MySQL Performance & Tuning

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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](http://www.mysql.com/training/courses/performance_tuning.html)

- **MySQL Performance Forum**
  
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”

```sql
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
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`

```shell
+----------------+----------+
| Variable_name   | Value    |
|----------------+----------|
| Aborted_clients | 0        |
| Aborted_connects| 0        |
```

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


- Enable the slow query log
  - 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
Were do I find a benchmark?

• Make your own
  – Can use general query log output
  – Could use MySQL Proxy and TCP Dump
• DBT2
  – http://osdldbtt.sourceforge.net/
• mysqlslap MySQL 5.1 +
• SysBench
  – http://sysbench.sourceforge.net/
• supersmack
  – http://vegan.net/tony/supersmack/
• mybench
  – http://jeremy.zawodny.com/mysql/mybench/
MySQL Supports Multiple Storage Engines

- Selecting the storage engine to use is a tuning decision

```sql
mysql> SHOW TABLE STATUS like 'Tommy%'
+-----------------------------+----------+------------------+
| Name: TommyTest             | Engine:  |
|                             | InnoDB   |
+-----------------------------+----------+------------------+
```

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

```sql
mysql> SHOW TABLE STATUS like 'Tommy%'
+-----------------------------+----------+------------------+
| 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
MySQL Server Tuning
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 STATUSlike '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
Cache hot application data in memory

<table>
<thead>
<tr>
<th>DBT-2 (W200)</th>
<th>Transactions per Minute</th>
<th>%user</th>
<th>%iowait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer pool 1G</td>
<td>1125.44</td>
<td>2%</td>
<td>30%</td>
</tr>
<tr>
<td>Buffer pool 2G</td>
<td>1863.19</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>Buffer pool 5G</td>
<td>4385.18</td>
<td>5.5%</td>
<td>33%</td>
</tr>
<tr>
<td>Buffer pool 30G (All data in cache)</td>
<td>36784.76</td>
<td>36%</td>
<td>8%</td>
</tr>
</tbody>
</table>

- **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](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           |
| Key_blocks_unused        | 28995       |
| Key_blocks_used         | 0           |
| Key_read_requests      | 0           |
| Key_reads             | 0           |
| Key_write_requests    | 0           |
| Key_writes           | 0           |
+----------------+-------------+
7 rows in set (0.00 sec)
```

- % of cache free: \( \frac{\text{Key\_blocks\_unused}}{\text{Key\_blocks\_unused} + \text{Key\_blocks\_used}} \)
- Cache read hit %: \( \frac{\text{Key\_reads}}{\text{Key\_read\_requests}} \)
- Cache write hit %: \( \frac{\text{Key\_writes}}{\text{Key\_write\_request}} \)
- `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** -

- **Aborted_connections** -
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
    - \texttt{SET SORT\_BUFFER\_SIZE=1024*1024*128}
  - Set small by default, increase in connections that need it

- \texttt{sort\_buffer\_size} - Used for ORDER BY, GROUP BY, SELECT DISTINCT, UNION DISTINCT
  - Monitor \texttt{Sort\_merge\_passes < 1-2 an hour optimal}
  - Usually a problem in a reporting or data warehouse database

- Other important session variables
  - \texttt{read\_rnd\_buffer\_size} - Set to 1/2 \texttt{sort\_buffer\_size}
  - \texttt{join\_buffer\_size} - (BAD) Watch \texttt{Select\_full\_join}
  - \texttt{read\_buffer\_size} - Used for full table scans, watch \texttt{Select\_scan}
  - \texttt{tmp\_table\_size} - Max temp table size in memory, watch \texttt{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
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**

