The Exciting MySQL 5.7 Replication Enhancements

Luís Soares (luis.soares@oracle.com)
Principal Software Engineer, MySQL Replication Team Lead

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Program Agenda

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Program Agenda

1. Background
2. MySQL 5.7 Replication Generally Available
3. The New Replication Features in MySQL 5.7
4. Development Sneak Peek
5. Roadmap
6. Summary

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1 MySQL 5.7 Replication Generally Available

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Interesting Stats Related to MySQL 5.7

- **40 replication worklogs** pushed to MySQL 5.7
  - 29 related to on MySQL replication Core
  - 11 are ground work for MySQL Group Replication.
- **8 contributions** merged into MySQL 5.7.
- **19 major enhancements** to the replication core.
- **14 refactoring and modularization** related changes to the code.

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2 Background

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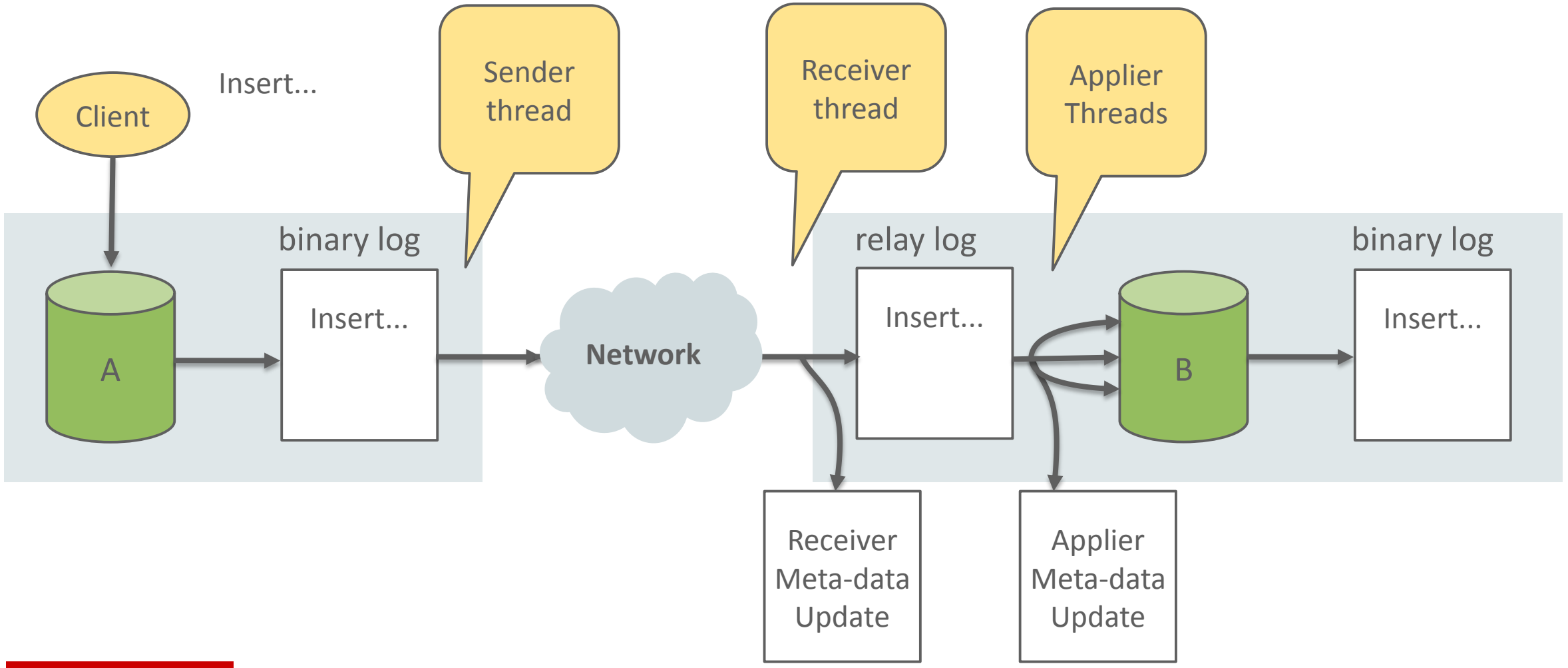
Background: Replication Components



