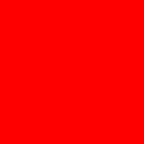




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MySQL Performance & Tuning

日本オラクル MySQL Global Business Unit
MySQL Sales Consulting Manager 梶山隆輔
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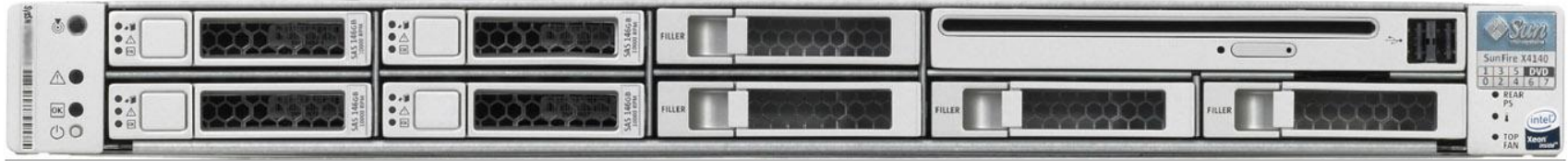
Agenda

- ***Overview***
- ***Hardware and Memory***
- ***Basics***
- ***Storage Engines***
- ***MySQL Server Tuning***
- ***Indexing***
- ***Query Tuning Rules***
- ***Schema***
- ***The New Stuff***
- ***What if I need more help?***

Overview

- ***Cover the main steps***
 - ***Show at least one example for each step***
 - ***Examples are things run into most commonly in the field***
 - ***Include links to MySQL manual for additional information***
- ***This will be technical***
- ***Most everything you need comes with MySQL!***
- ***You cannot become a performance tuning wizard in 45 minutes - PT Class is 4 day class***
http://www.mysql.com/training/courses/performance_tuning.html
- ***MySQL Performance Forum***
<http://forums.mysql.com/list.php?24>

Hardware: The Perfect MySQL Server



- ***The more cores the better (especially for 5.5 and later)***
- ***x86_64 - 64 bit for more memory is important***
 - ***The more the better***
- ***Linux or Solaris best, Windows and Unix also fine.***
- ***Fast HD (10-15k RPM SATA) or NAS/SAN.....***
 - ***RAID 10 for most, RAID 5 OK if very read intensive***
 - ***Hardware RAID battery backed up cache critical!***
 - ***More disks are always better! - 4+ recommended, 8-16 can increase IO***
- ***...Or SSD (for higher throughput)***
 - ***Intel, Fusion-IO good choices; good option for Slaves***
- ***At least 2 x NICs for redundancy***
- ***Slaves should be as powerful as the Master***

Basics

- The MySQL server is controlled by “System Variables”

```
mysql> show variables like 'auto%';
```

Variable_name	Value
auto_increment_increment	1
auto_increment_offset	1
autocommit	ON
automatic_sp_privileges	ON

```
4 rows in set (0.00 sec)
```

```
shell> mysqladmin -uroot -S /tmp/mysql.sock variables | grep auto
| auto_increment_increment          | 1
| auto_increment_offset             | 1
| autocommit                        | ON
| automatic_sp_privileges           | ON
```

- Set Via:
 - my.cnf / my.ini
 - SET [GLOBAL] <variable>=<value>
 - client, i.e mysql
 - Can be local (session) or global

Basics

- You monitor a system's performance using “**Status Variables**”

```
mysql> show status like 'innodb_buf%';
```

Variable_name	Value
Innodb_buffer_pool_pages_data	142
Innodb_buffer_pool_pages_dirty	0

```
shell> mysqladmin -uroot -S /tmp/mysql.sock extended
```

Variable_name	Value
Aborted_clients	0
Aborted_connects	0

```
- shell> mysqladmin -u -p ... ex -i 15 -r | grep -v ` 0 `
```

