MySQL Server and SQL 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 I 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
Perfect Hardware?

- Pre 5.5 – No real scale up
- Now with 5.5 we scale up into 64 cores
- x86_64 - 64 bit for more memory is important
- Linux or Solaris best, Windows and Unix also fine
- Big gains on Windows with 5.5
- 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 performance if needed
- Memory should be at least 1/3 to 1/10 data size
  - The more, the better
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)
```

- 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"

```shell
mysql> show status like 'innodb_buf%';
+----------------+--------+
| Variable_name  | Value  |
|----------------+--------+
| Innodb_buffer_pool_pages_data | 142    |
| Innodb_buffer_pool_pages_dirty | 0      |
```

```shell
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 ' 


- 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
- mysqlslap MySQL 5.1 +
- SysBench
- supersmack
  - [http://vegan.net/tony/supersmack/](http://vegan.net/tony/supersmack/)
- mybench
MySQL Storage Engines
MySQL Supports Multiple Storage Engines

- Selecting the storage engine to use is a tuning decision

```sql
mysql> SHOW TABLE STATUS like 'Tommy%'
+-----------------------------+-----------------------------+
<table>
<thead>
<tr>
<th>Name</th>
<th>Engine</th>
<th>Engine</th>
<th>Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>TommyTest</td>
<td>InnoDB</td>
<td>MyISAM</td>
<td>NDB</td>
</tr>
</tbody>
</table>

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%'
+-----------------------------+-----------------------------+
<table>
<thead>
<tr>
<th>Name</th>
<th>Engine</th>
<th>Engine</th>
<th>Engine</th>
</tr>
</thead>
<tbody>
<tr>
<td>TommyTest</td>
<td>MyISAM</td>
<td>MyISAM</td>
<td>More..</td>
</tr>
</tbody>
</table>
```
InnoDB

- Transactional and fully ACID compliant
- Behavior most like traditional databases such as Oracle, DB2, SQL Server, etc.
- Data size is normally 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
  - Non-Primary key lookups use the primary key to find the record, this means 2 key lookups
  - 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
  - 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

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 it's 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
Cache hot application data in memory

<table>
<thead>
<tr>
<th>Buffer pool</th>
<th>Transactions per Minute</th>
<th>%user</th>
<th>%iowait</th>
</tr>
</thead>
<tbody>
<tr>
<td>1G</td>
<td>1125.44</td>
<td>2%</td>
<td>30%</td>
</tr>
<tr>
<td>2G</td>
<td>1863.19</td>
<td>3%</td>
<td>28%</td>
</tr>
<tr>
<td>5G</td>
<td>4385.18</td>
<td>5.5%</td>
<td>33%</td>
</tr>
<tr>
<td>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:
  
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: `Key_blocks_unused / (Key_blocksUnused + Key_blocks_used)`
- Cache read hit %: `Key_reads / Key_read_requests`
- Cache write hit %: `Key_writes / 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 that 1-2 a minute
  - Usually only an issue if more than 1-2 a second
- Only an issue is 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
    - `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

- See
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

```sql
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)
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) ;

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 $239 \times 4079 \times 9 = 8,773,929$
- The new cost is $1 \times 1 \times 9 = 9$
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
  - I have done tests with 80,000 items in the in list
    - 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) \G
- **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**

```sql
mysql> SELECT EVENT_ID, EVENT_NAME, TIMER_WAIT
| 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     |
```

```sql
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!
Demo Time
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/
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