Indexed JSON performance Improves query from 12.85 seconds to 0.06 seconds.

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

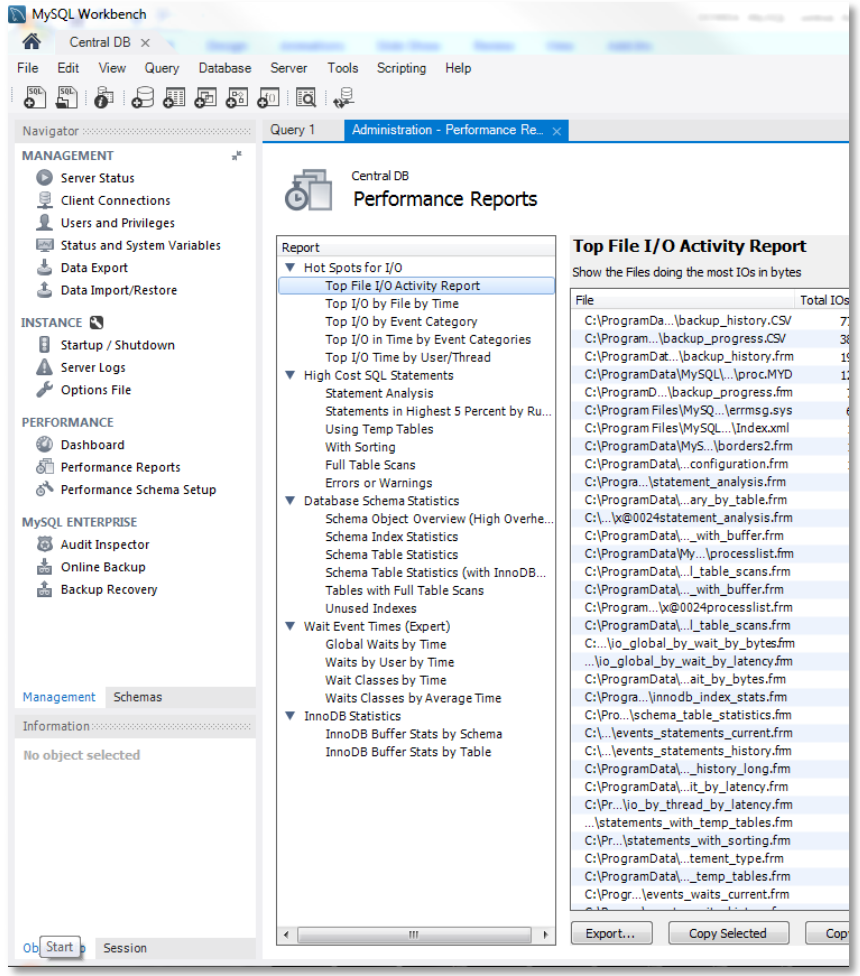
Additional Information

- 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

MySQL 5.7: SYS Schema

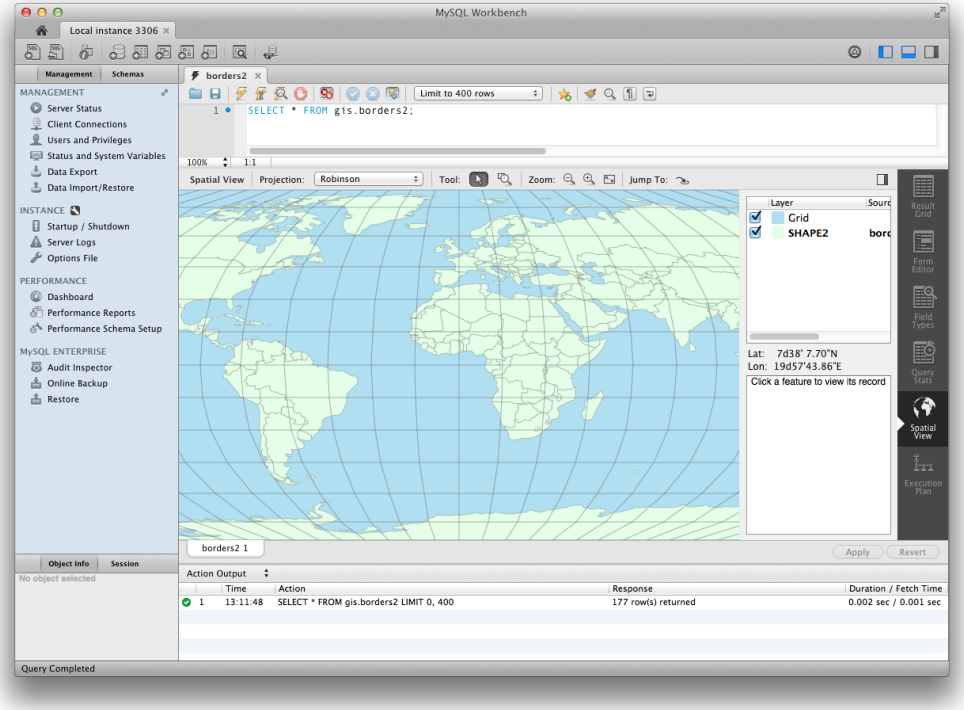
Helper objects for DBAs, Developers and Operations staff

- 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)