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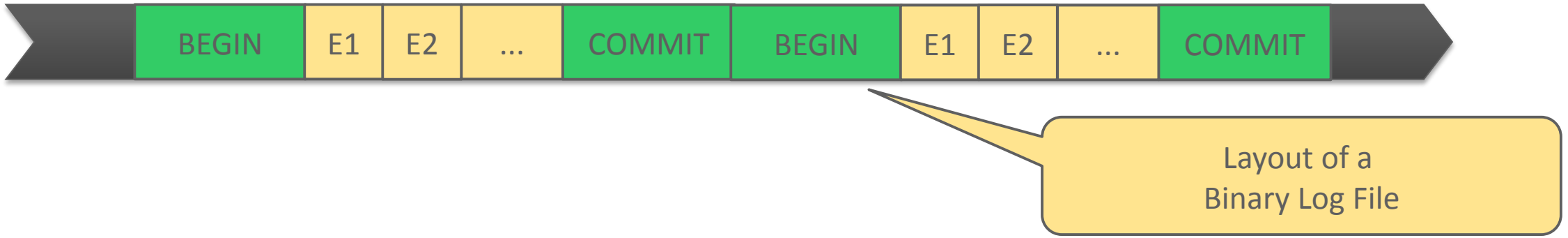
Background: Replication Components

- **Binary Log**
  - File based logical log that records the changes on the master.
  - Statement or Row based format (may be intermixed).
  - Each transaction is split into groups of events.
  - Control events: Rotate, Format Description, Gtid, ...



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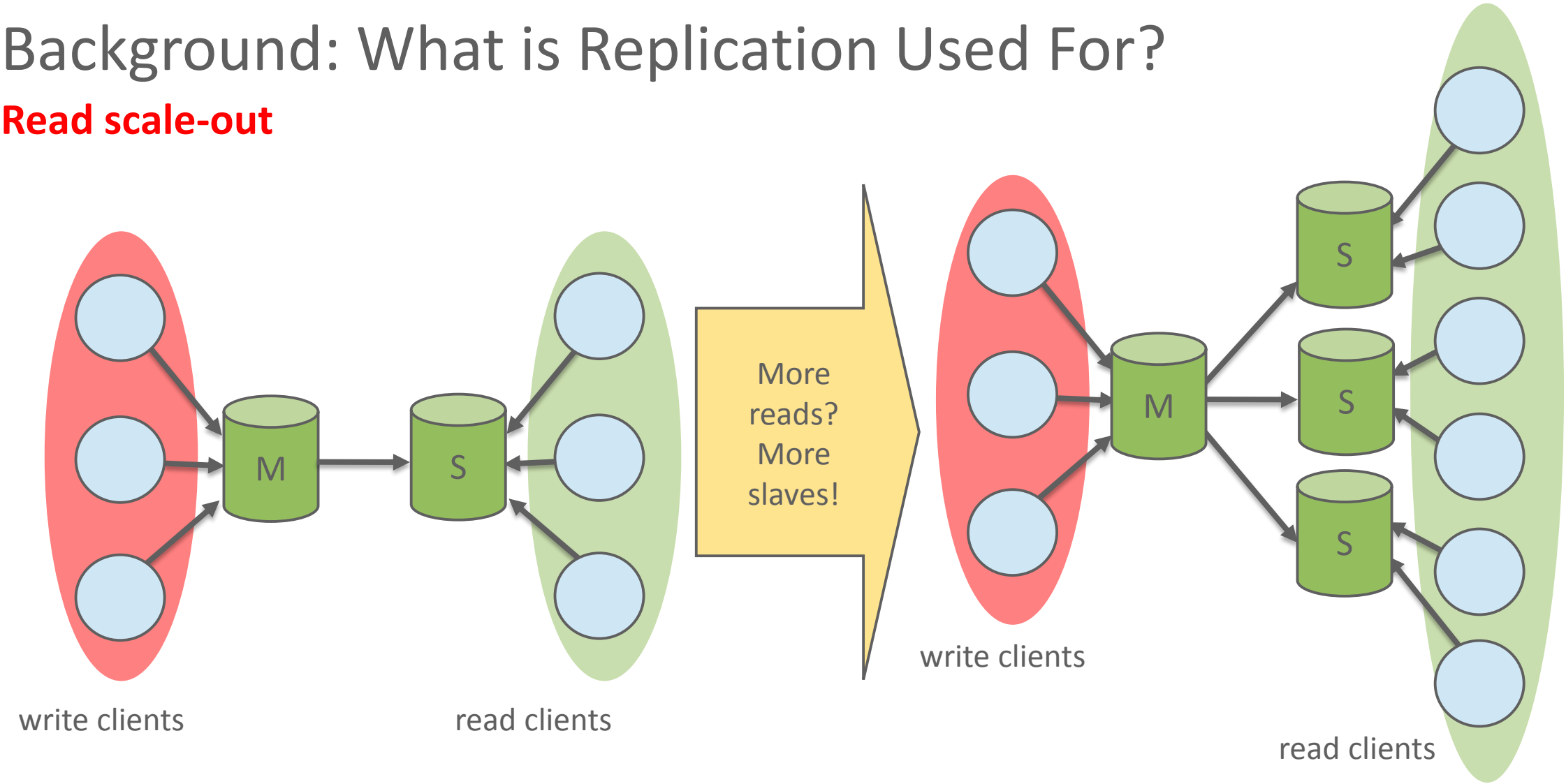
Background: What is Replication Used For?