<http://dev.mysql.com/doc/refman/5.1/en/server-status-variables.html>

- Enable the slow query log

<http://dev.mysql.com/doc/refman/5.1/en/slow-query-log.html>

– Analyze using **mysqldumpslow**

Rules of Tuning

- ***Never make a change in production first***
- ***Have a good benchmark or reliable load***
- ***Start with a good baseline***
- ***Only change 1 thing at a time***
 - *identify a set of possible changes*
 - *try each change separately*
 - *try in combinations of 2, then 3, etc.*
- ***Monitor the results***
 - ***Query performance - query analyzer, slow query log, etc.***
 - *throughput*
 - *single query time*
 - *average query time*
 - ***CPU - top, vmstat***
 - ***IO - iostat, top, vmstat, bonnie++***
 - ***Network bandwidth***
- ***Document and save the results***

Where do I find a benchmark?

- **Make your own**
 - Can use general query log output
 - Could use MySQL Proxy and TCP Dump
- **DBT2**
 - <http://osdl.dbt.sourceforge.net/>
 - <http://samurai-mysql.blogspot.com/2009/03/settingup-dbt-2.html>
- **mysqlslap MySQL 5.1 +**
 - <http://dev.mysql.com/doc/refman/5.1/en/mysqlslap.html>
- **SysBench**
 - <http://sysbench.sourceforge.net/>
- **supersmack**
 - <http://vegan.net/tony/supersmack/>
- **mybench**
 - <http://jeremy.zawodny.com/mysql/mybench/>

A photograph of a complex industrial piping system. In the foreground, a series of bright yellow pipes run horizontally, connected by flanges and valves. To the right, a more intricate network of blue pipes curves upwards and outwards, also featuring flanges and valves. The background shows a large industrial facility with structural beams and other piping, suggesting a power plant or refinery environment.

MySQL Storage Engines

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MySQL Supports Multiple Storage Engines

- **Selecting the storage engine to use *is a tuning decision***



```
mysql> SHOW TABLE STATUS like 'Tommy%'\G
***** 1. row *****
```

```
      Name: TommyTest
      Engine: InnoDB
```

```
mysql> ALTER TABLE TommyTest ENGINE=MyISAM;
Query OK, 0 rows affected (0.40 sec)
Records: 0  Duplicates: 0  Warnings: 0
```

```
mysql> SHOW TABLE STATUS like 'Tommy%'\G
***** 1. row *****
```

```
      Name: TommyTest
      Engine: MyISAM
```

InnoDB

- *Transactional and fully ACID compliant*
- *Behavior most like traditional databases such as Oracle, DB2, SQL Server, etc.*
- *Before 5.5 - data size 2-3 x MyISAM; not with 5.5!!*
- *MVCC = Non-blocking reads in most cases*
- *Fast, reliable recovery from crashes with zero committed data loss*
- ***Always*** *clustered on the primary key*
 - *Lookups by primary key, very fast*
 - *Range scans on primary key also very fast*
 - *Important to keep primary key small*

MyISAM

- ***Formerly the faster read only engine***
 - *Most web applications*
 - *Perfect for web search databases*
 - *80/20 read/modify or higher*
 - *pure inserts and deletes with partitions or merge engine*
 - *no transactions or foreign key support*
 - *reporting DB/ Data Warehouse*
- ***Most compact data of all non-compressed engines***
- ***Table locking***
- ***Not ACID compliant, non-transactional***
- ***Supports concurrent inserts***
- ***Full-Text and Geospatial support***

A low-angle, upward-looking photograph of two modern skyscrapers. The building on the left is a glass curtain wall, reflecting the sky and the other building. The building on the right has a dark, vertically-ribbed facade. The sky is a pale, overcast grey.