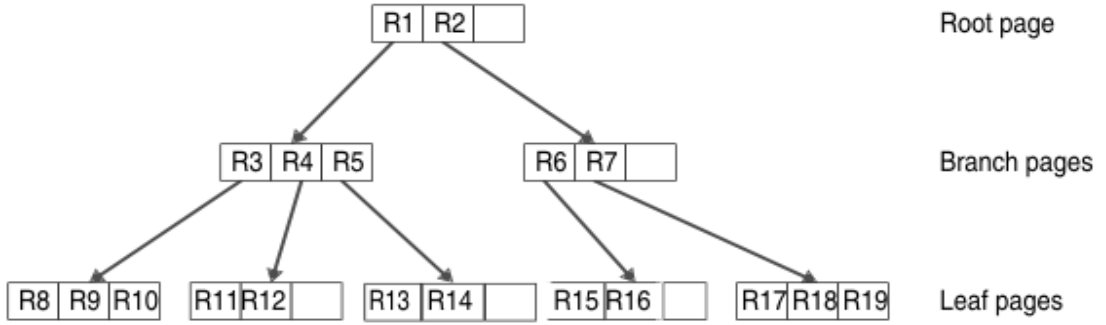
MySQL 5.7: GIS Improvements

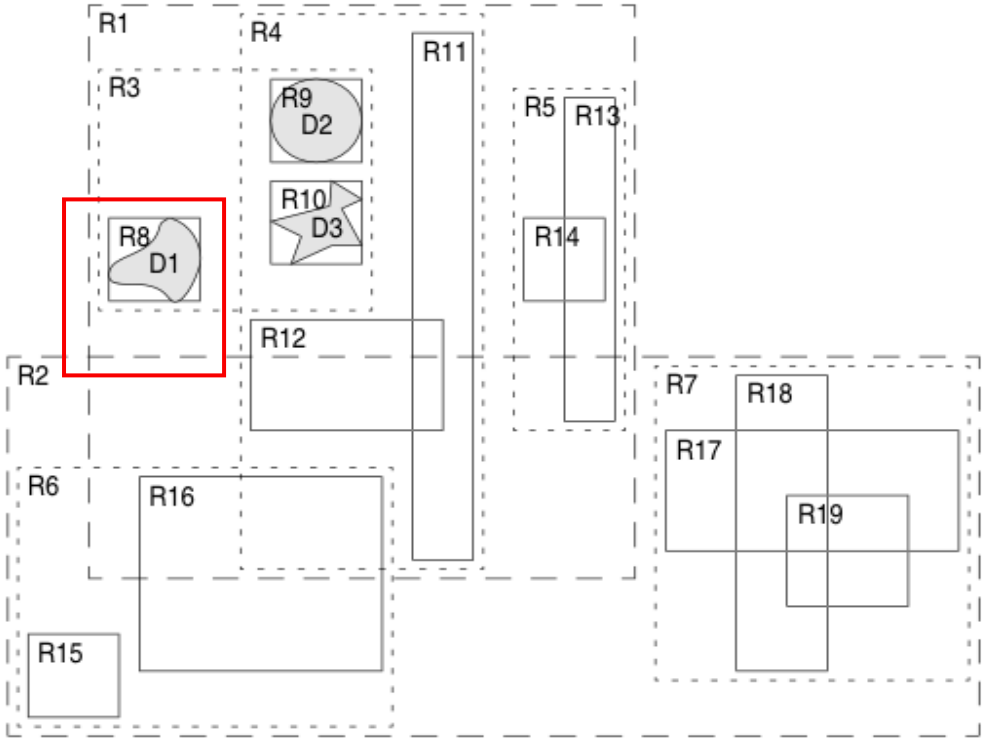
- Replaced custom code with Boost.Geometry
  - For spatial calculations
  - For spatial analysis
  - Enabling full OGC compliance
  - We're also Boost.Geometry contributors!
- InnoDB R-tree based spatial indexes
  - Full ACID, MVCC, & transactional support
  - Index records contain minimum bounding box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



MySQL 5.7: GIS - InnoDB Spatial Indexes

- R-tree based
  - Full transactional support
  - Predicate locking to prevent phantoms
  - Records contain minimum bounding box
    - Small and compact
  - Currently only supports 2D data
    - We would like to add 3D support in the future
  - Supports historical spatial index DDL syntax





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
- Improvements in storage footprint
  - Configurable innodb-fill-factor
  - Configurable merge_threshold per table
- Improved bulk-data load performance

MySQL 5.7: InnoDB – Always Online

- Resize the InnoDB Buffer Pool online
  - Allows DBAs to tune the buffer size without any downtime
  - Adapt in real-time to changes in database usage patterns
- Separate UNDO tablespace
  - With automatic online truncation
- Additional Online ALTER TABLE support
  - Enlarge VARCHAR, Rename Index
- Dynamic configuration
  - Making existing settings dynamically configurable
  - As a design principle for new features & settings

MySQL 5.7: InnoDB Bulk Load for Index Creation

- Much faster INDEX creation and bulk loads
- Sorted index builds, done from the bottom-up
  - Improves speed by increasing locality and decreasing node splitting
- Pages are compressed only when full
- New innodb_fill_factor option controls free space left in each page
- Performance results show
  - 2-3x performance improvement for ADD/CREATE INDEX operations
    - Up to 500x improvement with larger `--innodb_sort_buffer_size values`
  - 2-5% improvement for standard INSERT operations

MySQL 5.7: InnoDB Temporary Tables

- New separate tablespace for temporary tables
  - Improved CREATE/DROP performance
  - DDL changes are transient, which eliminates some disk IO
- Optimize DML operations
  - No REDO logging, no change buffering, less locking
- New intrinsic temporary tables
  - Specialized temporary tables with tailored ACID/MVCC semantics
  - Light weight and ultra-fast, great for intermediate query execution operations
- InnoDB as default storage engine for disk based temp tables
  - Optimizer switched from MyISAM to InnoDB (faster) for internal temp tables

MySQL 5.7: InnoDB Full-Text CJK Support

- Two new Full-Text Parser plugins
- N-gram parser supports Chinese, Japanese, & Korean
  - Supports all ideographic languages that do not use word delimiters
- MeCab parser supports Japanese
  - Native Japanese focused language support
- Easily customized
  - Token sizes, stop words, …
- Supports advanced searches
  - BOOLEAN MODE, NATURAL LANGUAGE MODE, with Ranking

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

MySQL 5.7: Syslog Support for Linux/Unix platforms

Thank you, Simon Mudd at booking.com

- Native support for syslog
- Simple option to (re)direct log output to native syslog facility
- Start-up server configuration option
- Dynamically in the running server
  - System variable log_syslog (ON/OFF, defaults to OFF).

MySQL 5.7: Security - Encryption, Passwords, Installation

- AES 256 Encryption
  - Default in MySQL 5.7
- 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

MySQL 5.7: Security – SSL, Proxy User

- 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

MySQL 5.7: Locking

Thank you, Konstantin Osipov!

Multiple User Level Locks per Connection

- User-level locks can be used to organize mutual exclusion
  - When accessing some resource
  - When table or row-level locks are not appropriate
- Request multiple locks by issuing a series of GET_LOCK statements
- Replaces custom user-level lock implementation
  - With one based on the MDL lock manager
  - Deadlocks between different connections acquiring user-level locks, metadata locks, and those waiting for table flushes are properly detected and reported as errors.

MySQL 5.7: Improved MDL locking

- Fast-path for DML locks
- Lock-free DML lock acquisition
- Lock-free hash
  - Now uses MurmurHash library
- Removes bottlenecks around DML access to a single table
  - 10% increased throughput in OLTP_RO/POINT_SELECT sysbench
  - Optimized for typical DML heavy workloads

MySQL 5.7: Server-Side Statement Timeouts

Thank you Davi Arnaut!

- Server side statement timeouts
  - Global for server, per session, or for individual SELECT statements

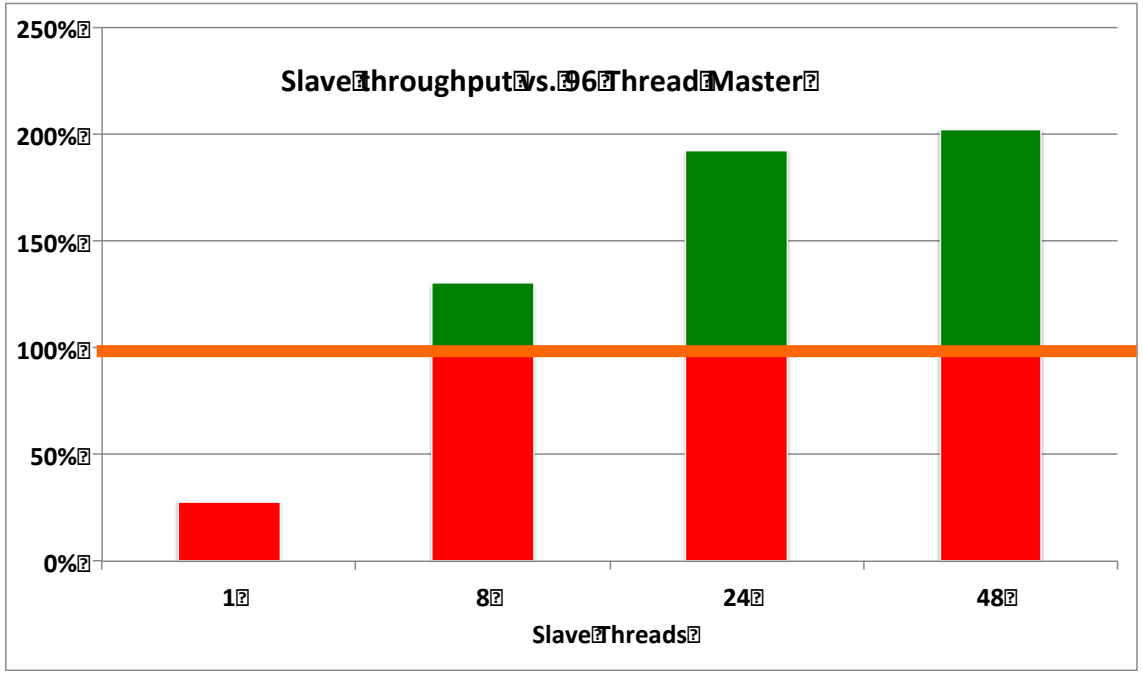
```
SELECT /*+ MAX_EXECUTION_TIME(1000) */  * FROM my_table;
```

