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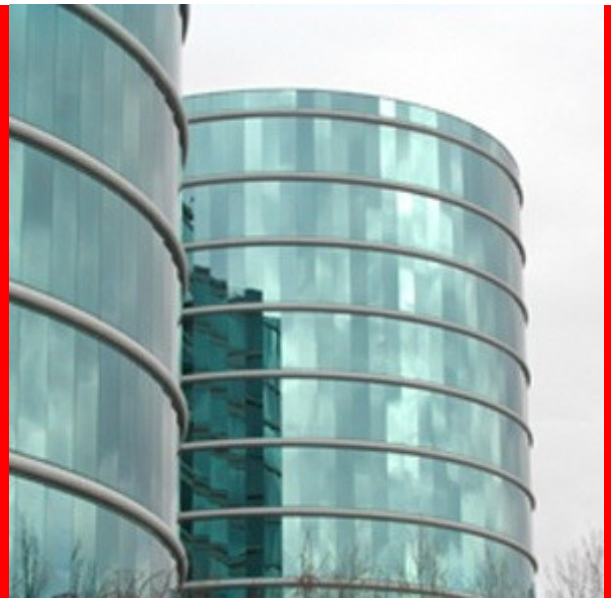

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MySQL: Replication

Keith Larson
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MySQL Community Manager
sqlhjalp.blogspot.com
sqlhjalp.com/pdf/2012_Replication.pdf

Safe Harbor Statement

The following is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions.

The development, release, and timing of any features or functionality described for Oracle's products remains at the sole discretion of Oracle.

Who am I and who are you?

Keith Larson
keith.larson@oracle.com
MySQL Community Manager
http://sqlhjalp.blogspot.com/

Started with MySQL during the dot.com days.
Primary real world work was with a MySQL InnoDB replicated chain environment that easily held over 4 billion rows of user data.
Numerous other sites developed on LAMP stack over the last 13 years.
Also a movie buff :)

Who are you?
DBAs?
Developers?
Already have replicated databases?
Have up to date slaves?
Cluster Users or Cluster curious?

RMOUG & MySQL SIG

The Rocky Mountain Oracle User Group has added a new MySQL Special Interest Group (SIG). The first official meeting will be held at the Quarterly Education Workshop on May 18th, 2012, with breakfast starting 7:30 am.

http://www.rmoug.org/2012/04/08/new-rmoug-mysql-special-interest-group-sig/

George J. Trujillo
Demystifying MySQL for Oracle DBAs and Developers

Ronald Bradford
MySQL Backup & Recovery Essentials

Ronald Bradford
Explaining the MySQL EXPLAIN

Dave Stokes
SQL and NoSQL

http://www.meetup.com/Colorado-MySQL-Meetup-Group/events/54718072/

Session Agenda

- MySQL Replication Overview
- Replication Configuration
- Examples of a real world set up
- MySQL 5.6 Replication Features
- Monitoring – MySQL Enterprise Monitor

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Who Uses Replication ?

"In my opinion, MySQL is the only database we would ever trust to power the Zappos.com website."

"On any given day we can sell close to 300,000 tickets on the Web site using MySQL as the database to search for events. It is amazing."

"As a leader in our field, we are committed to providing the best service to our users, and a web experience that meets members expectations and that starts with IT"

"We are one of the largest MySQL web sites in production

"craigslist infrastructure could not have handled the exponential growth in traffic without MySQL."

"They have a master server for all writes and slave servers for most Reads. The secret truth they claim behind configuring the master and slave machines is to make sure the slave machines are faster than the masters"

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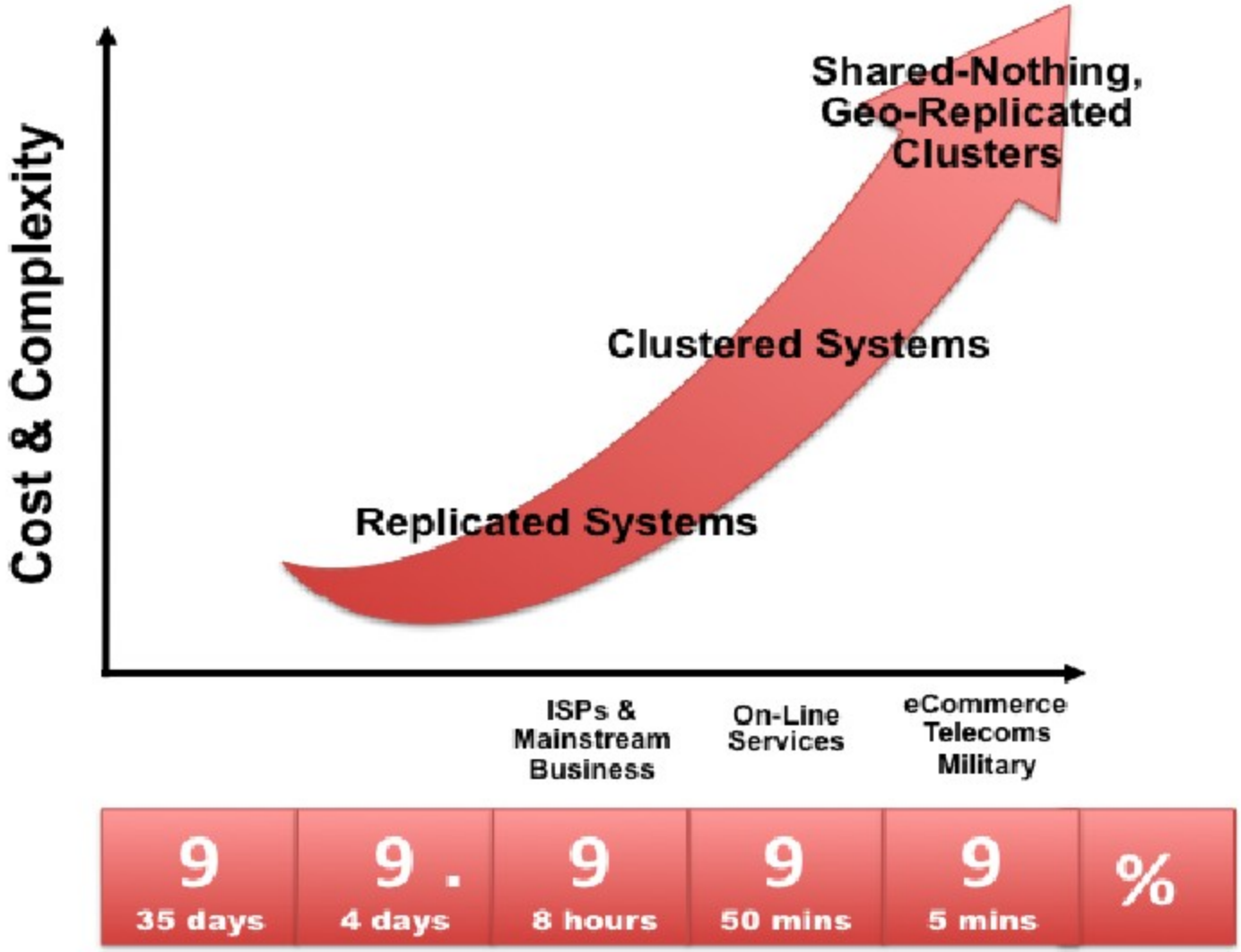
Who Uses Replication ?



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MySQL Replication Overview

Duplicates database from a "master" to a "slave"

Redundant copies of the data provide foundation for High Availability

Scale out by distributing queries across the replication cluster

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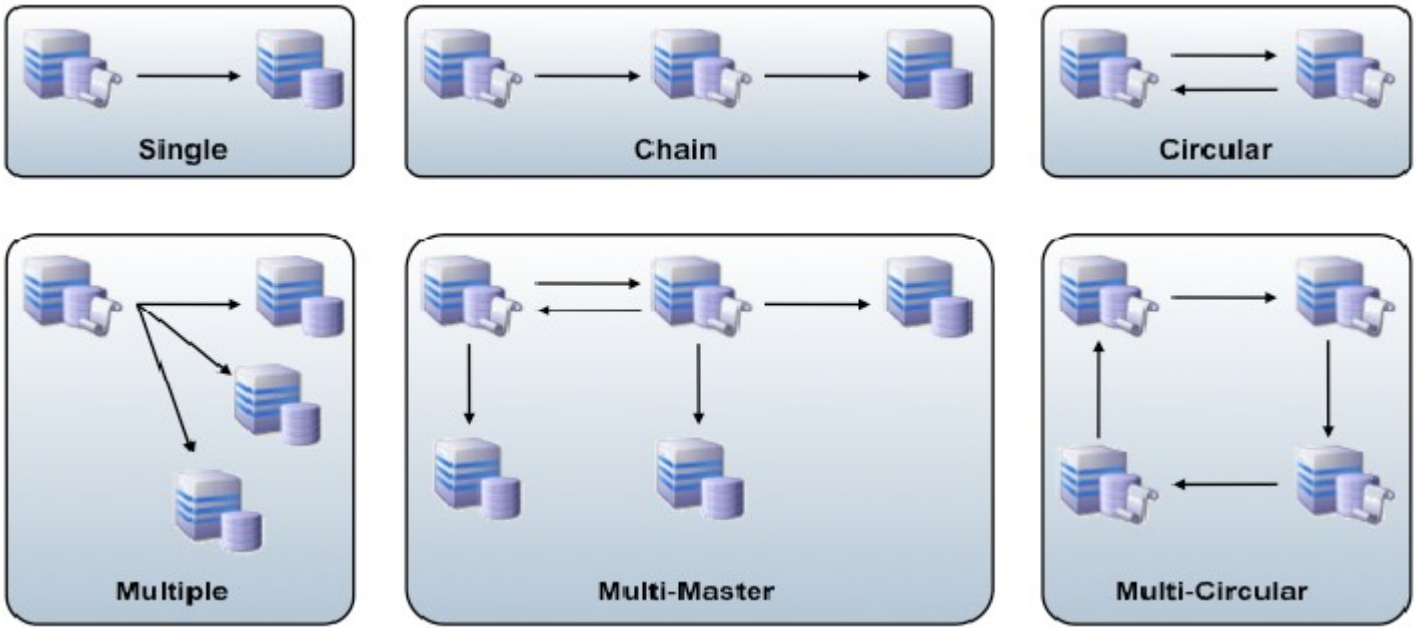
MySQL Replication Overview