MySQL Server Tuning

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InnoDB Tuning

- ***Unlike MyISAM - InnoDB uses a single cache for both index and data***
 - ***`innodb_buffer_pool_size`** - should be 70-80% of available memory.*
 - *It is not uncommon for this to be very large, i.e. 44GB on a system with 40GB of memory*
 - *Make sure its not set so large as to cause swapping!*
 - *`mysql>show status like 'Innodb_buffer%' ;`*
- ***InnoDB can use direct IO on systems that support it - Linux, FreeBSD, and Solaris***
 - ***`innodb_flush_method = O_DIRECT`***
- ***For more InnoDB tuning see***
<http://dev.mysql.com/doc/refman/5.1/en/innodb-tuning-troubleshooting.html>

Cache hot application data in memory

DBT-2 (W200)	Transactions per Minute	%user	%iowait
Buffer pool 1G	1125.44	2%	30%
Buffer pool 2G	1863.19	3%	28%
Buffer pool 5G	4385.18	5.5%	33%
Buffer pool 30G (All data in cache)	36784.76	36%	8%

- ***DBT-2 benchmark (write intensive)***
- ***20-25GB hot data (200 warehouses, running 1 hour)***
- ***Nehalem 2.93GHz x 8 cores, MySQL 5.5.2, 4 RAID1+0 HDDs***
- ***RAM size affects everything. Not only for SELECT, but also for INSERT/UPDATE/DELETE***
 - ***INSERT: Random reads/writes happen when inserting into indexes in random order***
 - ***UPDATE/DELETE: Random reads/writes happen when modifying records***

MyISAM Tuning

- *The primary tuning factors in MyISAM are its two caches:*
 - ***key_buffer_cache** - should be 25% of available memory*
 - *system cache - leave 75% of available memory free*
- *Available memory is:*
 - *All on a dedicated server, if the server has 8GB, use 2GB for the **key_buffer_cache** and leave the rest free for the system cache to use.*
 - *Percent of the part of the server allocated for MySQL, i.e. if you have a server with 8GB, but are using 4GB for other applications then use 1GB for the **key_buffer_cache** and leave the remaining 3GB free for the system cache to use.*
- *You can define multiple key buffer's*
- *You can pre-load the key buffers*
- *For more details on configuring the MyISAM key cache see:*
<http://dev.mysql.com/doc/refman/5.1/en/myisam-key-cache.html>

Monitoring the MyISAM Key Buffer Cache

```
mysql> SHOW STATUS like 'key%';
+-----+-----+
| Variable_name      | Value |
+-----+-----+
| Key_blocks_not_flushed | 0      | Dirty key blocks not flushed to disk
| Key_blocks_unused    | 28995  | Unused blocks in the cache
| Key_blocks_used      | 0      | Used blocks in the cache
| Key_read_requests    | 0      | Key read requests to the cache
| Key_reads            | 0      | times a key read request went to disk
| Key_write_requests   | 0      | Key write requests to the cache
| Key_writes           | 0      | times key write request went to disk
+-----+-----+
7 rows in set (0.00 sec)
```

- **% of cache free** : $\text{Key_blocks_unused} / (\text{Key_blocks_unused} + \text{Key_blocks_used})$
- **Cache read hit %** : $\text{Key_reads} / \text{Key_read_requests}$
- **Cache write hit %** : $\text{Key_writes} / \text{Key_write_request}$
- **cat /proc/meminfo to see the system cache in Linux**
 - **MemFree + Cached = memory available for system cache**

Connections

- **MySQL Caches the threads used by a connection**
 - *thread_cache_size* - Number of threads to cache
 - Setting this to 100 or higher is not unusual
- **Monitor *Threads_created* to see if this is an issue**
 - Counts connections not using the thread cache
 - Should be less than 1-2 a minute
 - Usually only an issue if more than 1-2 a second
- **Only an issue if you create and drop a lot of connections, i.e. PHP**
- **Overhead is usually about 250k per thread**
- ***Aborted_clients* -**
<http://dev.mysql.com/doc/refman/5.1/en/communication-errors.html>
- ***Aborted_connections* -**
<http://dev.mysql.com/doc/refman/5.1/en/communication-errors.html>