- Expanded to Windows and Solaris, restricted by removing USER option

MySQL 5.7: Replication Improvements

- GTID enhancements
  - On-line, phased deployment of GTIDs
  - Binary logging on slave now optional
- Enhanced Semi-synchronous replication
  - Write guaranteed to be received by slave before being observed by clients of the master
  - Option to wait on Acks from multiple slaves
- Multi-Source Replication
  - Consolidate updates from multiple Masters into one Slave
- Dynamic slave filters

- **8-10x** Faster slave throughput
  - Often removes slave as a bottleneck; keep pace with master with 8+ slave threads
  - Option to preserve Commit order
  - Automatic slave transaction retries



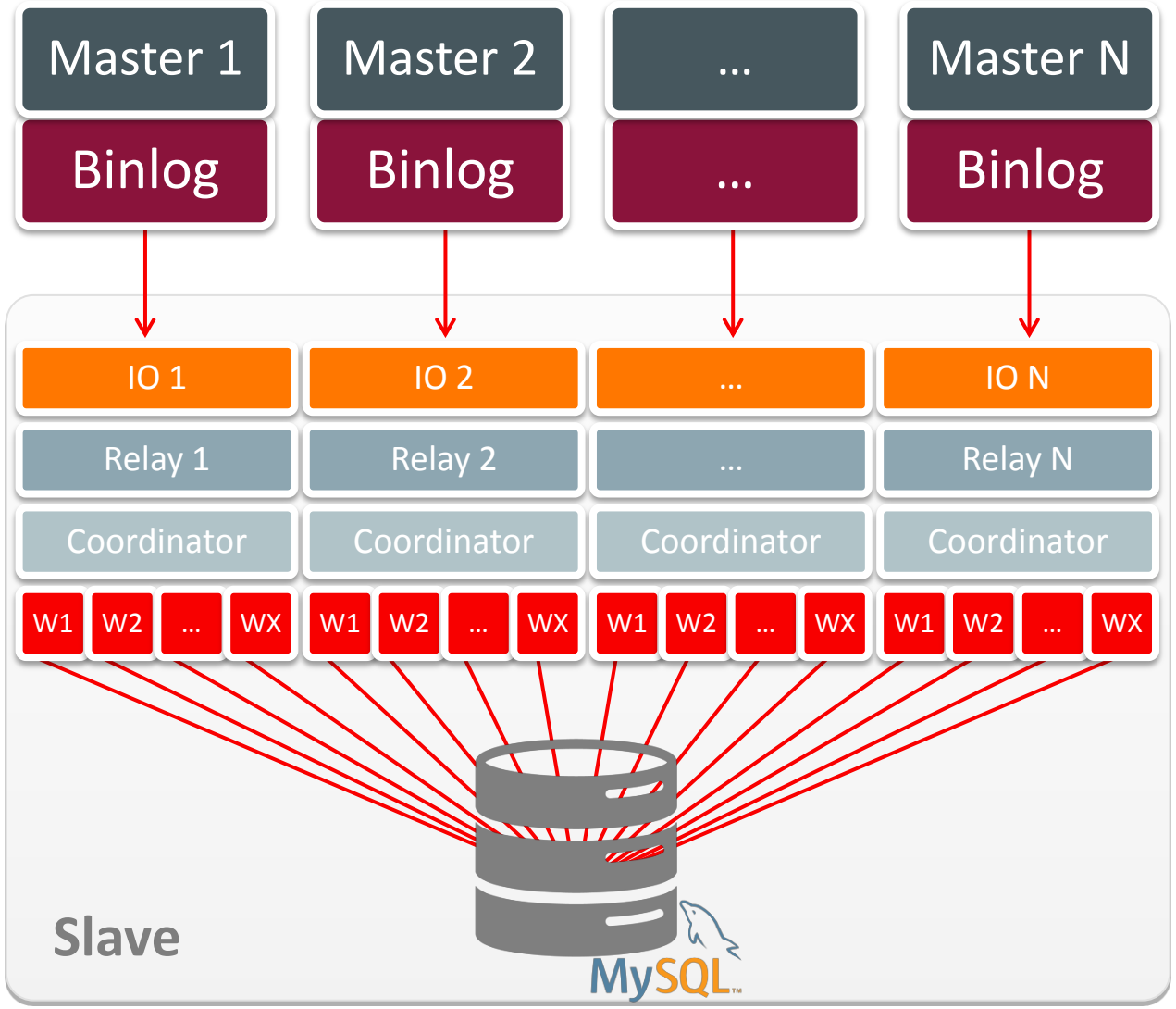
MySQL 5.7: Enabling GTIDs

Phased, On-line Introduction

- Server reports any incompatible operations
- All servers generate GTIDs but don't depend on them
- Allow all legacy events to work through all servers
- All Servers generate and expect GTIDs only
- Full benefits of GTIDs available

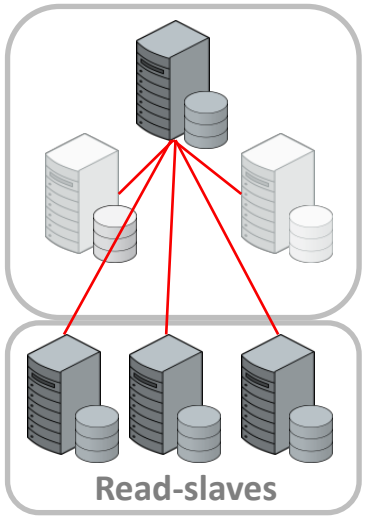
MySQL 5.7: Replication Improvements

- Multi-Source Replication
  - Consolidate updates from multiple Masters 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



MySQL 5.7: High Availability Improvements

- Support for tracking session transaction state
  - This offers better support for load balancing across nodes
- Server Version Tokens
  - This offers better support for caching in distributed systems
- New data migration tool : `mysqlpump`
  - Improves data migration and sharding operations between nodes
- Improved Replication options in HA groups
  - Improved slave performance with clock based parallelization
  - Loss-less Semi-Sync Replication plugin supporting multi-node acks
  - Synchronous replication (Group Replication plugin now in Labs)