Read scale-out



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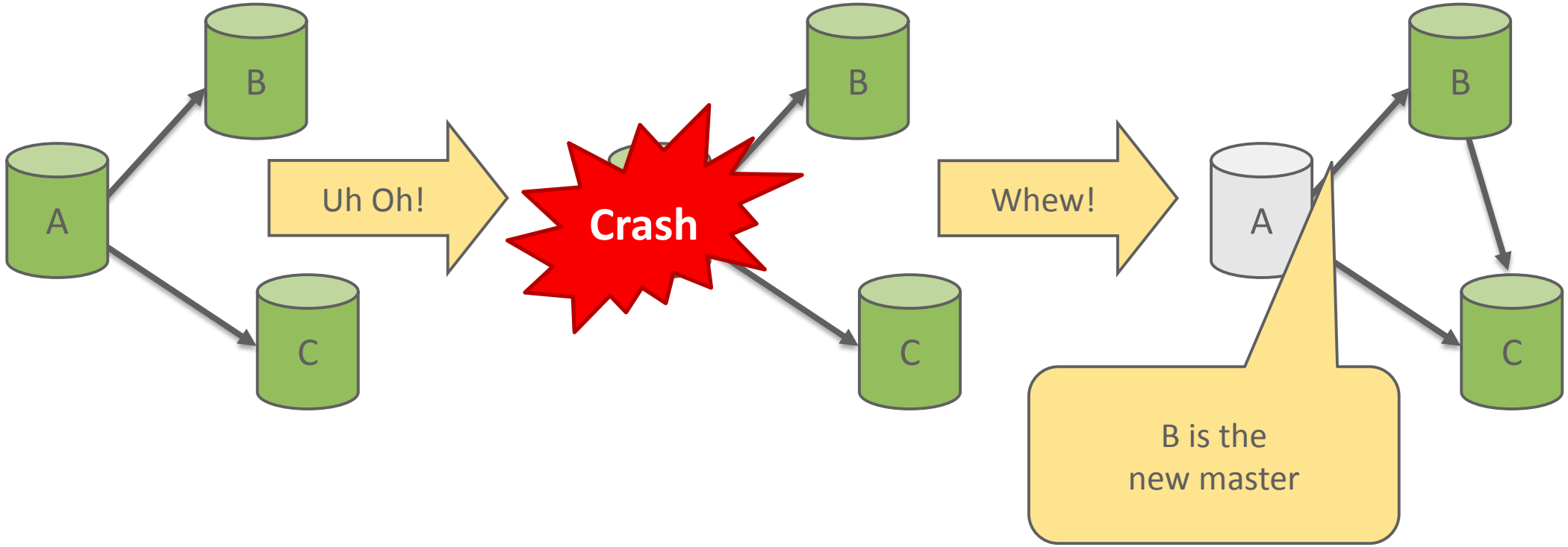
Background: What is Replication Used For?