Sessions

- **Some session variables control space allocated by each session (connection)**
 - Setting these to small can give bad performance
 - **Setting these too large can cause the server to swap!**
 - Can be set by connection
 - `SET SORT_BUFFER_SIZE=1024*1024*128`
 - Set small by default, increase in connections that need it
- **`sort_buffer_size` - Used for ORDER BY, GROUP BY, SELECT DISTINCT, UNION DISTINCT**
 - Monitor **`Sort_merge_passes`** < 1-2 an hour optimal
 - Usually a problem in a reporting or data warehouse database
- **Other important session variables**
 - `read_rnd_buffer_size` - Set to 1/2 `sort_buffer_size`
 - `join_buffer_size` - (BAD) Watch **`Select_full_join`**
 - `read_buffer_size` - Used for full table scans, watch **`Select_scan`**
 - `tmp_table_size` - Max temp table size in memory, watch **`Created_tmp_disk_tables`**

Query Cache

- **MySQL's 'Jekyll and Hyde' of performance tuning options, when it is useful it really helps, when it hurts, it really hurts**
- **MySQL Query Cache caches both the query and the full result set**
 - *query_cache_type* - Controls behavior
 - 0 or OFF - Not used (buffer may still be allocated)
 - 1 or ON cache all unless *SELECT SQL_NO_CACHE* (DEFAULT)
 - 2 or DEMAND cache none unless *SELECT SQL_CACHE*
 - *query_cache_size* - Determines the size of the cache
- **`mysql> show status like 'Qc%' ;`**
- **Gives great performance if:**
 - Identical queries returning identical data are used often
 - No or rare inserts, updates or deletes
- **Best Practice**
 - Set to *DEMAND*
 - Add *SQL_CACHE* to appropriate queries



Indexing

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Indexes in MySQL

- *Indexes allow for faster access to data*
- *Data accessed via an index is usually in sorted order*
- *Unique or Primary - Must refer to only one record*
- *Non-Unique - May refer to many records*
- *Can be on one or more columns*
 - *CREATE INDEX IDX ON TAB1 (col1,col2,col3) ;*
- *Can use prefix index for*
 - *CHAR, VARCHAR, BINARY, and VARBINARY*
 - *CREATE INDEX PRE ON TAB1 (COL1(10)) ;*
 - *Prefix is in bytes, not characters*
 - *Very useful for large strings*
 - *Works best when leading part of column is selective*

How Indexes are Used - Filter

- *You can use indexes to improve the access to filter data*
 - *SELECT * FROM TAB WHERE CITY= 'MIAMI' ;*
- *A filter Index returns, zero, one or more records*
 - *Usually zero or one for a unique or primary index*
 - *Zero, one, or more for a non-unique index*
- *If there is no ORDER BY clause then the data is returned in the order of the index*
- *The index will not be used if:*
 - *The table only has a few rows*
 - *The total number of rows is more than ~10% of the table*
 - *It is faster to do a full table scan without the index*

How Indexes are Used - Join

- *Indexes speed up joins*
 - *SELECT X.A, Y.B FROM X,Y*
 - *WHERE X.C = 'FL' and Y.A = X.A ;*
- *The Filter is on column C of table X*
 - *Table X needs an index on column C for the filter*
- *Table Y is joined to table X by column A*
 - *Table Y needs an index on column A*
- *MySQL reads each row of table X using the index on X.C with a value of 'FL'*
- *MySQL then uses the index on Y.A to join Y to A*
- *Optimizer may chose other path ...*

How Indexes are Used - Sort (not for HASH index)

- *MySQL can use indexes to speed up some ORDER BY operations*
- *SELECT Name from TAB1 ORDER By NAME*
 - *An Index on name can be used for the sort*
- *SELECT NAME FROM TAB WHERE NAME BETWEEN 'AAA' and 'CCC' ORDER By NAME ;*
 - *An index on name can still be used for the order by*
- *SELECT NAME FROM TAB WHERE NAME CITY = 'MIAMI' ORDER By NAME ;*
 - *You cannot use the NAME index for the order by.*
 - *Requires a sort.*
- *Sometimes a sort is faster than an index scan*