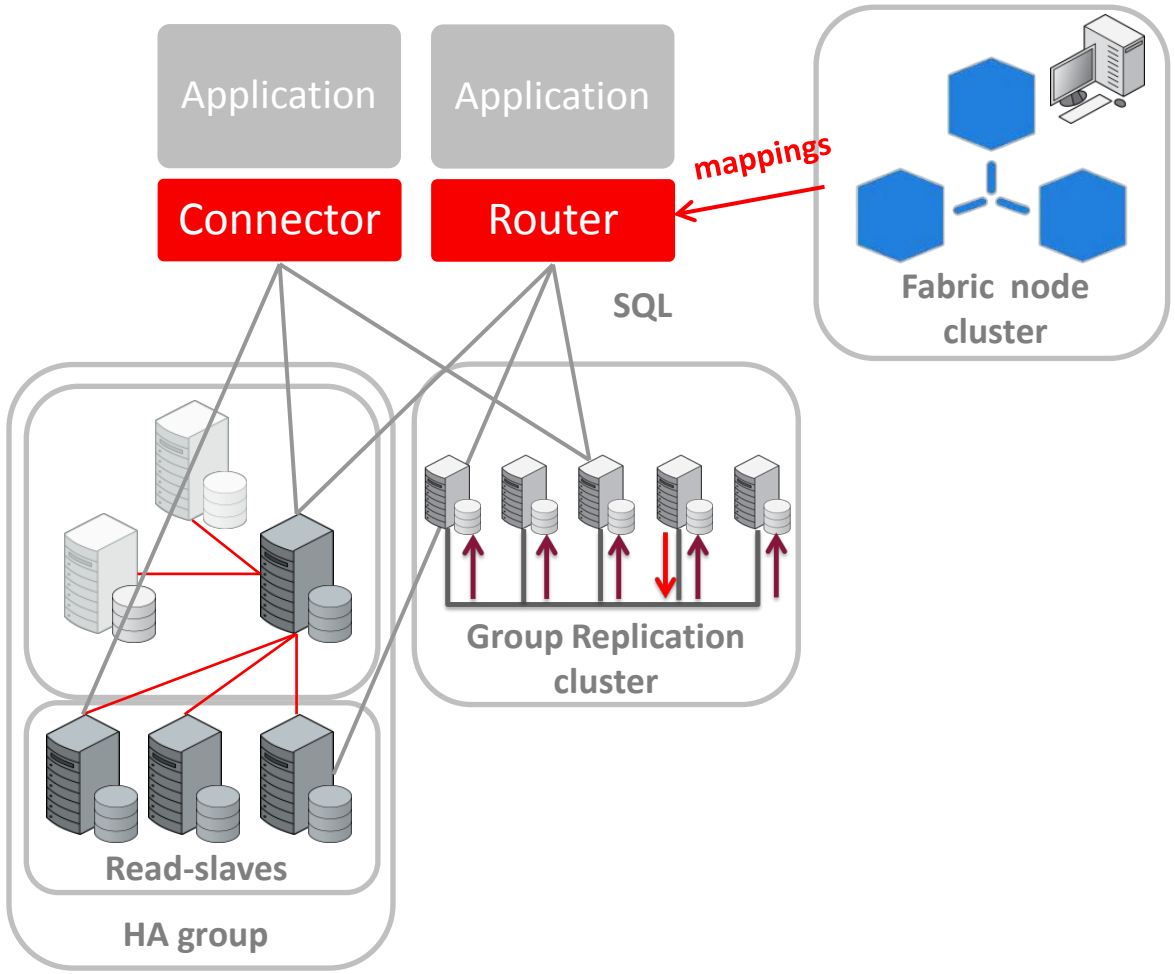


HA group

MySQL Fabric 1.6

High Availability + Sharding-Based Scale-out

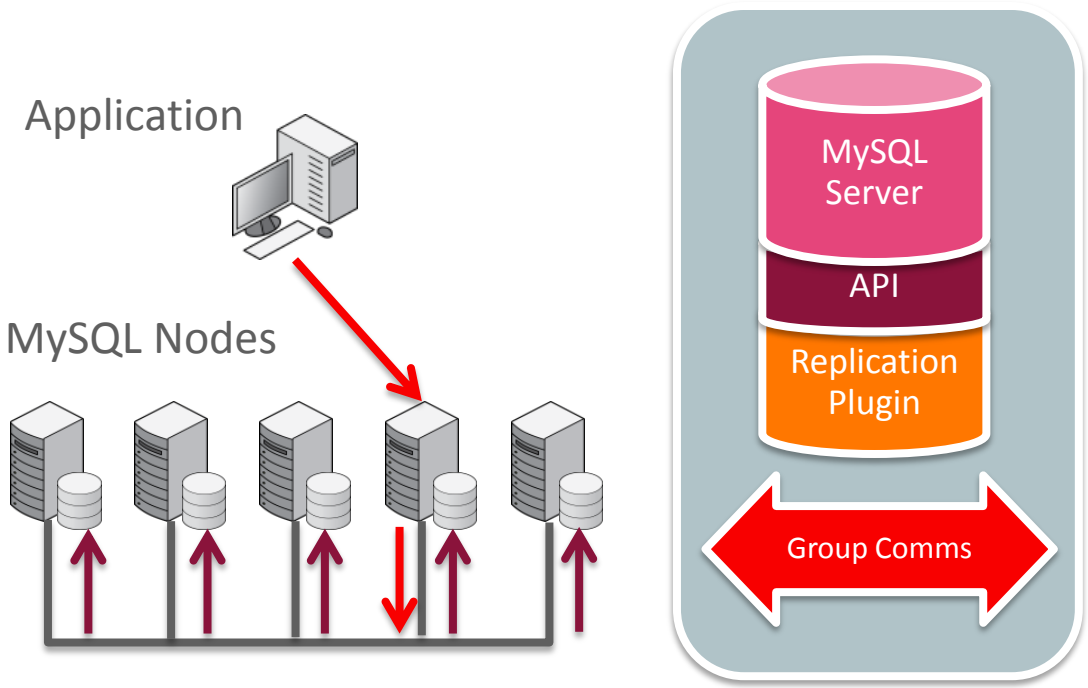
labs.mysql.com



- High Availability
  - Server monitoring with auto-promotion and transparent application failover
  - No single point of failure (SPOF)
- Optionally scale-out through sharding
  - Application provides shard key
  - Tools for shard management
  - Global updates & tables
- Connection options
  - Fabric-aware connectors
  - MySQL Router
- Server provisioning using OpenStack
  - Support for Nova and Neutron APIs

MySQL Group Replication

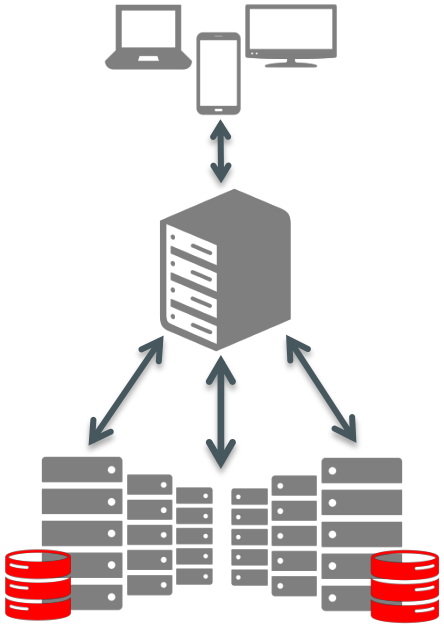
labs.mysql.com



- Active/Active Update Anywhere
  - Conflict detection and resolution (transaction rollback)
  - Optimistic State Machine Replication
- Automatic group membership management and failure detection
  - No need for server fail-over
  - Elastic scale out/in
  - No single point of failure
  - Automatic reconfiguration
- Well integrated
  - InnoDB
  - GTID-based replication
  - PERFORMANCE_SCHEMA