```
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' ;
```

```
+----+----------+------+----------+------------+-------+-------+-------------------+------+------+-------+
<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>C</td>
<td>ALL</td>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>239</td>
<td>Using where</td>
</tr>
<tr>
<td>1</td>
<td>SIMPLE</td>
<td>Y</td>
<td>ALL</td>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>NULL</td>
<td>4079</td>
<td>Using where; Using join buffer</td>
</tr>
<tr>
<td>1</td>
<td>SIMPLE</td>
<td>L</td>
<td>ref</td>
<td>PRIMARY</td>
<td>PRIMARY</td>
<td>3</td>
<td>world.Y.CountryCode</td>
<td>9</td>
<td>Using index</td>
</tr>
</tbody>
</table>
```

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:**

More Explain

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

```sql
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';
```

<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>C</td>
<td>ref</td>
<td>c2</td>
<td>c2</td>
<td>52</td>
<td>const</td>
<td>1</td>
<td>Using where; Using index</td>
</tr>
<tr>
<td>1</td>
<td>SIMPLE</td>
<td>Y</td>
<td>ref</td>
<td>c2</td>
<td>c2</td>
<td>35</td>
<td>const</td>
<td>1</td>
<td>Using where</td>
</tr>
<tr>
<td>1</td>
<td>SIMPLE</td>
<td>L</td>
<td>ref</td>
<td>PRIMARY</td>
<td>PRIMARY</td>
<td>3</td>
<td>world.Y.CountryCode</td>
<td>9</td>
<td>Using index</td>
</tr>
</tbody>
</table>

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
Queries I

- Often the # 1 issue in overall performance

- **Always, Always have your slow query log on!**
  
  
  - Use: `log_queries_not_using_indexes`
  
  - Check it regularly
  
  - Use `mysqldumpslow`:
    
  
  - Best practice is to automate running `mysqldumpslow` every morning and email results to DBA, DBDev, etc.

- **Understand and use EXPLAIN**


- `Select_scan` - Number of full table scans

- `Select_full_join` - Joins without indexes

- **MySQL Query Analyzer**

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**

Schema
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**
  - `mysql> select * from tab procedure analyse (64,2000) YG`

- **Consider the types:**

- **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`.

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

```
+----------+-----------------+-----------+
<table>
<thead>
<tr>
<th>EVENT_ID</th>
<th>EVENT_NAME</th>
<th>TIMER_WAIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>86</td>
<td>wait/synch/mutex/mysys/THR_LOCK::mutex</td>
<td>686322</td>
</tr>
<tr>
<td>87</td>
<td>wait/synch/mutex/mysys/THR_LOCK_malloc</td>
<td>320535</td>
</tr>
<tr>
<td>88</td>
<td>wait/synch/mutex/mysys/THR_LOCK_malloc</td>
<td>339390</td>
</tr>
<tr>
<td>89</td>
<td>wait/synch/mutex/mysys/THR_LOCK_malloc</td>
<td>377100</td>
</tr>
<tr>
<td>90</td>
<td>wait/synch/mutex/sql/LOCK_plugin</td>
<td>614673</td>
</tr>
<tr>
<td>91</td>
<td>wait/synch/mutex/sql/LOCK_open</td>
<td>659925</td>
</tr>
<tr>
<td>92</td>
<td>wait/synch/mutex/sql/THD::LOCK_thd_data</td>
<td>494001</td>
</tr>
<tr>
<td>93</td>
<td>wait/synch/mutex/mysys/THR_LOCK_malloc</td>
<td>222489</td>
</tr>
<tr>
<td>94</td>
<td>wait/synch/mutex/mysys/THR_LOCK_malloc</td>
<td>214947</td>
</tr>
<tr>
<td>95</td>
<td>wait/synch/mutex/mysys/LOCK_alarm</td>
<td>312993</td>
</tr>
</tbody>
</table>
```

```
UPDATE SETUP_INSTRUMENTS
SET ENABLED = 'NO'
WHERE NAME = 'wait/synch/mutex/myisammrg/MYRG_INFO::mutex';
```

```
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)

• MySQL Training Course – MySQL Performance Tuning

• MySQL Performance Forum

• 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
Engineered to Work Together