Index Best Practices

- ***Too many indexes can slow down inserts/deletes***
 - *Use only the indexes you must have*
 - *Check often*
 - *mysql>show create table tabname ;*
- ***Don't duplicate leading parts of compound keys***
 - *index key123 (col1,col2,col3)*
 - *index key12 (col1,col2) <- Not needed!*
 - *index key1 (col1) <-- Not needed!*
- ***Use prefix indexes on large keys***
- ***Best indexes are 16 bytes/chars or less***
- ***Indexes bigger than 32 bytes/chars should be looked at very closely***
 - *should have there own cache if in MyISAM*
- ***For large strings that need to be indexed, i.e. URLs, consider using a separate column using the MySQL MD5 to create a hash key and index on it instead***

Explain

- ***Order that the tables are accessed***
- ***Indexes used***
- ***Estimated number of rows accessed per table***
- *select C.Name, Y.Name, Y.Population, Language from Country as C, City as Y, CountryLanguage as L where Y.Name = C.Name and L.CountryCode = Y.CountryCode and C.Name = 'Macao' ;*

```
explain select C.Name, Y.Name, Y.Population, Language from Country as C, City as Y, CountryLanguage as L where Y.Name = C.Name and L.CountryCode = Y.CountryCode and C.Name = 'Macao' ;
```

```
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| id | select_type | table | type | possible_keys | key      | key_len | ref              | rows | Extra              |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| 1 | SIMPLE      | C      | ALL  | NULL          | NULL     | NULL    | NULL             | 239 | Using where        |
| 1 | SIMPLE      | Y      | ALL  | NULL          | NULL     | NULL    | NULL             | 4079 | Using where; Using join buffer |
| 1 | SIMPLE      | L      | ref  | PRIMARY       | PRIMARY  | 3       | world.Y.CountryCode | 9 | Using index        |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
3 rows in set (0.00 sec)
```

(Using the MySQL World database)

Explain - Details

- ***Tables are accessed from top to bottom***
- ***Columns***
 - ***Select Type - SELECT if no Union or Subquery***
 - ***Table, uses aliases***
 - ***Type - Most common ref or eq_ref***
 - ***Possible Keys - Indexes the optimizer is considering***
 - ***Key = The index the optimizer chose***
 - ***Ref - What column in what table (using alias) is referenced by the index***
 - ***Rows - Estimated number of rows per reference***
 - ***Multiple these to get overall cost***
- ***There are more values, see:***

<http://dev.mysql.com/doc/refman/5.1/en/using-explain.html>

More Explain

- *alter table Country add index c2 (Name) ;*
- *alter table City add index c2 (Name) ;*

```
mysql> explain select C.Name, Y.Name, Y.Population, Language from Country as C, City as Y, CountryLanguage as L where Y.Name = C.Name and L.CountryCode = Y.CountryCode and C.Name = 'Macao' ;
```

id	select_type	table	type	possible_keys	key	key_len	ref	rows	Extra
1	SIMPLE	C	ref	c2	c2	52	const	1	Using where; Using index
1	SIMPLE	Y	ref	c2	c2	35	const	1	Using where
1	SIMPLE	L	ref	PRIMARY	PRIMARY	3	world.Y.CountryCode	9	Using index

3 rows in set (0.00 sec)

- *The original cost was $239 * 4079 * 9 = 8,773,929$*
- *The new cost is $1 * 1 * 9 = 9$*

Query Tuning Rules

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Queries I

- **Often the # 1 issue in overall performance**
- **Always, Always have your slow query log on!**
 - <http://dev.mysql.com/doc/refman/5.1/en/slow-query-log.html>
 - Use: *log_queries_not_using_indexes*
 - Check it regularly
 - Use *mysqldumpslow*:
<http://dev.mysql.com/doc/refman/5.1/en/mysqldumpslow.html>
 - Best practice is to automate running *mysqldumpslow* every morning and email results to DBA, DBDev, etc.
- **Understand and use EXPLAIN**
 - <http://dev.mysql.com/doc/refman/5.1/en/using-explain.html>
- **Select_scan** - Number of full table scans
- **Select_full_join** - Joins without indexes
- **MySQL Query Analyzer**
 - <http://www.mysql.com/products/enterprise/query.html>