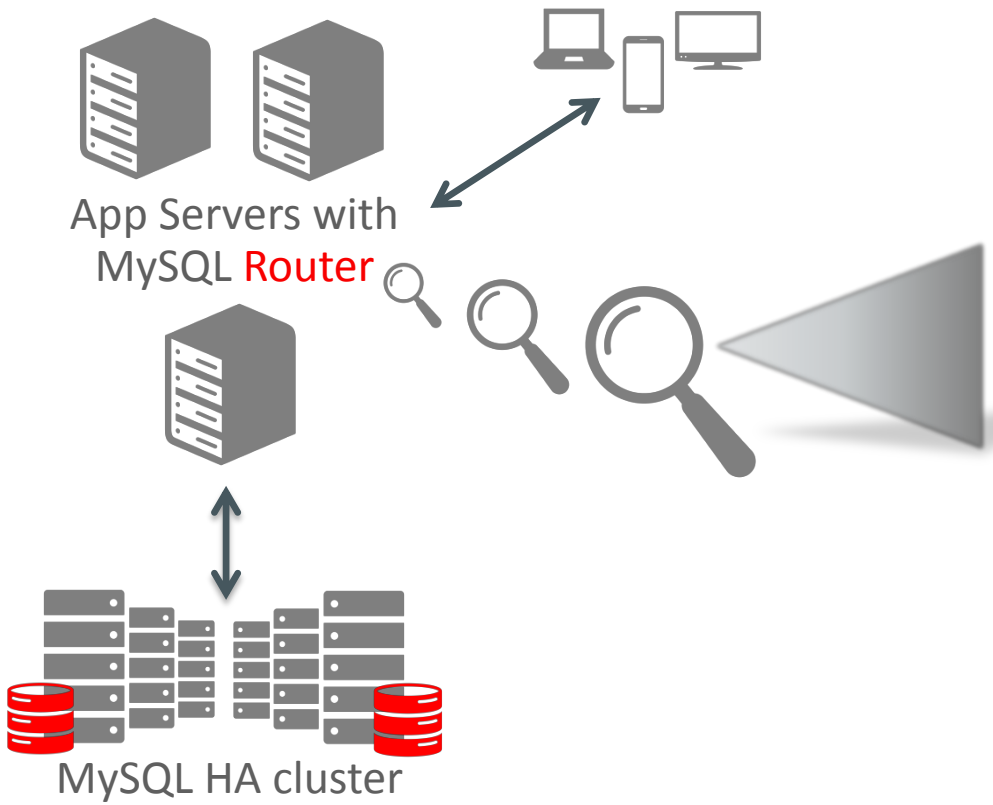
MySQL Router

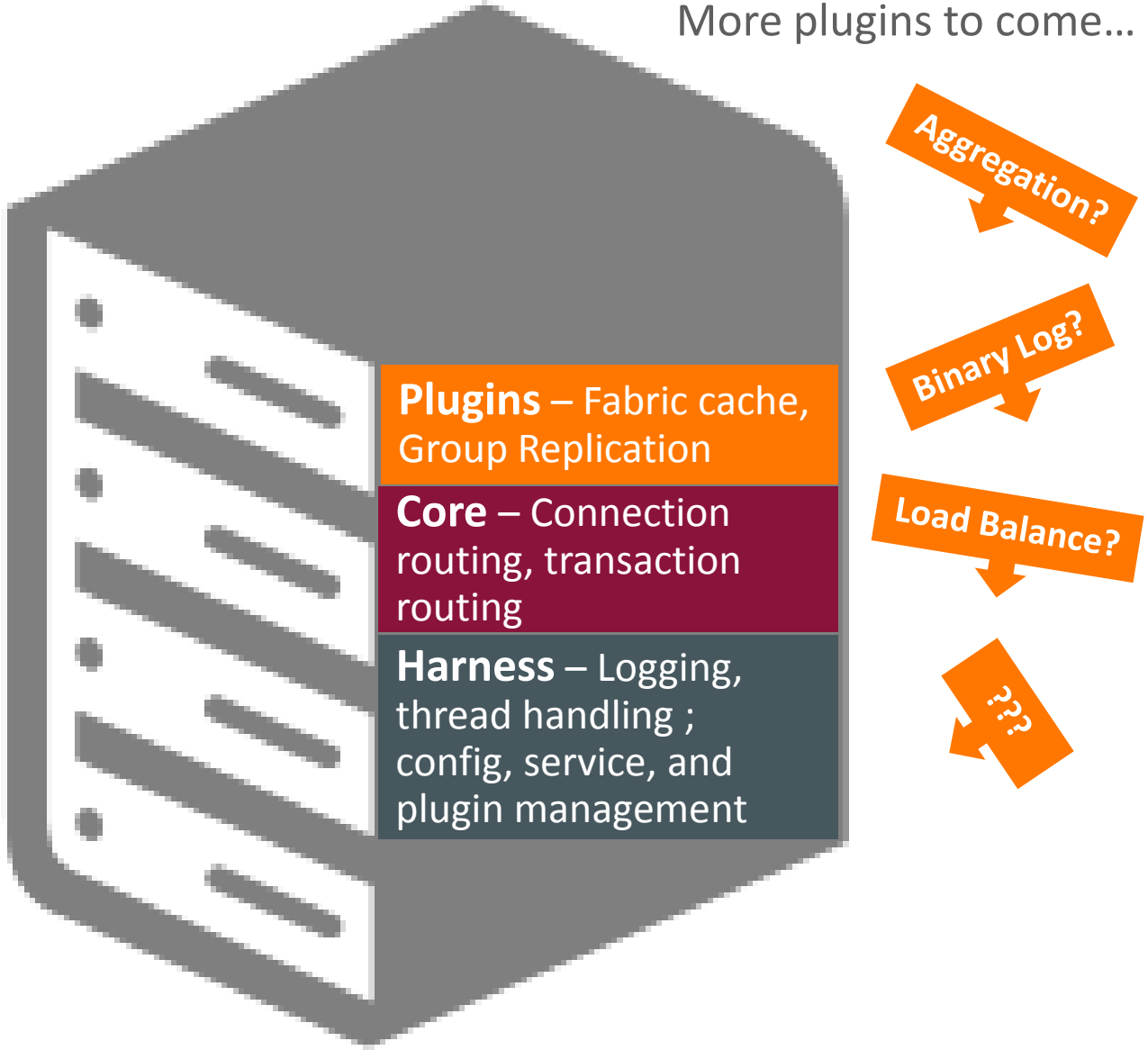
- Connection and Transaction routing
- Transparently improve your MySQL apps
  - Transparent MySQL Fabric support
    - Transparent HA
    - Transparent Sharding
  - Transparent support for MySQL Group Replication clusters
  - Transparent support for custom clusters and HA setups
- Easily extendable using plugin APIs
- Many new plugins to come – Aggregation, Binary Log, Load Balancing, …
  - What would you most like to see?