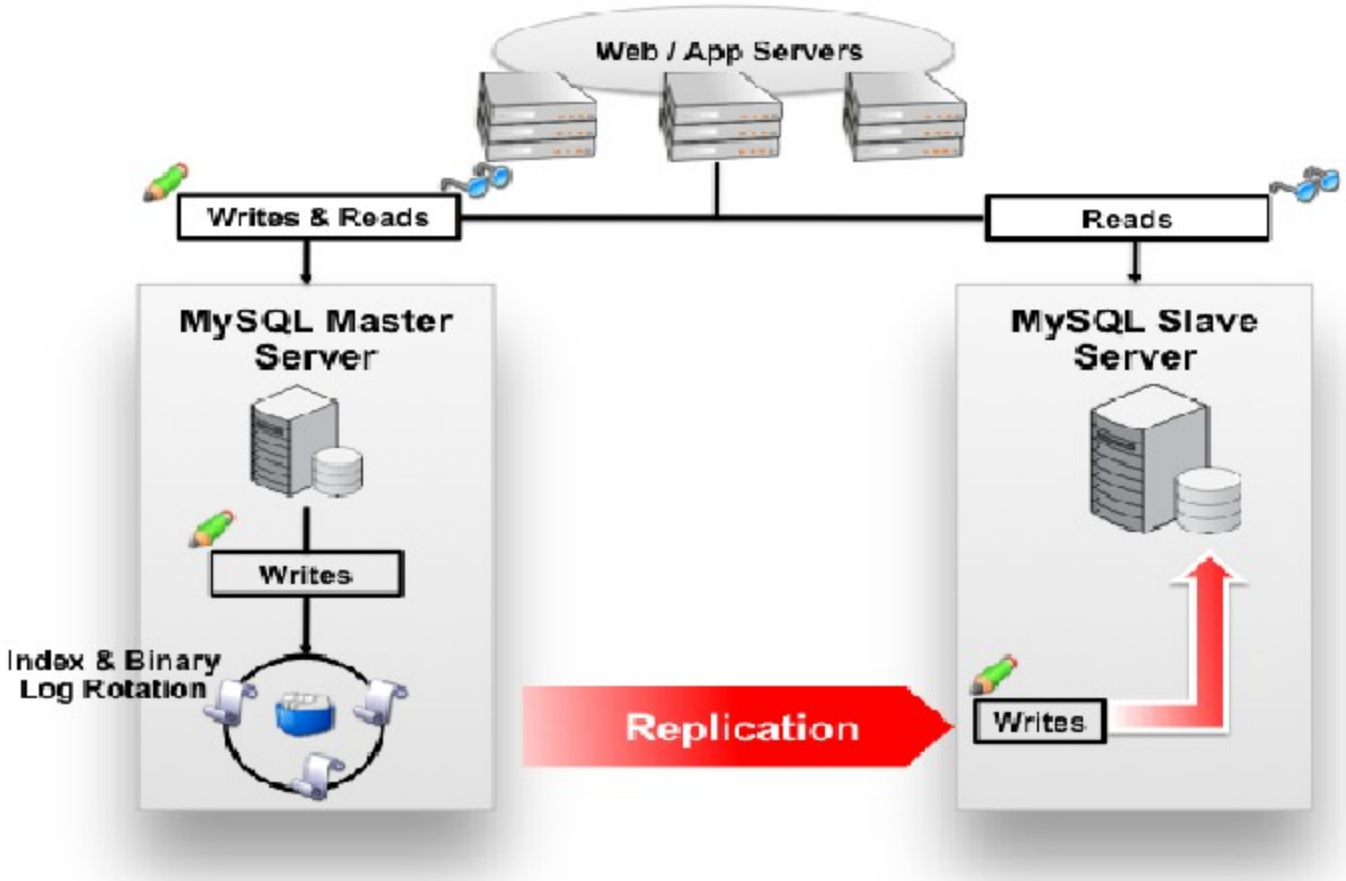
- Native in MySQL
- Replicate within and across data centers
- Failover is either scripted or provided by additional middleware
- Supports Asynchronous (standard) and Semi-Synchronous replication
- Each slave adds minimal load on master

MySQL Replication Overview

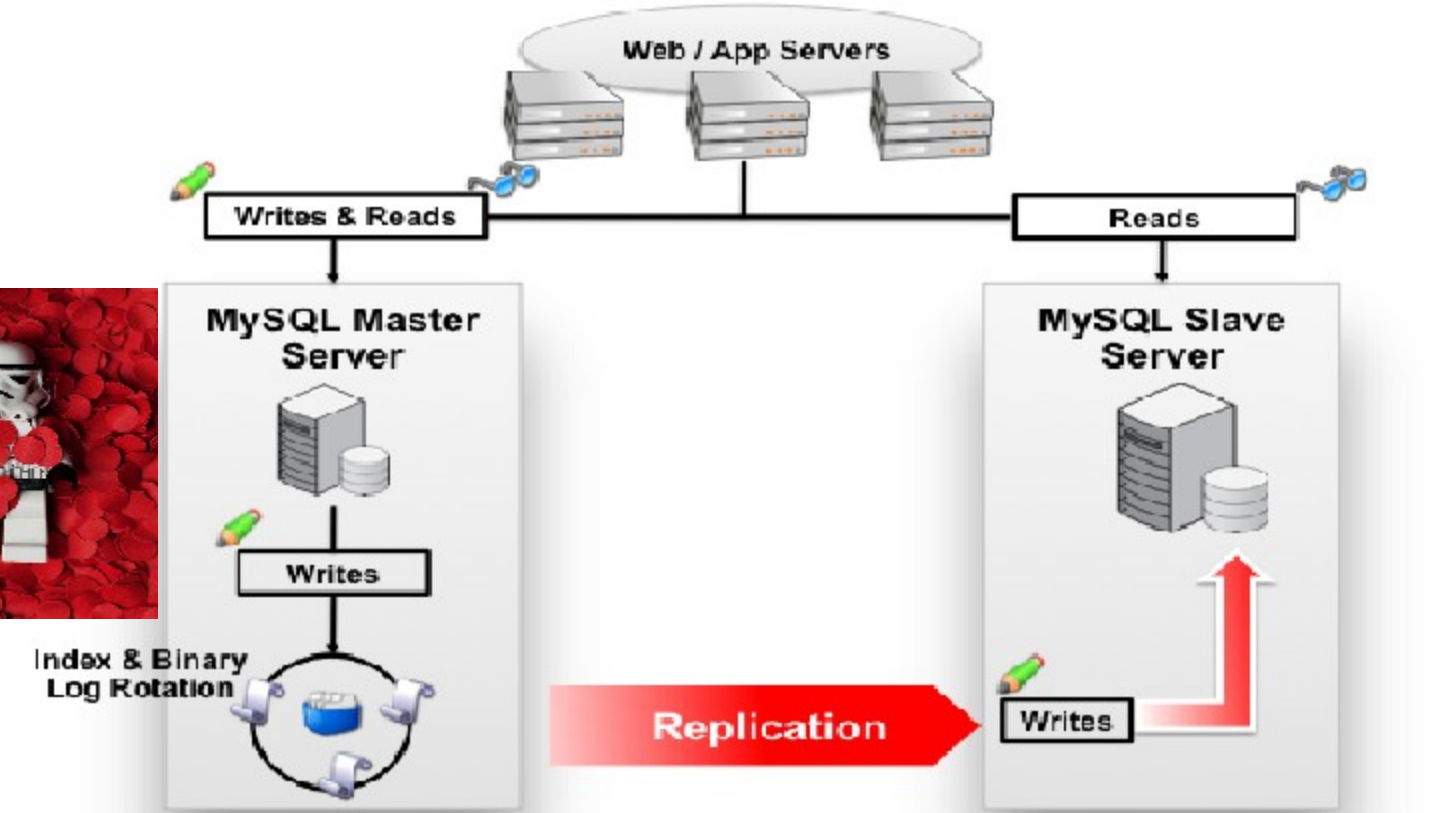
Replication Topologies



MySQL Replication Overview



MySQL Replication Overview



MySQL™

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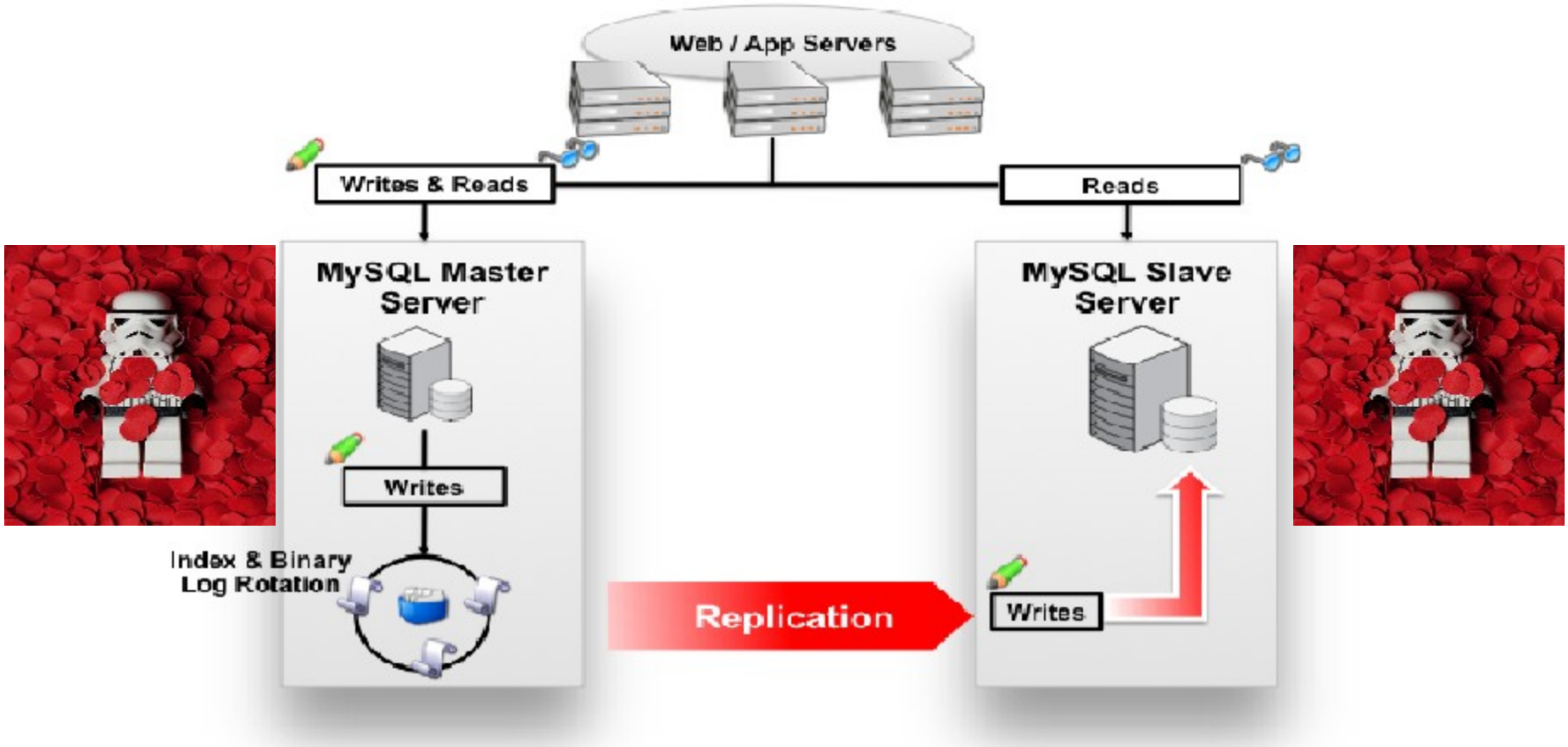
MySQL Replication Overview

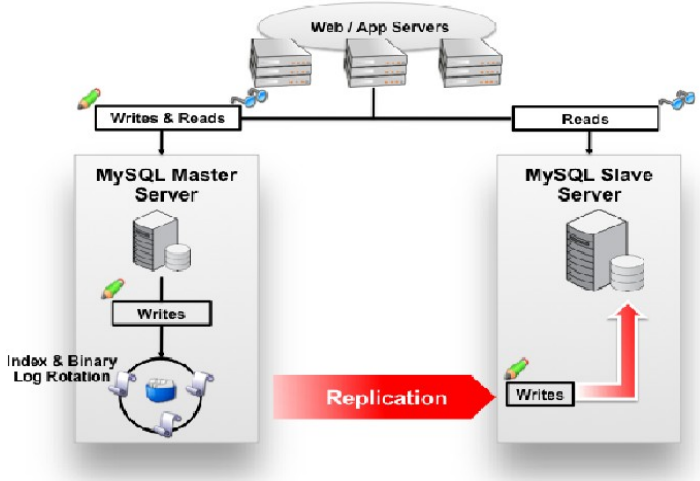


MySQL Replication Overview

- Used for Scalability and HA
- Asynchronous as standard
- Semi-Synchronous support added in MySQL 5.5
- Each slave adds minimal load on master

Replication Threads
- Binlog dump thread
- Slave I/O thread
- Slave SQL thread

Replication Files
- relay log
- master info log
- relay log info log



MySQL Replication Overview

- Used for Scalability and HA
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Replication Threads
- **Binlog dump thread**
- Slave I/O thread
- Slave SQL thread

Replication Files
- relay log
- master info log
- relay log info log

The master creates a thread to send the binary log contents to a slave when the slave connects. This thread can be identified in the output of SHOW PROCESSLIST on the master as the Binlog Dump thread.

