# 10x Performance Improvements in 10 steps

# A Case Study

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# Application

**Typical Web 2.0 social media site (Europe based)**

- Users  - Visitors, Free Members, Paying Members
- Friends
- User Content - Video, Pictures
- Forums, Chat, Email

# Server Environment

- 1 Master Database Server  (MySQL 5.0.x)
- 3 Slave Database Servers (MySQL 5.0.x)
- 5 Web Servers  (Apache/PHP)
- 1 Static Content Server (Nginx)
- 1 Mail Server

Step 1

# Monitor, Monitor, Monitor

# 1. Monitor, Monitor, Monitor

- What's happened?
- What's happening now?
- What's going to happen?

**Past, Present, Future**

# 1. Monitor, Monitor, Monitor


**Monitoring Software**

- Installation of Cacti - http://www.cacti.net/
- Installation of MySQL Cacti Templates - http://code.google.com/p/mysql-cacti-templates/
- (Optional) Installation of MONyog - http://www.webyog.com/

# 1. Monitor, Monitor, Monitor

Action 2

**Custom Dashboard**

- Most important - The state of NOW
- Single Page Alerts - GREEN YELLOW RED

# Database Servers

host - Load Avg (1m*,5m,15m)/ Ping (min/avg*/max/div) / DB Connections (con*,idle*,query*,locked*) / Slave Status (IO,SQL

| Masters | | Slaves | |
|---|---|---|---|
| db1 | sy:0.87 (22s),0.133, db:[34,25,2,0] (4s),0, | slave1 | sy:1.78 (18s),0.148, db:[11,7,1,0] (1s),0, |
| db2 | sy:0.00 (20s),0.252, db:[6,1,1,0] (2s),0, | slave2 | sy:0.26 (15s),0.090, db:[12,8,1,0] (0s),0, |
| dbmon | sy:0.33 (11s),0.019, db:[18,16,1,0] (5s), | slave3 | sy:1.06 (13s),0.142, db:[14,10,1,0] (6s),0, |

# Members Pages

Members Pages from www.example.com - location user (load time, size), non-location user (load time, size)
www.example.com m:0.088s, 84K, 2-3-0.0744 0.152s, 76K, 3-3-0.1293 (2s),

# Web Servers

WWW Server Status (Requests, Requests Per Sec) / index.htm (load time, size)
www1 w:, (10s), i:0.089s, 36K, 0-1-0.0666 (10s),
www2 w:, (8s), i:0.063s, 36K, 0-1-0.0472 (8s),
www3 w:, (6s), i:0.054s, 36K, 0-1-0.0386 (6s),
www4 w:, (4s), i:0.049s, 36K, 0-1-0.0357 (4s),
www5 w:, (2s), i:0.050s, 36K, 0-1-0.0359 (2s),

**Dashboard Example**

# 1. Monitor, Monitor, Monitor

Action 3

**Alerting Software**

- Installation of Nagios - http://www.nagios.org/
- MONyog also has some DB specific alerts

# 1. Monitor, Monitor, Monitor

Action 4

**Application Metrics**

- Total page generation time

Step 2

# Identify problem SQL

# 2. Identify Problem SQL

**Identify SQL Statements**

- Slow Query Log
- Processlist
- Binary Log
- Status Statistics

# 2. Identify Problem SQL

**Problems**

- Sampling
- Granularity

**Solution**

- tcpdump + mk-query-digest

# 2. Identify Problem SQL


- Install maatkit - http://www.maatkit.org
- Install OS tcpdump  (if necessary)
- Get sudo access to tcpdump