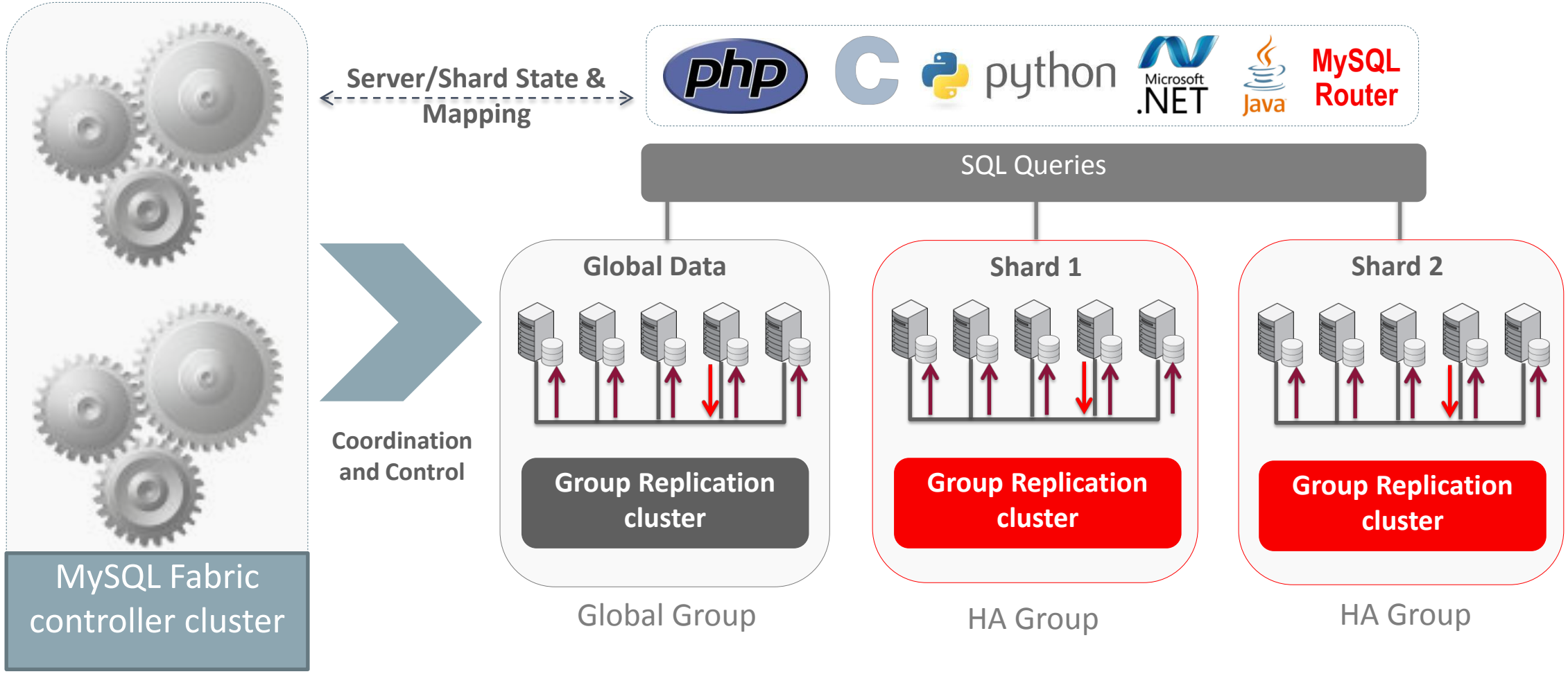
MySQL Router

Extensible Architecture





The Future of MySQL Scaling (HA + Sharding)



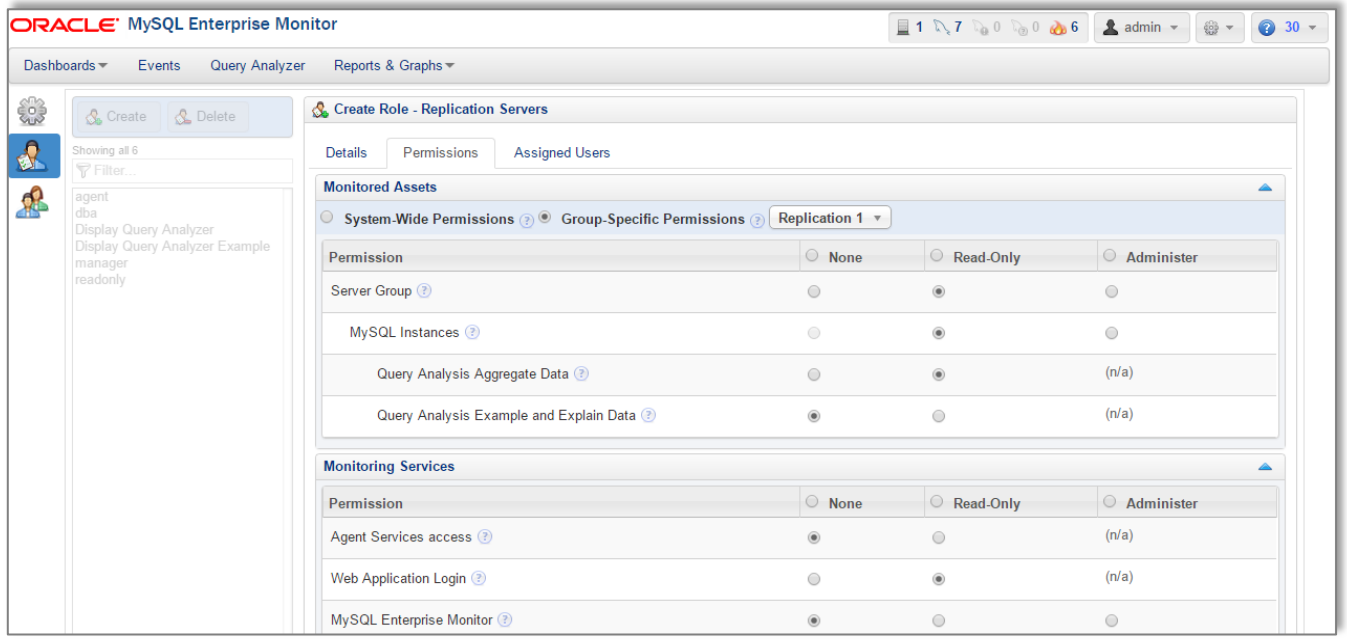
HTTP Plugin for MySQL

labs.mysql.com

- Server Plugin adds HTTP(S) endpoints to MySQL
- Results are serialized to JSON format encoded as UTF8
- Provides 3 choices of User Endpoint Types
  - SQL
  - CRUD - Key-Value
  - JSON - Document