Redundancy: If master crashes, promote slave to master



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Background: What is Replication Used For?

On-line Backup and Reporting

write clients

business intelligent client applications
reporting client applications
big queries client applications

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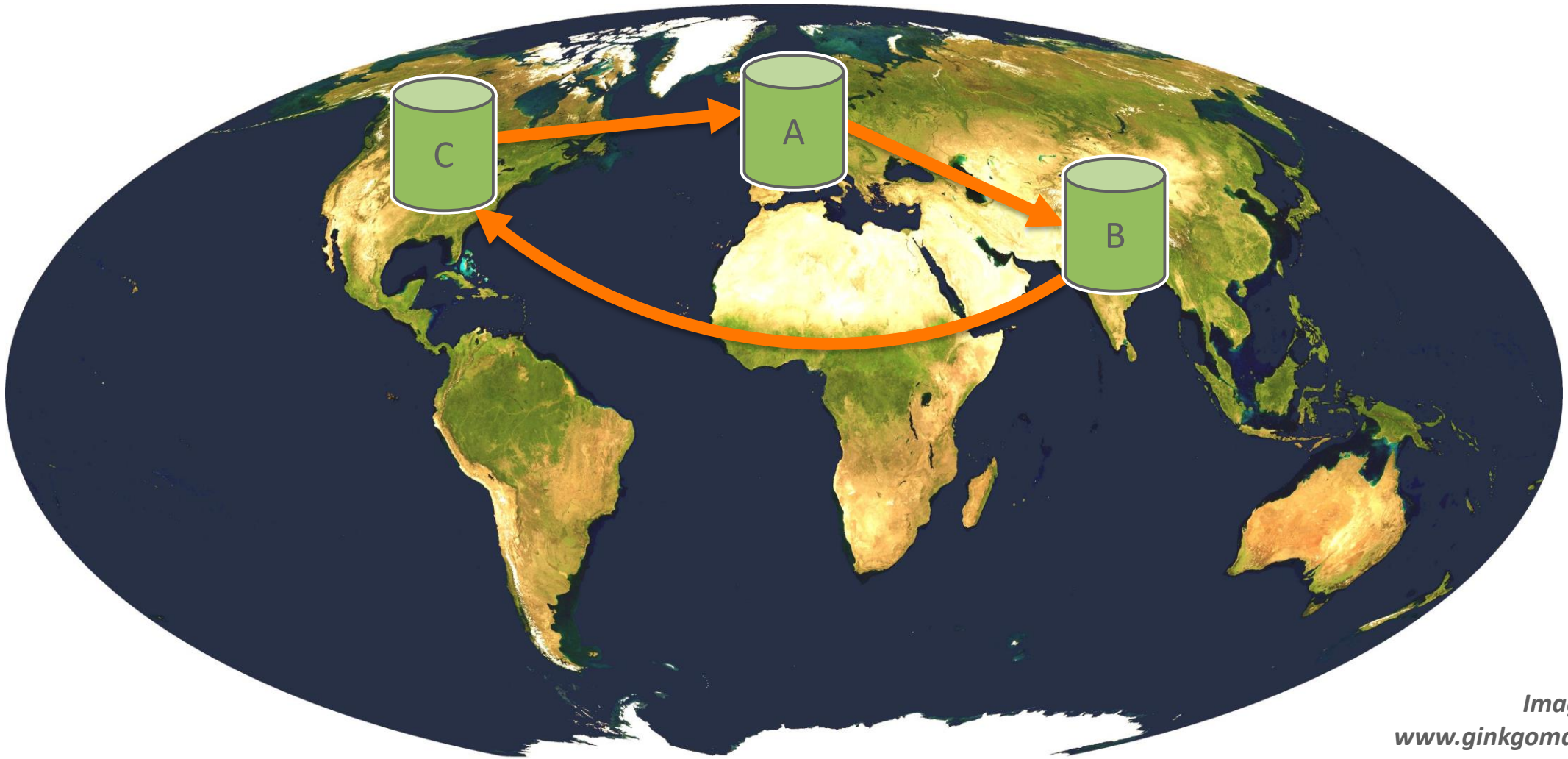
Background: What is Replication Used For?