http://ronaldbradford.com/blog/take-a-look-at-mk-query-digest-2009-10-08/

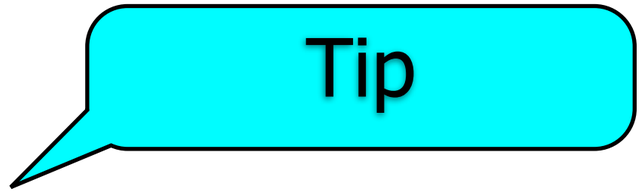
| # Rank | Query ID | Response time | | Calls | R/Call | Item |
|---|---|---|---|---|---|---|
| # 1 | 0xB8CE56EEC1A2FBA0 | 14.0830 | 26.8% | 78 | 0.180552 | SELECT c u |
| # 2 | 0x195A4D6CB65C4C53 | 6.7800 | **12.9%** | **257** | **0.026381** | **SELECT u** |
| # 3 | 0xCD107808735A693C | 3.7355 | 7.1% | 8 | 0.466943 | SELECT c u |
| # 4 | 0xED55DD72AB650884 | 3.6225 | 6.9% | 77 | 0.047046 | SELECT u |
| # 5 | 0xE817EFFFF5F6FFFD | 3.3616 | 6.4% | 147 | 0.022868 | SELECT UNION c |
| # 6 | 0x15FD03E7DB5F1B75 | 2.8842 | 5.5% | 2 | 1.442116 | SELECT c u |
| # 7 | 0x83027CD415FADB8B | 2.8676 | 5.5% | 70 | 0.040965 | SELECT c u |
| # 8 | 0x1577013C472FD0C6 | 1.8703 | 3.6% | 61 | 0.030660 | SELECT c |
| # 9 | 0xE565A2ED3959DF4E | 1.3962 | 2.7% | 5 | 0.279241 | SELECT c t u |
| # 10 | 0xE15AE2542D98CE76 | 1.3638 | 2.6% | 6 | 0.227306 | SELECT c |
| # 11 | 0x8A94BB83CB730494 | 1.2523 | 2.4% | 148 | 0.008461 | SELECT hv u |
| # 12 | 0x959C3B3A967928A6 | 1.1663 | 2.2% | 5 | 0.233261 | SELECT c t u |
| # 13 | 0xBC6E3F701328E95E | 1.1122 | 2.1% | 4 | 0.278044 | SELECT c t u |

```
# Query 2: 4.94 QPS, 0.13x concurrency, ID 0x195A4D6CB65C4C53 at byte 4851683
# This item is included in the report because it matches --limit.
#              pct   total     min     max     avg     95%  stddev  median
# Count          3     257
# Exec time     10      7s    35us   492ms    26ms   189ms    78ms   332us
# Time range 2009-10-16 11:48:55.896978 to 2009-10-16 11:49:47.760802
# bytes          2  10.75k      41      43   42.85   42.48    0.67   42.48
# Errors                 1    none
# Rows affe      0       0       0       0       0       0       0       0
# Warning c      0       0       0       0       0       0       0       0
# Query_time distribution
#   1us
#  10us  #
# 100us  ##############################################################
#   1ms  ####
#  10ms  ###
# 100ms  ########
#    1s
#  10s+
# Tables
#    SHOW TABLE STATUS LIKE 'u'\G
#    SHOW CREATE TABLE `u`\G
# EXPLAIN
SELECT ... FROM u ...\G
```

# 2. Identify Problem SQL


- Wrappers to capture SQL
- Re-run on single/multiple servers
  - e.g. Different slave configurations

# 2. Identify Problem SQL




- Enable General Query Log in Development/Testing
- Great for testing Batch Jobs

# 2. Identify Problem SQL

Action 3

**Application Logic**

- Show total master/slave SQL statements executed
- Show all SQL with execution time  (admin user only)

Tip

- Have abstracted class/method to execute ALL SQL

Step 3

# Analyze problem SQL

# 3. Analyze Problem SQL

- Query Execution Plan (QEP)
  - `EXPLAIN [EXTENDED] SELECT ...`
- Table/Index Structure
  - `SHOW CREATE TABLE <tablename>`
- Table Statistics
  - `SHOW TABLE STATUS <tablename>`

# 3. Analyze Problem SQL

Good

```
mysql> EXPLAIN SELECT id FROM example_table WHERE id=1\G

*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: example_table
         type: const
possible_keys: PRIMARY
          key: PRIMARY
      key_len: 4
          ref: const
         rows: 1
        Extra: Using index
```

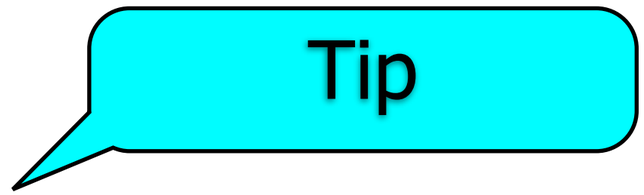
# 3. Analyze Problem SQL

Bad

```
mysql> EXPLAIN SELECT * FROM example_table\G

*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: example_table
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 59
        Extra:
```

# 3. Analyze Problem SQL




- SQL Commenting
  - Identify batch statement SQL
  - Identify cached SQL

```
SELECT /* Cache: 10m */ ....
SELECT /* Batch: EOD report */ ...
SELECT /* Func: 123 */  ....
```

Step 4

# The Art of Indexes

# 4. The Art of Indexes

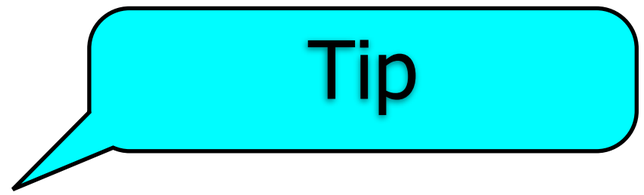
- Different Types
  - Column
  - Concatenated
  - Covering
  - Partial

http://ronaldbradford.com/blog/understanding-different-mysql-index-implementations-2009-07-22/

# 4. The Art of Indexes


- EXPLAIN Output
  - Possible keys
  - Key used
  - Key length
  - Using Index

# 4. The Art of Indexes




- Generally only 1 index used per table
- Make column NOT NULL when possible
- Statistics affects indexes
- Storage engines affect operations

## Before (7.88 seconds)

```
*************************** 2. row **
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: h_p
         type: ALL
possible_keys: NULL
          key: NULL
      key_len: NULL
          ref: NULL
         rows: 33789
        Extra: Using where
```