Queries II

- ***The IN clause in MySQL is very fast!***
 - *Select ... Where idx IN(1,23,345,456)*
 - *Much faster than a join*
 - *Tests with 80,000 items in the in list have been done*
 - *1,000-2,000 not unusual*
- ***Don't wrap your indexes in expressions in Where***
 - *Select ... Where func(idx) = 20 [index ignored]*
 - *Select .. Where idx = otherfunc(20) [may use index]*
 - *Best practice : Keep index alone on left side of condition*
- ***Avoid % at the start of LIKE on an index***
 - *Select ... Where idx LIKE('ABC%') can use index*
 - *Select ... Where idx LIKE('%XYZ') must do full table scan*
- ***Use UNION ALL when appropriate; default is UNION DISTINCT!***
- ***Understand left/right joins and use only when needed***

<http://dev.mysql.com/doc/refman/5.1/en/query-speed.html>

A close-up photograph of a person's hands holding a black smartphone. The person is wearing a grey suit jacket. The background is blurred. A red banner is overlaid on the left side of the image, and a white box with black and red text is on the right.

Schema

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Schemas

- **Size = performance, smaller is better**
 - **Size right! Do not automatically use 255 for VARCHAR**
 - Temp tables, most caches, expand to full size
- **Use “procedure analyse” to determine the optimal types given the values in your table**
 - <http://dev.mysql.com/doc/refman/5.1/en/procedure-analyse.html>
 - *mysql> select * from tab procedure analyse (64,2000) YG*
- **Consider the types:**
 - **enum** : <http://dev.mysql.com/doc/refman/5.1/en/enum.html>
 - **set** : <http://dev.mysql.com/doc/refman/5.1/en/set.html>
- **Compress large strings**
 - **Use the MySQL COMPRESS and UNCOMPRESS functions**
 - **Very important in InnoDB pre 5.5, now with barracuda not so bad**



**The NEW Stuff,
Making DBA Life EASIER!**

MySQL 5.5 Performance Schema

- **PERFORMANCE_SCHEMA** presents low level MySQL performance information
- Data can be cleared
- Filters with **WHERE** are allowed
- Must be enabled with **--performance_schema**

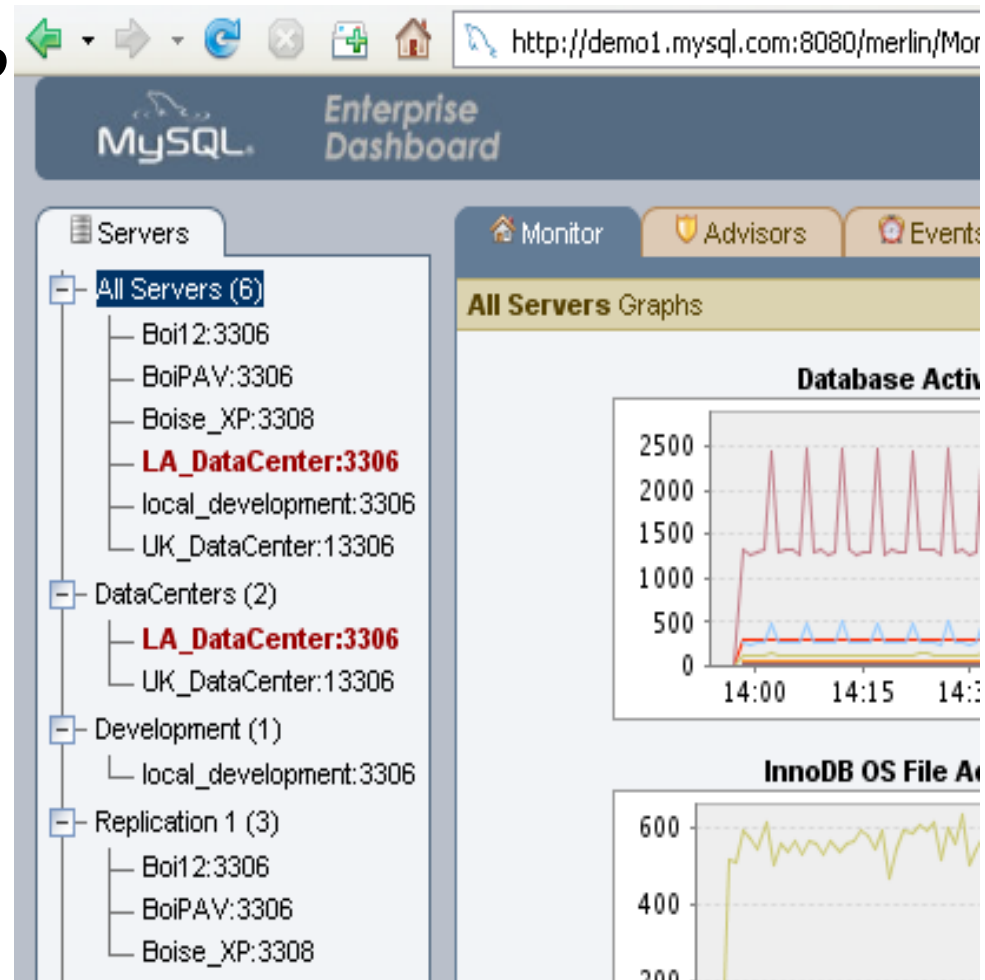
```
mysql> SELECT EVENT_ID, EVENT_NAME, TIMER_WAIT
-> FROM EVENTS_WAITS_HISTORY WHERE THREAD_ID = 13
-> ORDER BY EVENT_ID;
```