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3 The New Replication Features in MySQL 5.7

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3 The New Replication Features in MySQL 5.7

3.1 Usability / Online

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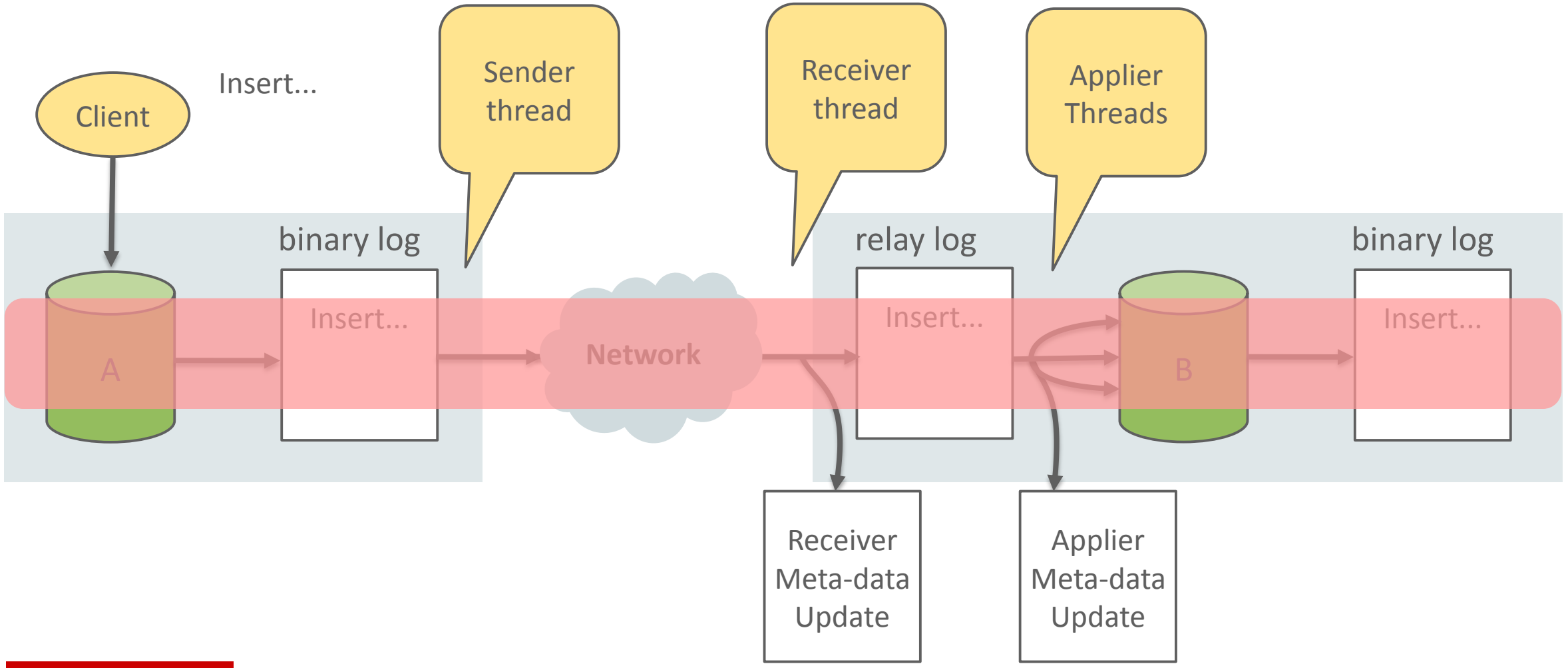
Online Reconfiguration of Global Transaction Identifiers