•The binlog dump thread acquires a lock on the master's binary log for reading each event that is to be sent to the slave. As soon as the event has been read, the lock is released, even before the event is sent to the slave.

****************************** 2. row ******************************
Id: 27
User: replication
Host: 192.168.0.11:47129
db: NULL
Command: Binlog Dump
Time: 499
State: Master has sent all binlog to slave; waiting for binlog to be updated
Info: NULL**

MySQL Replication Overview

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Replication Threads

- Binlog dump thread
- **Slave I/O thread**
- Slave SQL thread

Replication Files

- relay log
- master info log
- relay log info log

When a START SLAVE statement is issued on a slave server, the slave creates an I/O thread, which connects to the master and asks it to send the updates recorded in its binary logs.

The slave I/O thread reads the updates that the master's Binlog Dump thread sends and copies them to local files that comprise the slave's relay log.

The state of this thread is shown as Slave_IO_running in the output of SHOW SLAVE STATUS or as Slave_running in the output of SHOW STATUS.

```
Slave_IO_Running: Yes
| Slave_running | ON            |
```

MySQL Replication Overview

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Replication Threads

- Binlog dump thread
- Slave I/O thread
- **Slave SQL thread**

Replication Files

- relay log
- master info log
- relay log info log

The slave creates an SQL thread to read the relay log that is written by the slave I/O thread and execute the events contained therein.

Slave_SQL_Running: Yes

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MySQL Replication Overview

- Used for Scalability and HA
- Asynchronous as standard
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Replication Threads

- Binlog dump thread
- Slave I/O thread
- Slave SQL thread

Replication Files

- **relay log**
- master info log
- relay log info log

The relay log consists of the events read from the binary log of the master and written by the slave I/O thread. Events in the relay log are executed on the slave as part of the SQL thread. caption text here.

MySQL Replication Overview

- Used for Scalability and HA
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- Each slave adds minimal load on master

Replication Threads

- Binlog dump thread
- Slave I/O thread
- Slave SQL thread

Replication Files

- relay log
- **master info log**
- relay log info log

The master info log contains status and current configuration information for the slave's connection to the master. This log holds information on the master host name, login credentials, and coordinates indicating how far the slave has read from the master's binary log.

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MySQL Replication Overview

- Used for Scalability and HA
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Replication Threads

- Binlog dump thread
- Slave I/O thread
- Slave SQL thread

Replication Files

- relay log
- master info log
- **relay log info log**

The relay log info log holds status information about the execution point within the slave's relay log

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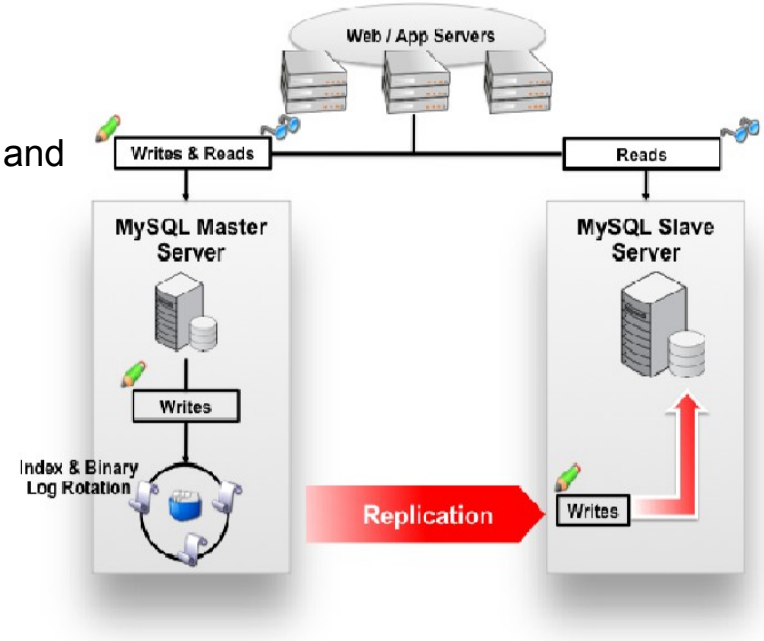
MySQL Replication Overview

Replication Formats **SHOW VARIABLES LIKE '%binlog_format%';**

- Statement-based replication (SBR)
  - SET GLOBAL **binlog_format = 'STATEMENT'**
  - Advantages
    - Less data written to log files
    - taking and restoring from backups are faster
  - Disadvantages
    - Some functions or queries are nondeterministic and hard to replicate

- Row-based replication (RBR)
  - SET GLOBAL **binlog_format = 'ROW'**
  - Advantages
    - safest form of replication
    - Fewer row locks are required on the slave
  - Disadvantages
    - generate more data that must be logged
    - Blob values take longer to replicate

- Mixed-format
  - SET GLOBAL **binlog_format = 'MIXED'**
  - statement-based logging is used by default
  - automatically switches to row-based logging in particular cases



http://dev.mysql.com/doc/refman/5.5/en/replication-formats.html

http://dev.mysql.com/doc/refman/5.5/en/binary-log-setting.html

MySQL Replication Overview

Asynchronous is standard
•events are occurring independently

•The master writes events to its binary log but does not know whether or when a slave has retrieved and processed them

• if the master crashes, transactions that it has committed might not have been transmitted to any slave

Semi-Synchronous support added in MySQL 5.5
•Original patch: Mark Callaghan and Wei Li, Google
Adoptions: Zhenxing He, Sun Microsystems
•acknowledges receipt of a transaction's events only after the events have been written to its relay log and flushed to disk not fully executed sql.

•best for close servers communicating over fast networks

•timeout occurs without any slave having acknowledged the transaction, the master reverts to asynchronous replication. When at least one semisynchronous slave catches up, the master returns to semisynchronous replication.

http://dev.mysql.com/doc/refman/5.5/en/replication-semisync.html

MySQL Steps in Replication

Master Setup:

```
# vi /etc/my.cnf
    [mysqld]
    server-id=1
        log-bin = /var/lib/mysql/yoda-bin

Start and Log into MySQL
master_yoda>show master status\G
*************************** 1. row ***************************
            File: yoda-bin.000001
        Position: 114
    Binlog_Do_DB:
Binlog_Ignore_DB:
1 row in set (0.00 sec)
```

```
# mysqldump -p --all-databases --master-data=2 > /tmp/replication_example.sql
```

THIS LOCKS THE DATABASE!

http://dev.mysql.com/doc/refman/5.5/en/replication-howto-masterbaseconfig.html

MySQL Steps in Replication

On Master :

```
mysql_yoda>CREATE USER 'replication'@'192.168.0.%' IDENTIFIED BY 'slavepass';
mysql_yoda>GRANT REPLICATION SLAVE ON *.* TO 'replication'@'%';
mysql_yoda>flush privileges;
```

Adjust all firewall rules if required for MySQL Port. (3306)

http://dev.mysql.com/doc/refman/5.5/en/replication-howto-masterbaseconfig.html

MySQL Steps in Replication

Slave Setup:

```
vi /etc/my.cnf
    [mysqld]
    Server-id=2
    relay-log=/var/lib/mysql/luke-relay-bin

    # optional below
    log-bin = /var/lib/mysql/luke-bin
```

```
luke>show master status\G
*************************** 1. row ***************************
             File: luke-bin.000003
         Position: 114
     Binlog_Do_DB:
Binlog_Ignore_DB:
1 row in set (0.00 sec)
```

LOAD DATA:

```
# mysql --user=root -p < /tmp/replication_example.sql
```

MySQL Steps in Replication

On Slave :

```
mysql_luke> CHANGE MASTER TO
  MASTER_HOST='yoda',
  MASTER_USER='replication',
  MASTER_PASSWORD='slavepass',
  MASTER_PORT=3306,
  MASTER_LOG_FILE='yoda-bin.000002',
  MASTER_LOG_POS=83415,
  MASTER_CONNECT_RETRY=10;
```

We gathered this info from the mysqldump file via the **" --master-data=2 "** flag.

```
-- CHANGE MASTER TO
MASTER_LOG_FILE='yoda-bin.000002',
MASTER_LOG_POS=83415;
```

```
Mysql > start slave;
Query OK, 0 rows affected (0.00 sec)
```

MySQL Steps in Replication

On Slave :

```
mysql_luke> show slave status\G

mysql_luke> show slave status\G
*************************** 1. row ***************************
               Slave_IO_State: Waiting for master to send event
                  Master_Host: yoda
                  Master_User: replication
                  Master_Port: 3306
                Connect_Retry: 10
              Master_Log_File: yoda-bin.000003
          Read_Master_Log_Pos: 323
               Relay_Log_File: luke-relay-bin.000004
                Relay_Log_Pos: 475
        Relay_Master_Log_File: yoda-bin.000003
             Slave_IO_Running: Yes
            Slave_SQL_Running: Yes
                  Master_Server_Id: 1
      Master_UUID: 75d407df-2be4-11e1-9668-b4be9bce39b0
        Seconds_Behind_Master: 0
       SQL_Remaining_Delay: NULL
```

MySQL Steps in Replication

Setting up replication
mysqlreplicate \ --master=root@master.example.com \
--slave=root@slave.example.com \ --rpl-user=repl:xyzzy

http://dev.mysql.com/doc/workbench/en/mysql-utils-man-mysqlreplicate.html

Require master and slave to be off-line!

https://github.com/greyrl/generaltools/blob/master/mysqlreplicate.py

MySQL Steps in Replication

•DB Luke processes all of DB Yoda's data via the relay log.

•If Vadar adjusts a table within DB Luke and then DB Luke tries to apply duplicate data you will crash replication.
•Make Slave Read only with a global variable.
- SET GLOBAL read_only=1;
- This will keep all non-SUPER and non-replication users from writing to the database.