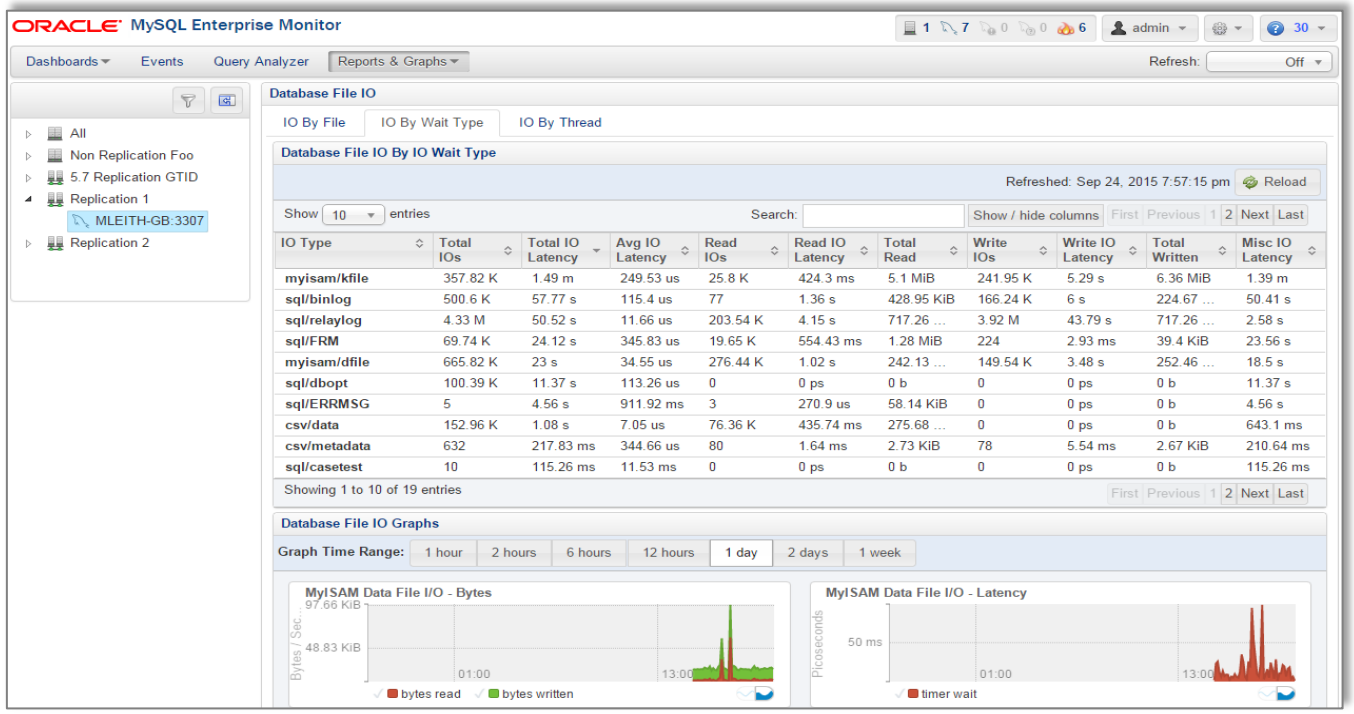
MEM 3.1: Access Control Lists

- Supports multi-tenancy
  - Critical for large orgs and SaaS providers
- Users/roles/groups permission control
- “relaxed” and “strict” modes
- easy migration/conversion from 3.0
- LDAP/Active Directory role-mapping support



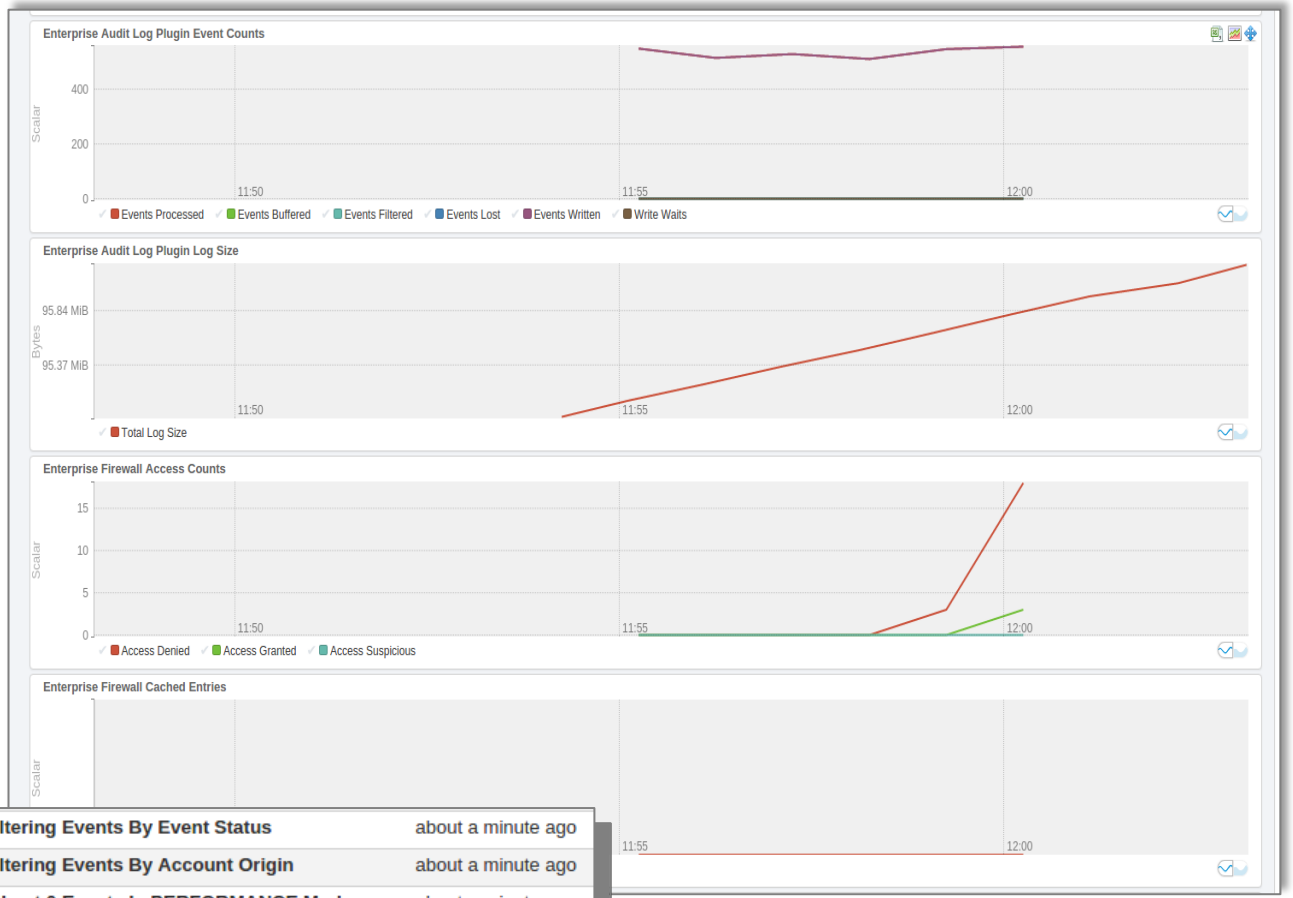
MEM 3.1: New Reports

- SYS Based File I/O Reports
  - IO By File
  - IO By Wait Type
  - IO By Thread
- SYS Based Lock Wait Reports
  - InnoDB Row Locks
  - Table MetaData Locks



MEM 3.1: 5.7 Support

- Metric collection and graphing for 5.7 variables
- Enterprise plugin integration
  - Enterprise Firewall
  - Enterprise Audit