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Online Reconfiguration of Global Transaction Identifiers

- The procedure is online.
  - Both reads and writes are allowed while global transaction identifiers are being turned on or off in the entire replication cluster.
- No need to synchronize servers, ever.
- No need to restart servers.
- No need to change replication topology.
  - Works in arbitrary topologies.
- Should anything happen in the middle of the procedure, you can always roll back.

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Online Reconfiguration of Global Transaction Identifiers

- Over simplified procedure to turn on global transaction identifiers:

1) SET @@GLOBAL.GTID_MODE = OFF_PERMISSIVE; (on every server)
2) SET @@GLOBAL.GTID_MODE = ON_PERMISSIVE; (on every server)
3) wait for a bit longer than your replication lag
4) SET @@GLOBAL.GTID_MODE = ON; (on every server)

- Details: http://dev.mysql.com/doc/refman/5.7/en/replication-mode-change-online-enable-gtids.html

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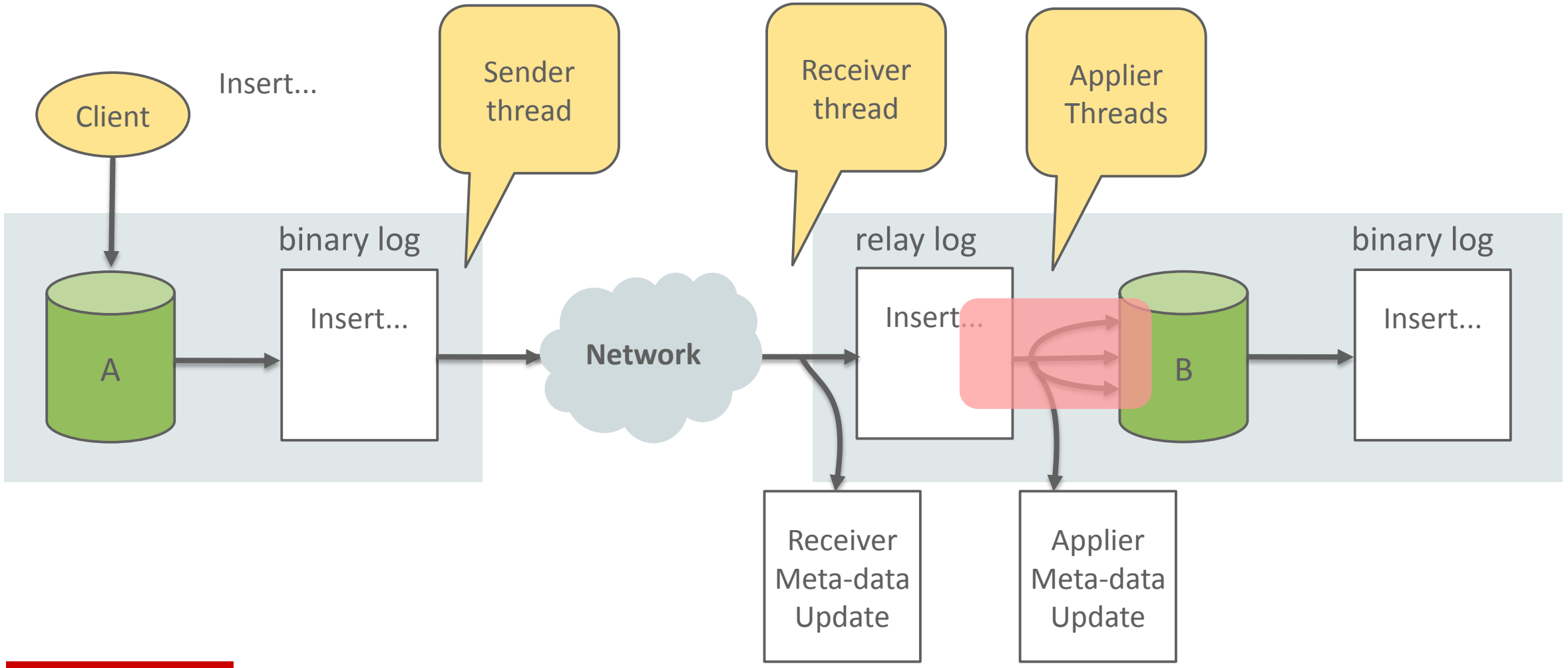
Online Reconfiguration of Replication Filters