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MySQL Steps in Replication

Master to Master

mysql> SET GLOBAL auto_increment_offset=2;
mysql> SET GLOBAL auto_increment_increment=2;

```
mysql_yoda>show global variables like '%auto_increment%';
+--------------------------+-------+
| Variable_name            | Value |
+--------------------------+-------+
| auto_increment_increment | 2     |
| auto_increment_offset    | 1     |
+--------------------------+-------+
```

```
mysql_luke>show global variables like '%auto_increment%';
+--------------------------+-------+
| Variable_name            | Value |
+--------------------------+-------+
| auto_increment_increment | 2     |
| auto_increment_offset    | 2     |
+--------------------------+-------+
```

```
mysql_luke>SHOW MASTER STATUS\G
*************************** 1. row ***************************
            File: luke-bin.000005
        Position: 295
```

```
mysql_yoda>CHANGE MASTER TO
  MASTER_HOST='luke',
  MASTER_USER='replication2',
  MASTER_PASSWORD='slavepass',
  MASTER_PORT=3306,
  MASTER_LOG_FILE='luke-bin.000005',
  MASTER_LOG_POS=295,
  MASTER_CONNECT_RETRY=10;
mysql_yoda> start slave;
```

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MySQL 5.6 Replication Features

5.6 DMR

http://sqlhjalp.blogspot.com/2012/04/mysql-565-m8-dmr-table-of-contents.html

- Slave Tables for Replication Information
- Replication Event Checksums
- Multi-Threaded Slave
- Time Delayed Replication
- Optimized Row Based Replication
- Informational Log Events
- Remote Backup of Binary logs
- Global Transaction IDs
- Golden Gate Replication

http://dev.mysql.com/doc/refman/5.6/en/replication-features.html
http://dev.mysql.com/downloads/mysql/#downloads Under Development Releases

MySQL 5.6 Replication Features

Slave Tables for Replication Information

Problem: Slave thread commits and then updates slave data.
what if it crashes in-between?

- recovery issues - where to restart replication from?
- file corruption vulnerability
- administration hassle

Solution: store data in (transactional) tables:

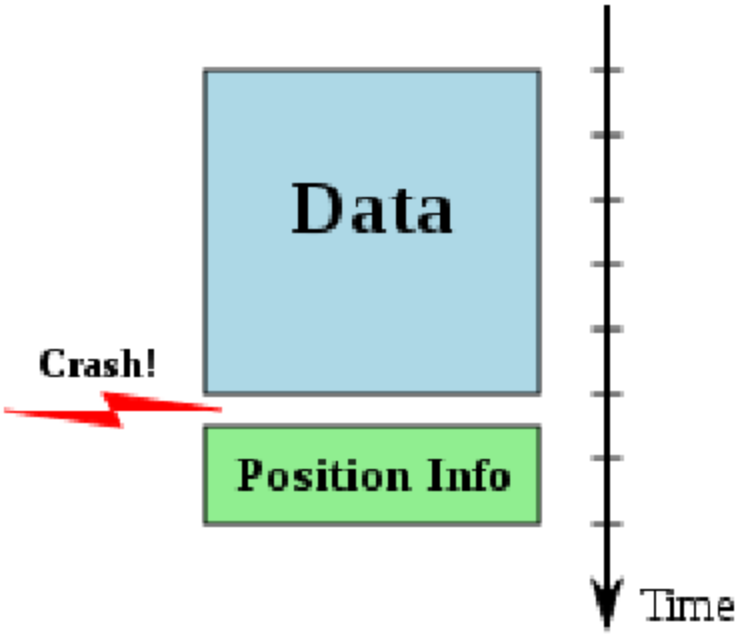
- slave's data is updated transactionally
- engine agnostic
- crash-safeness (requires transactional tables) frees the DBA to manually recover transactions after a crash

http://dev.mysql.com/downloads/mysql/#downloads Under Development Releases

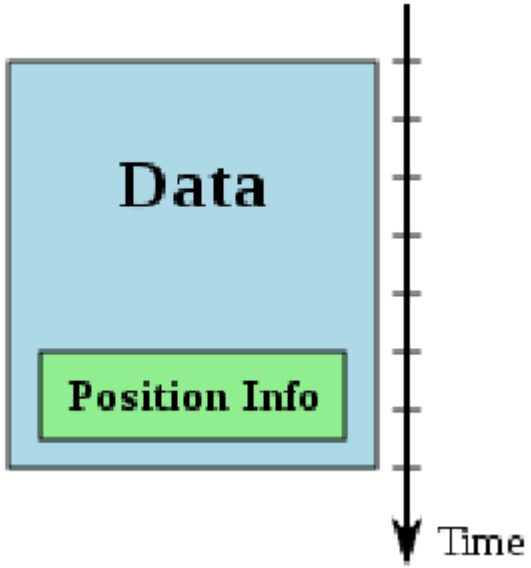
MySQL 5.6 Replication Features

Slave Tables for Replication Information

MySQL <5.6
Transaction Data: in tables
Replication Info: in files



MySQL 5.6
Transaction Data: in tables
Replication Info: in tables



MySQL 5.6 Replication Features

Slave Tables for Replication Information

- System tables:
  - slave_master_info (mysql.slave_master_info)
    - --master-info-repository=TABLE
  - slave_relay_log_info (mysql.slave_relay_log_info)
    - --relay-log-info-repository=TABLE

```
mysql_slave> stop slave;
mysql_slave> SET GLOBAL master_info_repository = 'TABLE';
mysql_slave> SET GLOBAL relay_log_info_repository = 'TABLE';
mysql_slave> start slave;
```

Make sure you add to my.cnf

- master-info-repository =TABLE
- relay-log-info-repository =TABLE

- Transactional tables enables transactional slave positions
- Automatic conversion between files and tables on startup
- Long time awaited feature

http://dev.mysql.com/doc/refman/5.6/en/replication-options-binary-log.html

MySQL 5.6 Replication Features

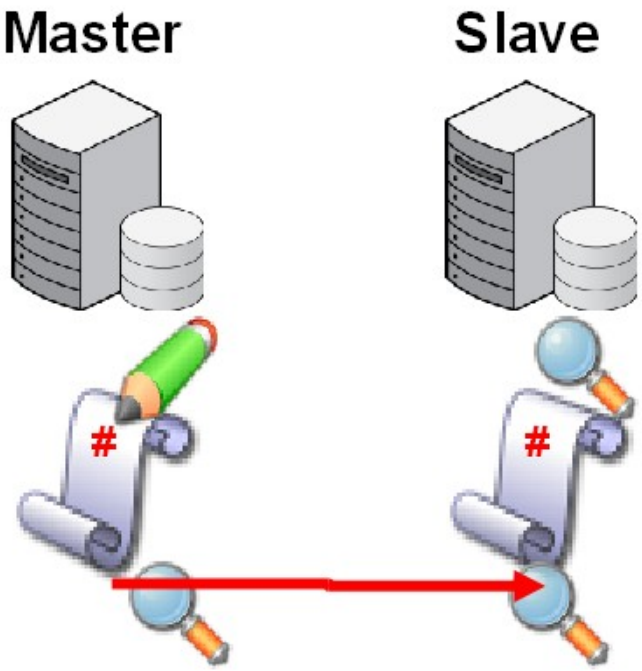
Slave Tables for Replication Information

```
mysql_slave> select * from slave_master_info \G
*************************** 1. row ***************************
            Master_id: 2
     Number_of_lines: 22
     Master_log_name: yoda-bin.000003
      Master_log_pos: 323
                Host: yoda
           User_name: replication
       User_password: slavepass
                Port: 3306
      Connect_retry: 10
         Enabled_ssl: 0
              Ssl_ca:
          Ssl_capath:
            Ssl_cert:
          Ssl_cipher:
             Ssl_key:
 Ssl_verify_server_cert: 0
           Heartbeat: 1800
                Bind:
   Ignored_server_ids: 0
                Uuid: 75d407df-2be4-11e1-9668-b4be9bce39b0
        Retry_count: 86400
             Ssl_crl:
         Ssl_crlpath:
1 row in set (0.00 sec)
```

MySQL 5.6 Replication Features

Replication Event Checksums

- Detects corrupt replication events before they are applied
- Guards against bugs and disk or network corruptions
- CRC-32 checksum, more precisely ISO-3309 (supplied with zlib)
- New mysqld options:
  - binlog-checksum= NONE or CRC32
    generated by the session thread and written to the binary log
    - SET GLOBAL binlog_checksum = 1;
  - master-verify-checksum= 0 or 1
    Master validates checksum read from the binary log
    - SET GLOBAL master_verify_checksum = 1;
  - slave-sql-verify-checksum= 0 or 1
    SQL thread should verify the checksum when reading it from the relay log on the slave
    - mysql> SET GLOBAL slave_sql_verify_checksum=1;



http://mysqlmusings.blogspot.com/2011/04/replication-event-checksum.html

MySQL 5.6 Replication Features

Replication Event Checksums

Problem: events get corrupted while en route from master to slave.
Why and where it got corrupted?
Disk corruption, network, bugs in replication, faulty memory, cosmic ray, act of God?

Solution: include in each event its control checksum and verify it before:

sending it to the slave (master - dump thread)
storing it in the relay log (slave - IO thread)
applying it (slave - SQL thread)
several verification points: flexibility

```
mysql> show global variables like '%checksum%';
+--------------------------+--------+
| Variable_name            | Value  |
+--------------------------+--------+
| binlog_checksum          | CRC32  |
| innodb_checksum_algorithm | innodb |
| innodb_checksums         | ON     |
| master_verify_checksum   | ON     |
| slave_sql_verify_checksum | ON     |
+--------------------------+--------+
```

MySQL 5.6 Replication Features

5.6 DMR

Multi-Threaded Slave

Throughput of slave increased by allowing multiple slave threads:

- 0 - functionality disabled
- 0 to 1024

Exec_Master_Log_Posn in SHOW SLAVE STATUS represents a "low-water" mark, before which no uncommitted transactions remain.

Configure using:

- slave-parallel-workers=4

On a per-database basis

- can process successive transactions on a given database without waiting for updates on other databases to complete

http://dev.mysql.com/doc/refman/5.6/en/replication-options-slave.html#sysvar_slave_parallel_workers

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MySQL 5.6 Replication Features

5.6 DMR

Multi-Threaded Slave

```
mysql_luke> show slave status\G
*************************** 1. row ***************************
           ....
          Exec_Master_Log_Pos: 114

mysql> show global variables like '%workers%';
+----------------------+-------+
| Variable_name        | Value |
+----------------------+-------+
| slave_parallel_workers | 0     |
+----------------------+-------+
1 row in set (0.00 sec)

mysql> SET GLOBAL slave_parallel_workers=4;
Query OK, 0 rows affected (0.00 sec)

mysql> show global variables like '%workers%';
+----------------------+-------+
| Variable_name        | Value |
+----------------------+-------+
| slave_parallel_workers | 4     |
+----------------------+-------+
1 row in set (0.00 sec)
```

http://dev.mysql.com/doc/refman/5.6/en/replication-options-slave.html#sysvar_slave_parallel_workers

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MySQL 5.6 Replication Features

Time Delayed Replication

Problem: Make replication slave to lag a specified amount of time behind the master to:

- To protect against user mistakes on the master.
- To test how the system behaves when there is a lag.
- To inspect what the database looked like long ago, without having to reload a backup.