## After (0.04 seconds)

```
*************************** 2. row ***
           id: 2
  select_type: DEPENDENT SUBQUERY
        table: h_p
         type: index_subquery
possible_keys: UId
          key: UId
      key_len: 4
          ref: func
         rows: 2
        Extra: Using index
```

```
ALTER TABLE h_p ADD INDEX (UId);
```

```
mysql> explain SELECT UID, FUID, COUNT(*) AS Count FROM f
                GROUP BY UID, FUID ORDER BY Count DESC LIMIT 2000\G
*************************** 1. row ***************************
           id: 1
  select_type: SIMPLE
        table: f
         type: index
possible_keys: NULL
          key: UID
      key_len: 8
          ref: NULL
         rows: 2151326
        Extra: Using index; Using temporary; Using filesort
```

```
ALTER TABLE f DROP INDEX UID,
ADD INDEX (UID,FUID)
```

# 4. The Art of Indexes

**Indexes can hurt performance**

Step 5

# Offloading Master Load

# 5. Offloading Master Load

- Identify statements for READ ONLY slave(s)
  - e.g. Long running batch statements

**Single point v scalable solution**

Step 6

# Improving SQL

# 6. Improving SQL

- Poor SQL Examples
    - ORDER BY RAND()
    - SELECT *
    - Lookup joins
    - ORDER BY

**The database is best for storing and retrieving data not logic**

Step 7

# Storage Engines

# 7. Storage Engines

- MyISAM is default
- Table level locking
  - Concurrent SELECT statements
  - INSERT/UPDATE/DELETE blocked by long running SELECT
  - All SELECT's blocked by INSERT/UPDATE/DELETE
- Supports FULLTEXT

# 7. Storage Engines

- InnoDB supports transactions
- Row level locking with MVCC
- Does not support FULLTEXT
- Different memory management
- Different system variables

# 7. Storage Engines

- There are other storage engines
  - Memory
  - Archive
  - Blackhole
  - Third party

# 7. Storage Engines

## Using Multiple Engines

- Different memory management
- Different system variables
- Different monitoring
- Affects backup strategy

# 7. Storage Engines


- Configure InnoDB correctly
  - `innodb_buffer_pool_size`
  - `innodb_log_file_size`
  - `innodb_flush_log_at_trx_commit`

# 7. Storage Engines


- Converted the two primary tables
  - Users
  - Content

**Locking eliminated**

Step 8

# Caching

# 8. Caching

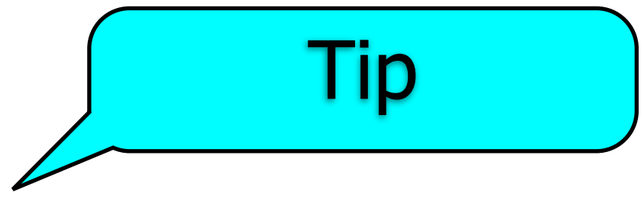
- Memcache is your friend - http://memcached.org/
  - Cache query results
  - Cache lookup data (eliminate joins)
  - Cache aggregated per user information
- Caching Page Content
  - Top rated (e.g. for 5 minutes)

# 8. Caching

Action 2

- MySQL has a Query Cache
  - Determine the real benefit
  - Turn on or off dynamically
  - `SET GLOBAL query_cache_size = 1024*1024*32;`

# 8. Caching




**The best performance improvement for an SQL statement is to eliminate it.**

Step 9

# Sharding

# 9. Sharding

- Application level horizontal and vertical partitioning
- Vertical Partitioning
  - Grouping like structures together (e.g. logging, forums)
- Horizontal Partitioning
  - Affecting a smaller set of users (i.e. not 100%)

# 9. Sharding

- Separate Logging
  - Reduced replication load on primary server

Step 10

# Database Management

# 10. Database Management

**Database Maintenance**

- Adding indexes (e.g. ALTER)
- OPTIMIZE TABLE
- Archive/purging data (e.g DELETE)

**Blocking Operations**

# 10. Database Maintenance


- Automate slave inclusion/exclusion
- Ability to apply DB changes to slaves
- Master still a problem

# 10. Database Maintenance


- Install Fail-Over Master Server
  - Slave + Master features
  - Master extra configuration
- Scripts to switch slaves
- Scripts to enable/disable Master(s)
- Scripts to change application connection

# 10. Database Maintenance

## Higher Availability

## &

## Testing Disaster Recovery


# Front End Improvements

# 11. Front End Improvements

- Know your total website load time - http://getfirebug.com/
  - How much time is actually database related?
- Reduce HTML page size - 15% improvement
  - Remove full URL's, inline css styles
- Reduce/combine css & js files
- Identify blocking elements (e.g. js)

# 11. Front End Improvements

- Split static content to different ServerName
- Spread static content over multiple ServerNames (e.g. 3)
- Sprites - Combining lightweight images - http://spriteme.org/
- Cookie-less domain name for static content

# Conclusion

# Before

- Users experienced slow or unreliable load times
- Management could observe, but no quantifiable details
- Concern over load for increased growth
- Release of some new features on hold

# Now

- Users experienced consistent load times  (~60ms)
  - Quantifiable and visible real-time results
- Far greater load now supported  (Clients + DB)
- Better testability and verification for scaling
- New features can be deployed

# Consulting Available Now

# http://ronaldbradford.com