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Online Reconfiguration of Replication Filters

- Change Slave's Replication Filters dynamically.
  - No need to stop and restart the slave server for setting new replication filtering rules.
  - All slave filters are supported.
  - Values can be input in various character sets.

```
mysql> CHANGE REPLICATION FILTER REPLICATE_DO_DB= (db1, db2)
```


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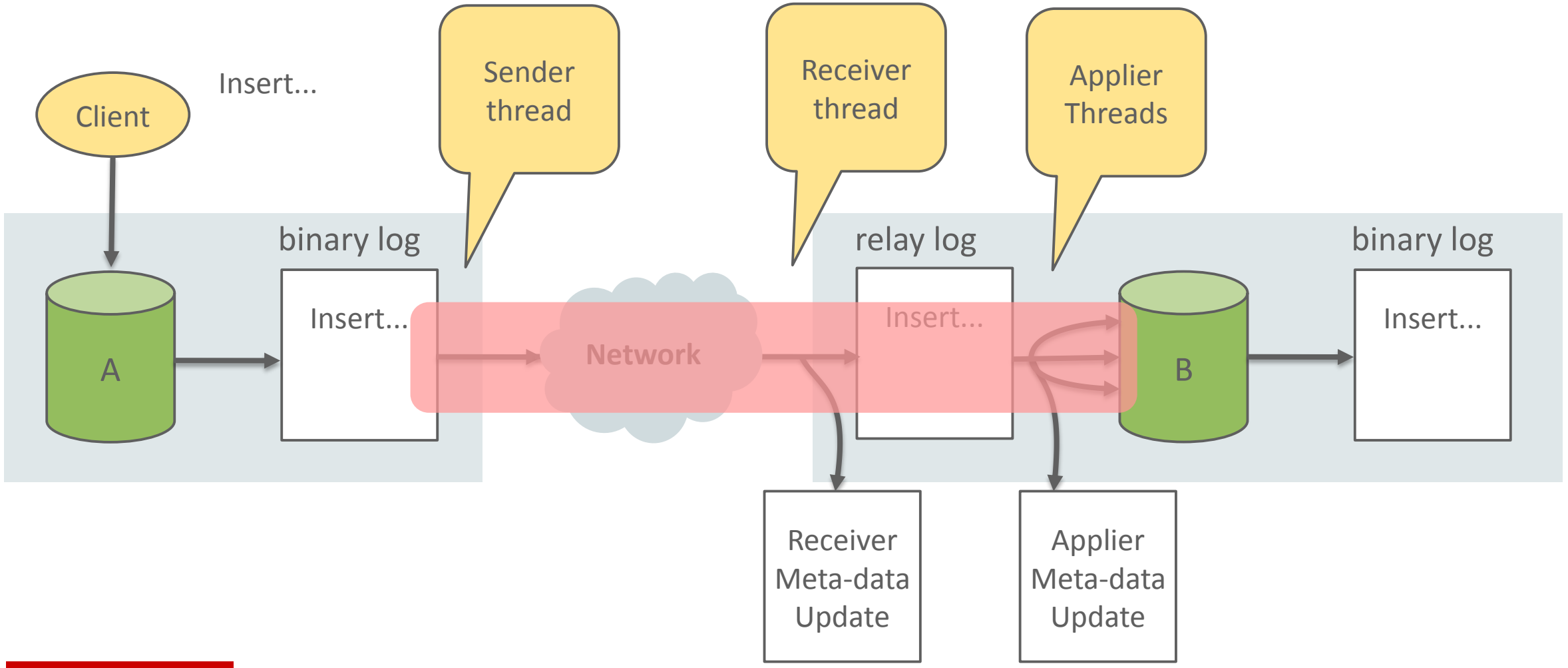
Online Reconfiguration of Replication Receiver/Applier