Solution: The slave waits until a given number of seconds elapses before applying the changes:

- Delays configured per slave: flexible deployment;
- Are implemented in the SQL thread layer.
- Rolling Database Backups with Relayed Replication

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MySQL 5.6 Replication Features

Time Delayed Replication

User interface:

- CHANGE MASTER TO MASTER_DELAY = <NUM_SECONDS>;
  - mysql> stop slave;
  - mysql> CHANGE MASTER TO MASTER_DELAY=86400; start slave;

- SHOW SLAVE STATUS:
  - SQL_Delay: 86400
  - SQL_Remaining_Delay: 86395
  - Slave_SQL_Running_State: Waiting until MASTER_DELAY seconds after master executed event
- RESET SLAVE clears the configured delay;

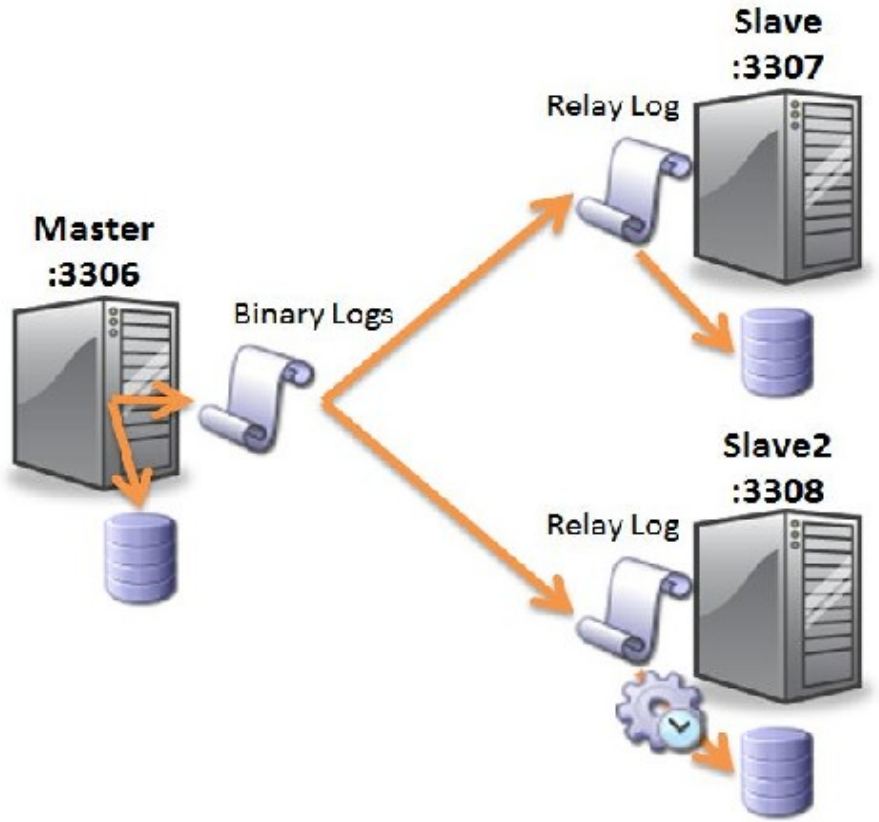
Rolling forward delayed slaves until bad event:

START SLAVE [SQL_THREAD] UNTIL MASTER_LOG_FILE = 'log_name', MASTER_LOG_POS = log_pos

http://dev.mysql.com/doc/refman/5.6/en/replication-delayed.html
http://dev.mysql.com/doc/refman/5.6/en/start-slave.html

MySQL 5.6 Replication Features

Time Delayed Replication



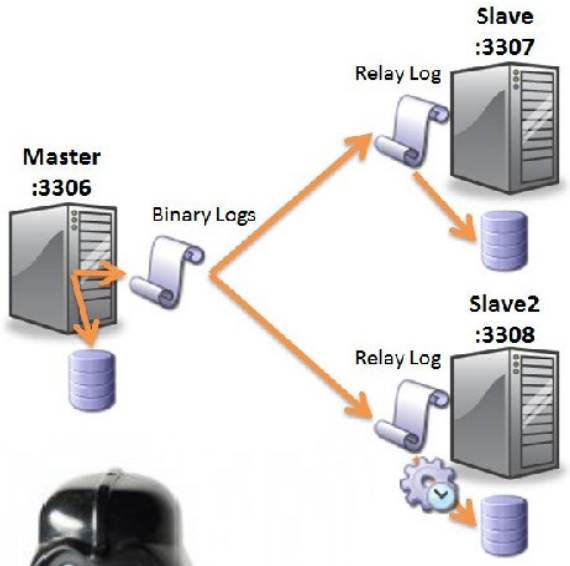
86400 seconds in a day.

```
slave2> CHANGE MASTER TO
 -> MASTER_HOST = 'localhost',
 -> MASTER_PORT = 3306,
 -> MASTER_USER = 'repl_user',
 -> MASTER_PASSWORD = 'pw',
 -> MASTER_DELAY = 86400;

slave2> START SLAVE;
```

MySQL 5.6 Replication Features

Time Delayed Replication



```
mysql_luke> STOP SLAVE;

mysql_luke>SHOW RELAYLOG EVENTS FROM 2337\G
*************************** 4. row ***************************
   Log_name: luke-relay-bin.000005
        Pos: 2674
 Event_type: Query
  Server_id: 1
End_log_pos: 2623
       Info: drop database Tatooine

mysql_luke> START SLAVE UNTIL
 -> MASTER_LOG_FILE='luke-relay-bin.000005',
 -> MASTER_LOG_POS=2674;
```

MySQL 5.6 Replication Features

5.6 DMR

Optimized Row Based Replication

In MySQL row-based replication (RBR), each row change event contains two images, a “before” image whose columns are matched against when searching for the row to be updated, and an “after” image containing the changes.

- can often save disk, memory, and network usage by logging only those columns which are actually required.
- Default is full : Log all columns in both the before image and the after image.
- New option: binlog-row-image= **minimal**

- no effect when the binary logging format is STATEMENT. When binlog_format is MIXED, the setting for binlog_row_image is applied to changes that are logged using row-based format, but this setting no effect on changes logged as statements.

```
mysql> show global variables like '%binlog_row_image%';
mysql> SET GLOBAL binlog_row_image=minimal;
```

http://d2-systems.blogspot.com/2011/04/mysql-562-dm-optimized-row-based.html
http://dev.mysql.com/doc/refman/5.6/en/replication-options-binary-log.html#sysvar_binlog_row_image

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MySQL 5.6 Replication Features

5.6 DMR

Optimized Row Based Replication

Problem: all columns are logged for a row, even if only some are requested or changed (this is valid for Before and After Images - BI/AI):

network bandwidth waste, increased memory footprint, disk space overuse...

Solution: Make the server to dynamically choose which columns to log for DELETE, UPDATE and INSERT row events:

Minimal - PK or UK for BI and changed columns for AI
Noblob - no blobs columns when not needed
Full - all columns always

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MySQL 5.6 Replication Features

Informational Log Events

Problem: no way to send informational events down the replication stream.

Solution: Create a class of events that carry information from master to slave(s):

- Use case: log the query that originated several rows events up-front as an informational event;
- Feature often requested for debugging.

http://d2-systems.blogspot.com/2011/04/mysql-562-dm-binlog-informational.html
http://dev.mysql.com/doc/refman/5.6/en/replication-options-binary-log.html#option_mysqld_binlog-rows-query-log-events

MySQL 5.6 Replication Features

Informational Log Events

Enhances auditing and debugging when using Row-Based Replication by writing the original query to the binary log, which is then replicated with its associated row-based event to the slave.

write informational log events such as row query log events into its binary log.
sysvar_binlog_rows_query_log_events must be disabled during logging.
Logs the query that originated the subsequent rows changes.
Shows up in mysqlbinlog and SHOW SLAVE STATUS output.
New variable:

--binlog-rows-query-log-events= ON|OFF (default: OFF)

```
mysql> SET GLOBAL binlog_rows_query_log_events=ON;
mysql> show global variables like '%binlog_rows_query_log_events%';
+-------------------------------+-------+
| Variable_name                 | Value |
+-------------------------------+-------+
| binlog_rows_query_log_events | ON    |
+-------------------------------+-------+
```

MySQL 5.6 Replication Features

Informational Log Events

```
mysql> SET binlog_format=ROW;
Query OK, 0 rows affected (0.00 sec)

mysql> SET SESSION binlog_rows_query_log_events=ON;
Query OK, 0 rows affected (0.00 sec)

mysql> CREATE TABLE t1 (a INT);
Query OK, 0 rows affected (0.07 sec)

mysql> INSERT INTO t1 VALUES (1), (2), (3);
Query OK, 3 rows affected (0.00 sec)
Records: 3  Duplicates: 0  Warnings: 0

mysql> SHOW BINLOG EVENTS;
+------------------+-----+-------------+-----------+-------------+----------------------------------------+
| Log_name         | Pos | Event_type  | Server_id | End_log_pos | Info                                   |
+------------------+-----+-------------+-----------+-------------+----------------------------------------+
| master-bin.000001 |   4 | Format_desc |         1 |         114 | Server ver: 5.6.3-m5-debug-log, Binlog ver: 4 |
| master-bin.000001 | 114 | Query       |         1 |         200 | use `test`; CREATE TABLE t1 (a INT)    |
| master-bin.000001 | 200 | Query       |         1 |         268 | BEGIN                                  |
| master-bin.000001 | 268 | Rows_query  |         1 |         323 | # INSERT INTO t1 VALUES (1), (2), (3)  |
| master-bin.000001 | 323 | Table_map   |         1 |         364 | table_id: 54 (test.t1)                 |
| master-bin.000001 | 364 | Write_rows  |         1 |         408 | table_id: 54 flags: STMT_END_F         |
| master-bin.000001 | 408 | Query       |         1 |         477 | COMMIT                                 |
+------------------+-----+-------------+-----------+-------------+----------------------------------------+
7 rows in set (0.00 sec)
```

http://d2-systems.blogspot.com/2011/04/mysql-562-dm-binlog-informational.html

MySQL 5.6 Replication Features

Remote Backup of Binary logs

Problem: There is no way to create real-time backups of the master's binary logs.

Solution: Make use of mysqlbinlog facilities that retrieve and dump remote MySQL log contents as SQL statements to make it output in raw format:

- DBAs don't need to do remote logins to retrieve master's binlogs or setup an intermediate slave.

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MySQL 5.6 Replication Features

Remote Backup of Binary logs

Make use of mysqlbinlog facilities that retrieve and dump remote MySQL log contents. Writes to a local file with the same name as the original.

DBAs don't need to do remote logins to retrieve master's binlogs or setup an intermediate slave.

Relevant new options for mysqlbinlog:

- raw: dump in raw format
- stop-never: waits for new data upon reaching the end of the log
- stop-never-slave-server-id: id that mysqlbinlog will use to emulate itself as a slave.

Raw format use cases:

- make a static backup
- backing up a set of log files and stopping when the end of the last file is reached
- continuous (“live”) backup

```
$> mysqlbinlog --read-from-remote-server –raw -h secret_server -P 3306 -u root mysql-bin.000001
```

http://dev.mysql.com/doc/refman/5.6/en/mysqlbinlog-backup.html

MySQL 5.6 Replication Features

5.6.5-m8 DMR

Global Transaction IDs

A global transaction identifier is a tuple (SID, GNO). SID is normally the SERVER_UUID and GNO is a sequence number (1 for the first transaction committed on SID, 2 for the second, and so on).