EVENT_ID	EVENT_NAME	TIMER_WAIT
86	wait/synch/mutex/mysys/THR_LOCK::mutex	686322
87	wait/synch/mutex/mysys/THR_LOCK_malloc	320535
88	wait/synch/mutex/mysys/THR_LOCK_malloc	339390
89	wait/synch/mutex/mysys/THR_LOCK_malloc	377100
90	wait/synch/mutex/sql/LOCK_plugin	614673
91	wait/synch/mutex/sql/LOCK_open	659925
92	wait/synch/mutex/sql/THD::LOCK_thd_data	494001
93	wait/synch/mutex/mysys/THR_LOCK_malloc	222489
94	wait/synch/mutex/mysys/THR_LOCK_malloc	214947
95	wait/synch/mutex/mysys/LOCK_alarm	312993

```
mysql> UPDATE SETUP_INSTRUMENTS
-> SET ENABLED = 'NO'
-> WHERE NAME = 'wait/synch/mutex/myisammrg/MYRG_INFO::mutex';
mysql> UPDATE SETUP_CONSUMERS
-> SET ENABLED = 'NO' WHERE NAME = 'file_summary_by_instance';
```

MySQL Enterprise Monitor

- ***Single, consolidated view into entire MySQL environment***
- ***Auto-discovery of MySQL servers, replication topologies***
- ***Customizable rules-based monitoring and alerts***
- ***Query monitoring and analysis***
- ***Identifies problems before they occur***
- ***Reduces risk of downtime***
- ***Makes it easier to scale out without requiring more DBAs***



A Virtual MySQL DBA Assistant!

Learn More: Resources

- **View MySQL Essentials Webinars (Part 1 – Part 7)**
<http://mysql.com/news-and-events/web-seminars/mysql-essentials.html>
- **MySQL Training Course – MySQL Performance Tuning**
http://education.oracle.com/pls/web_prod-plq-dad/db_pages.getCourseDesc?dc=D61820GC10&p_org_id=1001
- **MySQL Performance Forum**
<http://forums.mysql.com/list.php?24>
- **Download MySQL 5.5**
<http://www.mysql.com/downloads/mysql/>
- **Download Free MySQL White Papers**
<http://dev.mysql.com/why-mysql/white-papers/>
- **Try MySQL Enterprise Edition (including MySQL Enterprise Monitor):**
<http://www.mysql.com/trials/>



Hardware and Software

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