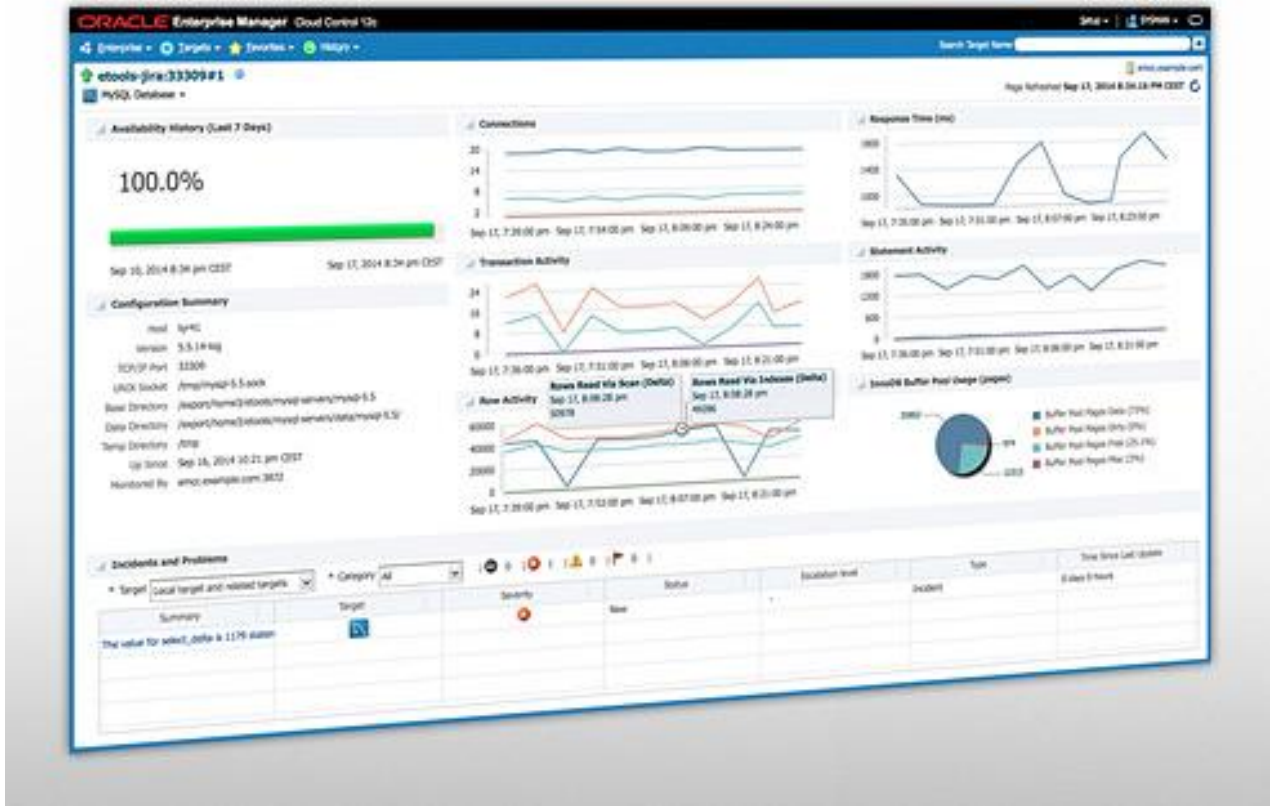


The Enterprise Audit Log Plugin is Filtering Events By Event Status	about a minute ago
The Enterprise Audit Log Plugin is Filtering Events By Account Origin	about a minute ago
The Enterprise Audit Log Plugin Has Lost 0 Events In PERFORMANCE Mode	about a minute ago
The Enterprise Audit Log Plugin Has Filtered 0 Events	about a minute ago
The Enterprise Audit Log Plugin is Experiencing 0% Write Waits	about a minute ago
The Enterprise Firewall is Installed and OFF.	about a minute ago
The Enterprise Firewall Has Detected 0 Suspicious Statements During The La...	2 minutes ago

Oracle Enterprise Manager for MySQL

New Version Available!

- MySQL 5.7 Support
- Enterprise Audit Support
- Enterprise Firewall Support

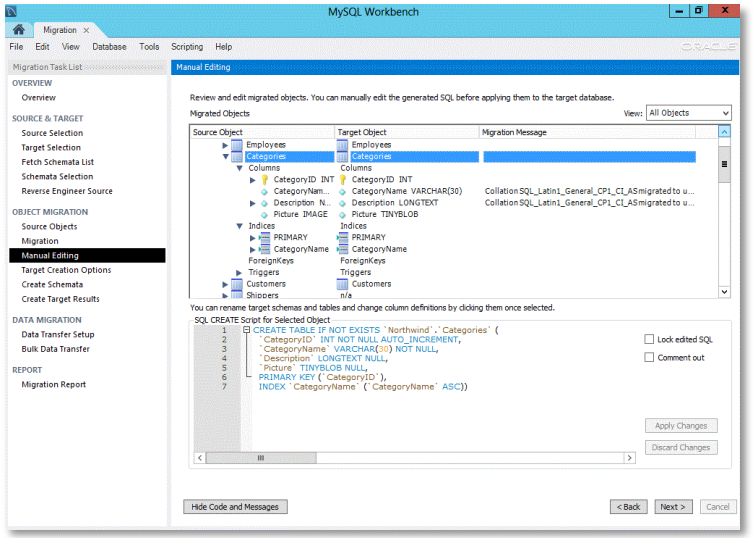


MEB 4.0: New Features

- Support for MySQL 5.7
  - General Tablespaces
- Improved SBT Backups to MMS Systems
  - OSB, TSM, NetBackup, NetWorker

MySQL Workbench 6.3

- Fabric
  - Add node, browse, view, connect
- Performance Dashboard
  - Performance Schema Reports & Graphs
- Visual Explain
- GIS Viewer
- Migration
  - New: Microsoft Access
  - Microsoft SQL Server, Sybase, PostgreSQL, SQLite



- New Easy to Use Wizards for
  - Fast Data Migration
  - Table<->File Data Import/Export (like Excel)
  - SSL Certificate Creation

MySQL on Windows

- MySQL Installer for Windows
- MySQL Workbench
- MySQL Migration Wizard
  - Microsoft SQL Server
  - Microsoft Access
- MySQL for Visual Studio
- MySQL for Excel
- MySQL Notifier
- MySQL Connector/.Net
- MySQL Connector/ODBC

MySQL Repos

- Distributions
  - Oracle, Red Hat, CentOS
  - Fedora
  - Ubuntu, Debian
  - SUSE
- Official MySQL Docker Image from Oracle
- Coming Soon
  - Preconfigured Containers
  - Improved support for popular DevOps deployment tools

https://dev.mysql.com/downloads/repo

MySQL on GitHub

- Git for MySQL Engineering
  - Fast, flexible and great for a distributed team
  - Great tooling
  - Large and vibrant community
- GitHub for MySQL Community
  - Easy and fast code availability to the community and to downstream projects
  - New Pull Requests

https://github.com/mysql

MySQL 5.7: Additional Info

- http://mysqlserverteam.com/whats-new-in-mysql-5-7-first-release-candidate/
- http://mysqlserverteam.com/json-labs-release-overview/
- http://mysqlserverteam.com/?s=query+rewrite
- http://mysqlserverteam.com/category/performance/optimizer/
- http://mysqlserverteam.com/category/innodb/
- http://mysqlserverteam.com/category/mysql/performance-schema/
- http://mysqlserverteam.com/category/gis/
- http://mysqlserverteam.com/category/full-text-search/
- http://mysqlserverteam.com/category/dictionary/
- http://dev.mysql.com/doc/refman/5.7/en/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