Basically, a GTID is a logical identifier that maps into physical coordinates (log file name, file offset). Physical coordinates are likely to be different at each different server. In contrast, global transaction identifiers are not.

Start the server with GTIDs ON, requires four switches :

- –log-bin
- –log-slave-updates
- –gtid-mode=ON
- –disable-gtid-unsafe-statements

more /var/lib/mysql/auto.cnf
[auto]
server-uuid=a38141b4-833a-11e1-8fea-0800272afe48

https://dev.mysql.com/doc/refman/5.6/en/replication-gtids.html

http://drcharlesbell.blogspot.com/2012/04/mysql-utilities-and-global-transaction.html
http://d2-systems.blogspot.com/2012/04/global-transaction-identifiers-are-in.html
http://d2-systems.blogspot.com/2011/10/global-transaction-identifiers-feature.html

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MySQL 5.6 Replication Features

5.6.5-m8 DMR

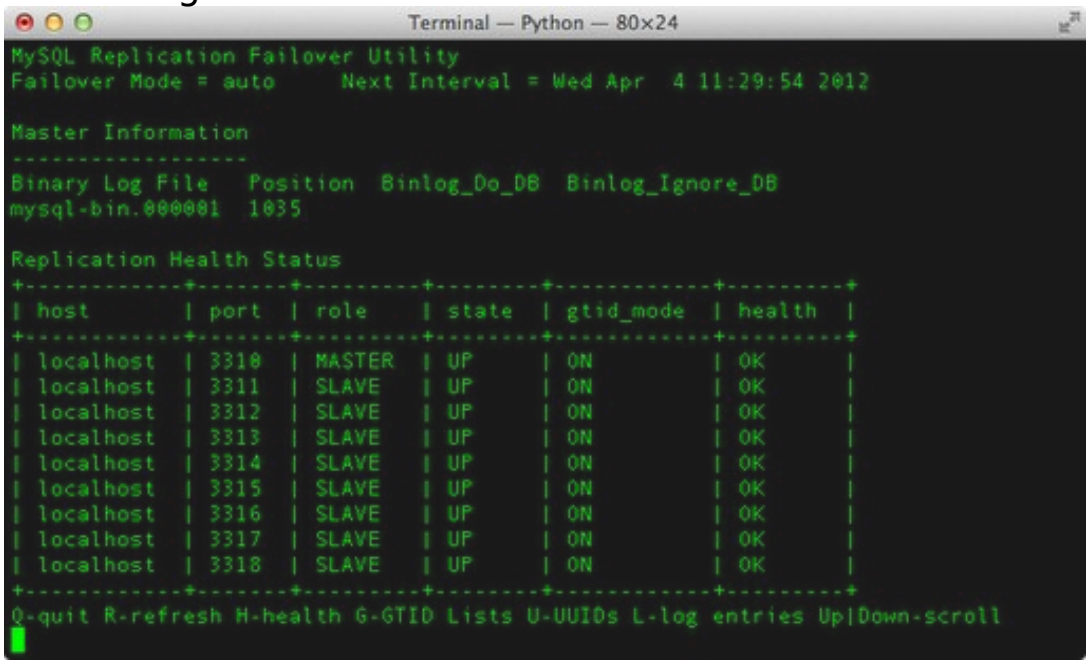
Global Transaction IDs

The new GTID utilities are included in Workbench version 5.2.39.(GA)

Automatic Failover Utility

The most impressive utility is mysqlfailover, It is an interactive tool used to report replication health, report GTIDs in use, and perform automatic failover.

You can setup mysqlfailover to automatically failover to one of a specific set of slaves whenever the master goes offline



http://drcharlesbell.blogspot.com/2012/04/mysql-utilities-and-global-transaction.html
http://d2-systems.blogspot.com/2012/04/global-transaction-identifiers-are-in.html
http://d2-systems.blogspot.com/2011/10/global-transaction-identifiers-feature.html

MySQL 5.6 Replication Features

5.6.5-m8 DMR

Global Transaction IDs

```
MySQL Demo {root} (test) > CREATE TABLE t1 (a INT);
Query OK, 0 rows affected (0.31 sec)

MySQL Demo {root} (test) > INSERT INTO t1 VALUES (1);
Query OK, 1 row affected (0.04 sec)

MySQL Demo {root} (test) > SHOW BINLOG EVENTS;
+------------------------+-----+---------------+-----------+-------------+-----------------------------------------------------------------------+
| Log_name               | Pos | Event_type    | Server_id | End_log_pos | Info                                                                  |
+------------------------+-----+---------------+-----------+-------------+-----------------------------------------------------------------------+
| oraclelinux61-bin.000001 |   4 | Format_desc   |         1 |         120 | Server ver: 5.6.5-m8-log, Binlog ver: 4                               |
| oraclelinux61-bin.000001 | 120 | Previous_gtids |         1 |         147 |                                                                       |
| oraclelinux61-bin.000001 | 147 | Gtid          |         1 |         191 | SET @@SESSION.GTID_NEXT= 'A38141B4-833A-11E1-8FEA-0800272AFE48:1'     |
| oraclelinux61-bin.000001 | 191 | Query         |         1 |         284 | use `test`; CREATE TABLE t1 (a INT)                                   |
| oraclelinux61-bin.000001 | 284 | Gtid          |         1 |         328 | SET @@SESSION.GTID_NEXT= 'A38141B4-833A-11E1-8FEA-0800272AFE48:2'     |
| oraclelinux61-bin.000001 | 328 | Query         |         1 |         403 | BEGIN                                                                 |
| oraclelinux61-bin.000001 | 403 | Query         |         1 |         498 | use `test`; INSERT INTO t1 VALUES (1)                                 |
| oraclelinux61-bin.000001 | 498 | Xid           |         1 |         525 | COMMIT /* xid=11 */                                                   |
+------------------------+-----+---------------+-----------+-------------+-----------------------------------------------------------------------+
8 rows in set (0.00 sec)
```

http://drcharlesbell.blogspot.com/2012/04/mysql-utilities-and-global-transaction.html
http://d2-systems.blogspot.com/2012/04/global-transaction-identifiers-are-in.html
http://d2-systems.blogspot.com/2011/10/global-transaction-identifiers-feature.html

MySQL 5.6 Replication Features

5.6.5-m8 DMR

Global Transaction IDs

```
mysql> CHANGE MASTER TO MASTER_HOST='127.0.0.1',
MASTER_PORT=13000, MASTER_USER='root', MASTER_AUTO_POSITION=1;
Query OK, 0 rows affected (0,00 sec)

mysql> START SLAVE;
Query OK, 0 rows affected (0,00 sec)

mysql> SHOW SLAVE STATUS\G
(...)
                Master_Host: 127.0.0.1
                Master_User: root
                Master_Port: 13000
(...)
             Slave_IO_Running: Yes
            Slave_SQL_Running: Yes
(...)
           Retrieved_Gtid_Set: 4B2CBA63-8082-11E1-BE2D-F0DEF11A08B7:1-2
            Executed_Gtid_Set: 4B2CBA63-8082-11E1-BE2D-F0DEF11A08B7:1-2
1 row in set (0,00 sec)
```

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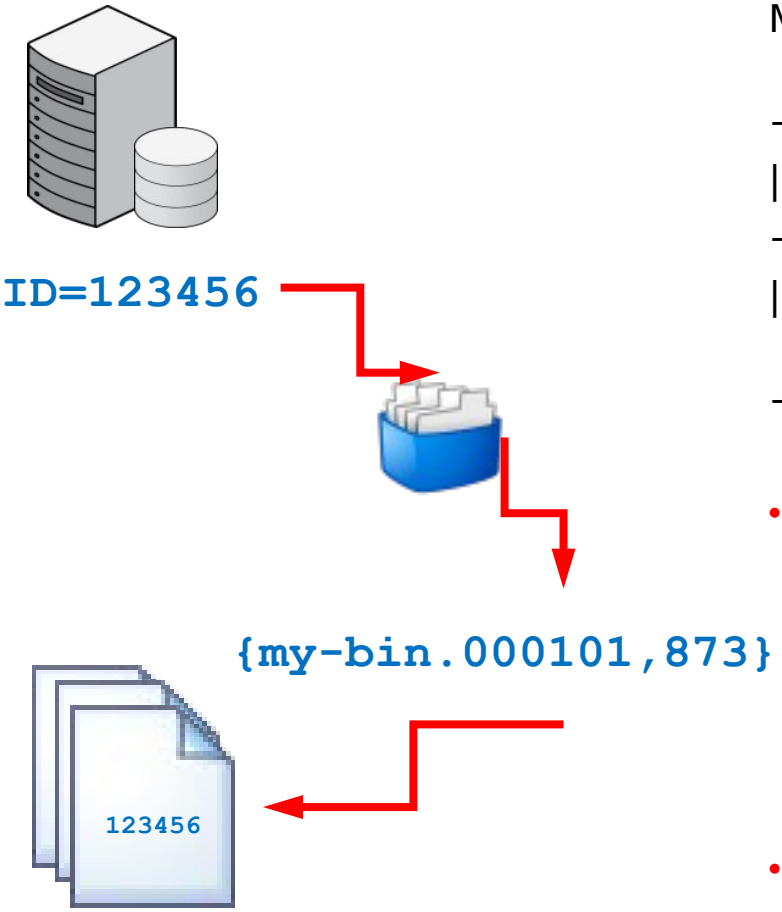
MySQL 5.6 Replication Features

5.6.5-m8 DMR

Global Transaction IDs




```
MySQL Demo {root} (test) > SELECT
    @@GLOBAL.GTID_DONE;
+-----------------------------------------+
| @@GLOBAL.GTID_DONE                      |
+-----------------------------------------+
| A38141B4-833A-11E1-8FEA-0800272AFE48:1-2
    |
+-----------------------------------------+
```

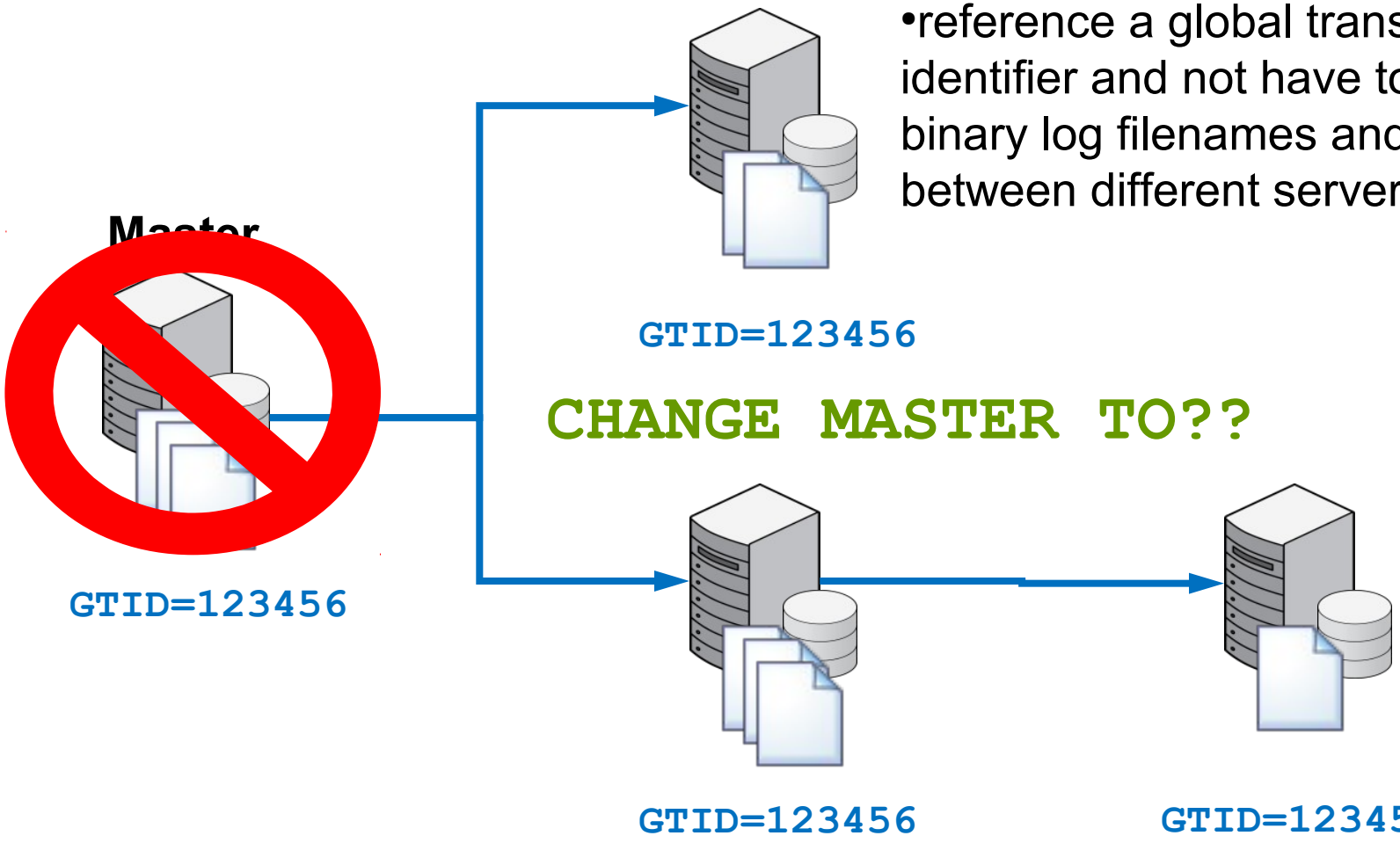
- Each transaction identified by logical id rather than physical (file + offset)
  - Same for all servers
  - Contained in binary log
  - Index to map global ID to local physical position
  - Doesn't change during failover
- Simpler slave promotion & maintenance of complex replication topologies

http://drcharlesbell.blogspot.com/2012/04/mysql-utilities-and-global-transaction.html
http://d2-systems.blogspot.com/2012/04/global-transaction-identifiers-are-in.html
http://d2-systems.blogspot.com/2011/10/global-transaction-identifiers-feature.html

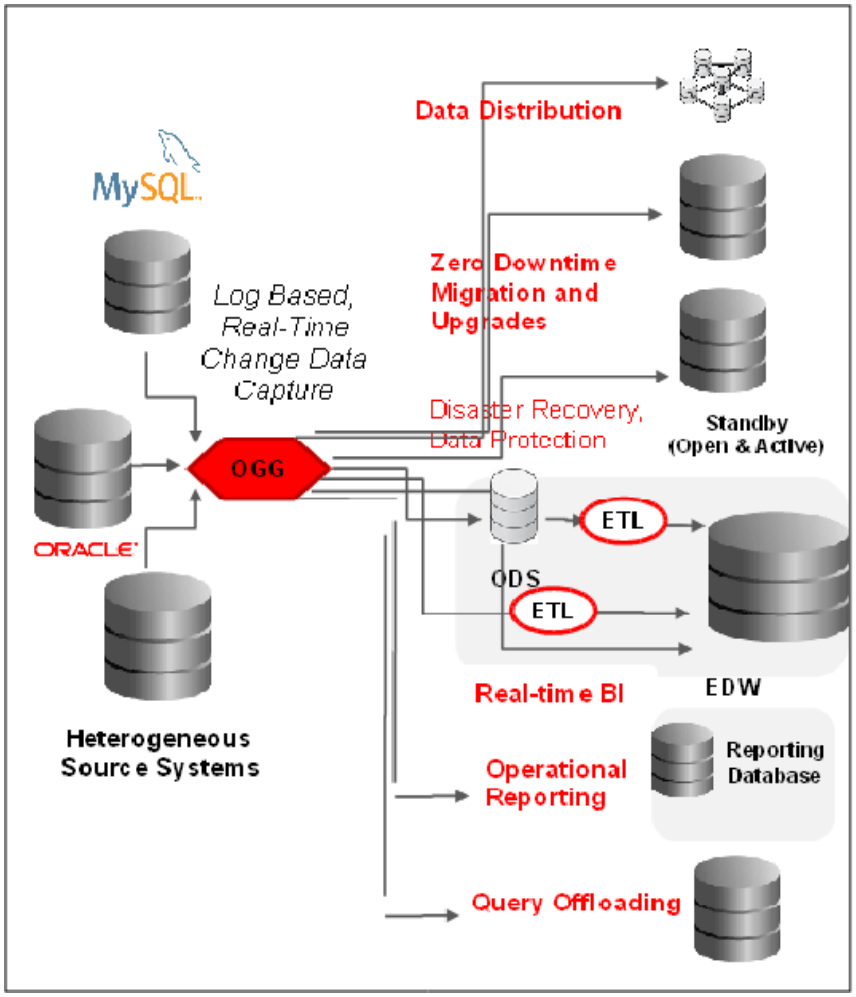
MySQL 5.6 Replication Features

Global Transaction IDs

Slave(s) can start from same GTID
- reference a global transaction identifier and not have to convert binary log filenames and offsets between different servers



MySQL Replication



Oracle Integrations: Golden Gate

- Heterogeneous Replication between MySQL, Oracle
- MySQL specific optimizations
- Hybrid web, enterprise applications (Sabre Holdings)
- Offload, scale query activity to MySQL read-only slaves
- Real-time access to web-based analytics, reporting
- Migration path from/to MySQL from other databases with minimal downtime

ORACLE FUSION MIDDLEWARE 11g GOLDENGATE

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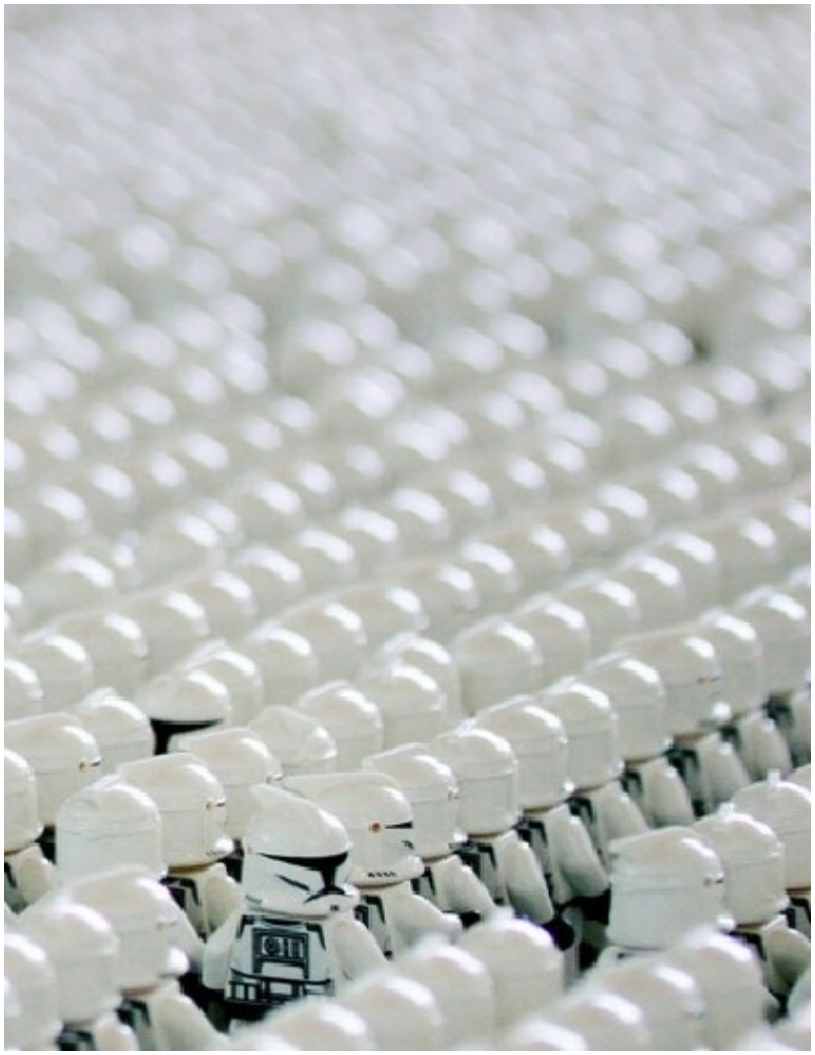
MySQL Enterprise Monitor

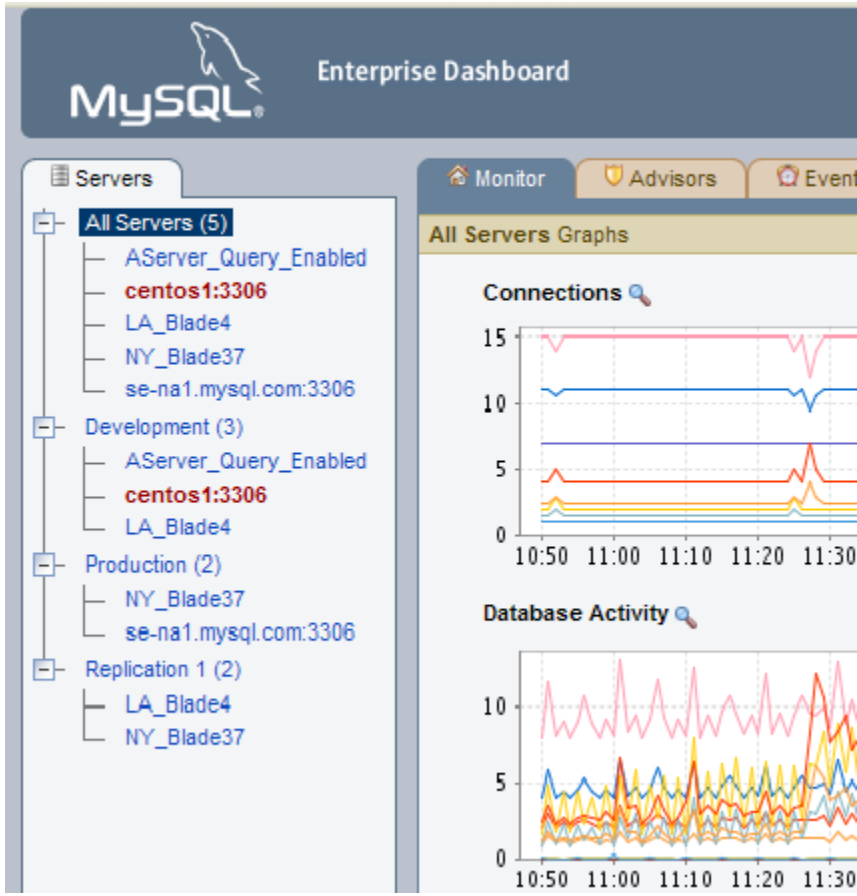


All the slaves paying attention?

- Do you know when a slave is behind?
- What type of topology do you have?
- Alerted on Errors?
- Slow Queries?

MySQL Enterprise Monitor

- Global view of MySQL environment
- Automated, rules-based monitoring and alerts (SMTP, SNMP enabled)
- Query capture, monitoring, analysis and tuning, correlated with Monitor graphs
- Visual monitoring of “hot” applications and servers
- Real-time Replication Monitor with auto-discovery of master-slave topologies
- Integrated with MySQL Support



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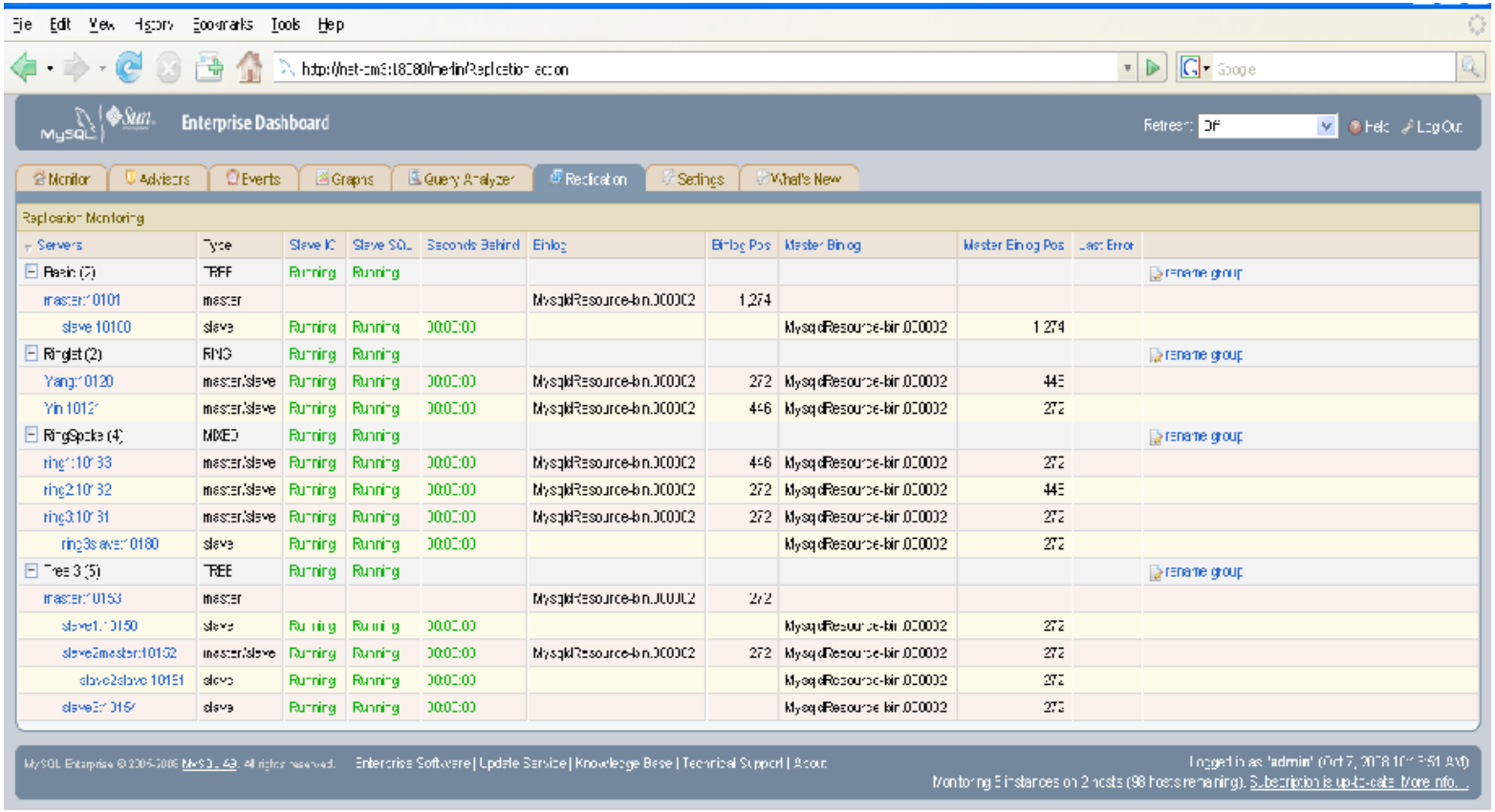
MySQL Enterprise Monitor

MySQL Replication Monitoring



MySQL Replication Common Questions

Do you need two different mysql servers
 to be installed ?
•Yes - replication happens between MySQL servers

How do you know if replication is behind ?
•"SHOW SLAVE STATUS" on the slave and check the Seconds_Behind_Master value

MySQL Replication Common Questions

Do you have to replicate everything or can I just replicate certain databases or tables?

- You do not have to replicate everything. What you replicate is dependent on your replication topology and application. Be careful and mindful of your replication type RBR or SBR. Read more on this.

- --replicate-do-db=db_name
- --replicate-ignore-db=db_name

http://dev.mysql.com/doc/refman/5.6/en/replication-options-slave.html#option_mysqld_replicate-do-db

MySQL Replication Common Questions

Does semi-synchronous replication work on windows platform ?

•Yes, replication is not OS dependent.

Can you promote a slave to a master in the event that the master server has a hardware failure?

Can you also switch the master back to a slave at a later time?

- Absolutely, covered in a white paper...
- http://www.mysql.com/why-mysql/white-papers/mysql-wp-replication.php

MySQL Replication Common Questions

If you are using circular replication and you have an auto_increment column, how can you make sure two inserts at the same time will not get the same id on two different servers?

- When using multi-master replication together with auto-increment columns, you should use the auto_increment_offset and auto_increment_increment parameters on each server to make sure that there are no duplicate values assigned. They should use the same auto_increment_increment value but different auto_increment_offset values to make sure they don't clash

MySQL User Groups

Top Active MySQL User Groups

North America

- *Atlanta, GA*
- *Austin, TX*
- *Boise, ID*
- *Boston, MA*
- *Cleveland, OH*
- *Denver, CO*
- *Dallas, TX*
- *Huntsville, AL*
- *Los Angeles, CA*
- *Montreal, CAN*
- *Minneapolis, MN*
- *New York, NY*
- *New Jersey, NJ*
- *Philadelphia, PA*
- *Raleigh, NC*
- *San Francisco, CA*
- *Seattle, WA*
- *Toronto, CAN*

Japan and APAC

- *Taiwan*
- *Indonesia*

Europe

- *Helsinki*
- *London*
- *France*

Middle East

- *Dubai*
- *Turkey*

South America

- *Brazil*
- *Indonesia*

Oceania

- *Sydney Australia*

Middle East

- *Dubai*
- *Turkey*

Complete list of MySQL user groups
https://wikis.oracle.com/display/mysql/List+of+MySQL+User+Groups

MySQL Community Managers
Dave Stokes (david.stokes@oracle.com)
Keith Larson (keith.larson@oracle.com)

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MySQL Available Now

Development Releases:
•http://dev.mysql.com/downloads/mysql/#downloads

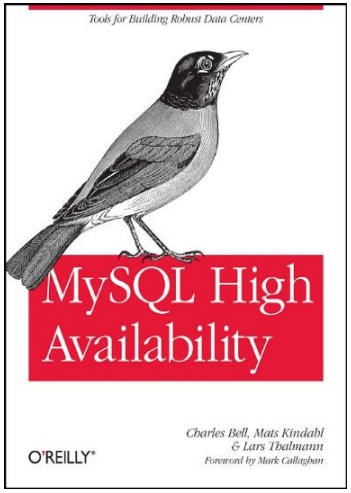
Evaluate the new features
•Questions & Feedback: forums.mysql.com/list.php?26
•Bugs: bugs.mysql.com/

Replication in MySQL 5.5
•mysql.com/why-mysql/white-papers/mysql-wp-replication.php

Replication 5.6 documentation
•dev.mysql.com/doc/refman/5.6/en/replication.html

Planet
•Planet.mysql.com

MySQL High Availability
•http://shop.oreilly.com/product/9780596807290.do



Learn more about HA Solutions for MySQL
•mysql.com/why-mysql/white-papers/mysql_wp_ha_strategy_guide.php

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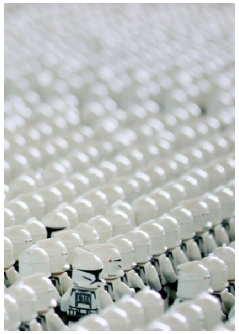
Credits






http://www.starwars.com/
http://starwars.lego.com/en-us/Default.aspx
http://thewondrous.com/wp-content/uploads/2010/04/Largest-display-of-Star-Wars-clone-troopers-built-with-interlocking-plastic-bricks.jpg
http://www.betabeat.com/2011/09/02/clone-wars-rise-of-the-fast-follower-startups/
http://www.minifigures.co.uk/lego/star-wars/master-yoda/
http://www.minifigures.co.uk/lego/star-wars/luke-skywalker-on-tatooine/
http://www.minifigures.co.uk/lego/star-wars/darth-vader-minifig/
http://farm6.static.flickr.com/5024/5554971120_df447dd31c.jpg
http://www.stormgrounds.com/wallpaper/Miscellaneous/Storm-Trooper-Legos
http://www.jorymon.com/images/2009/june/stormtrooper_1.jpg
http://203.148.253.29/wp-content/photos/KIS_Levi/
http://highdefinitionwallpapers.com/hd-wallpapers/funny-wallpapers/lego-storm-trooper-keyboard-funny-wallpaper/
http://www.stormgrounds.com/wallpaper/Entertainment/Srorm-Trooper

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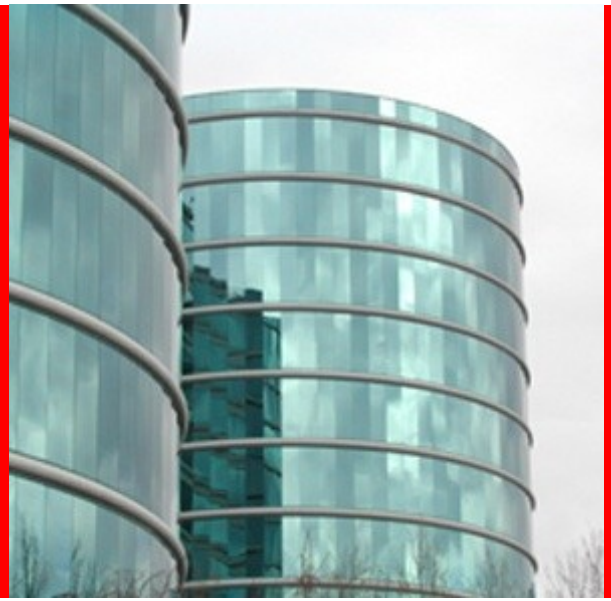

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Thanks for attending!

keith.larson@oracle.com

sqlhjalp.blogspot.com

sqlhjalp.com/pdf/2012_Replication.pdf


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