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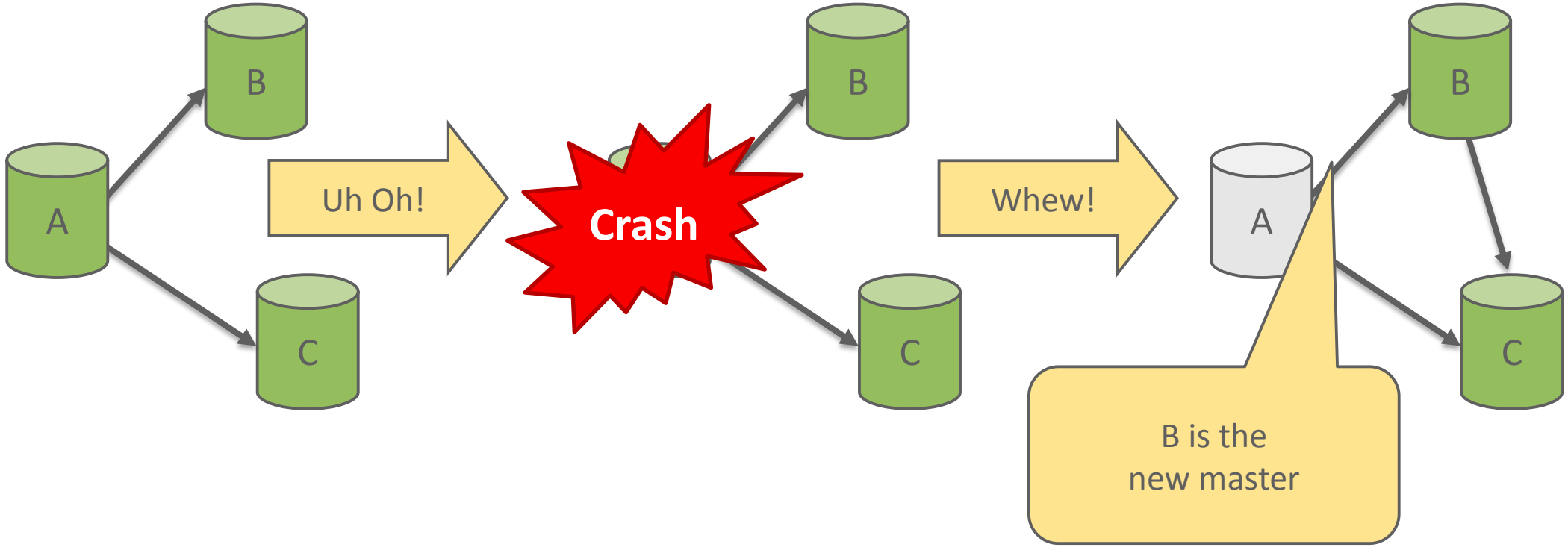
Online Reconfiguration of Replication Receiver/Applier

Change master from A to B without stopping the applier threads.



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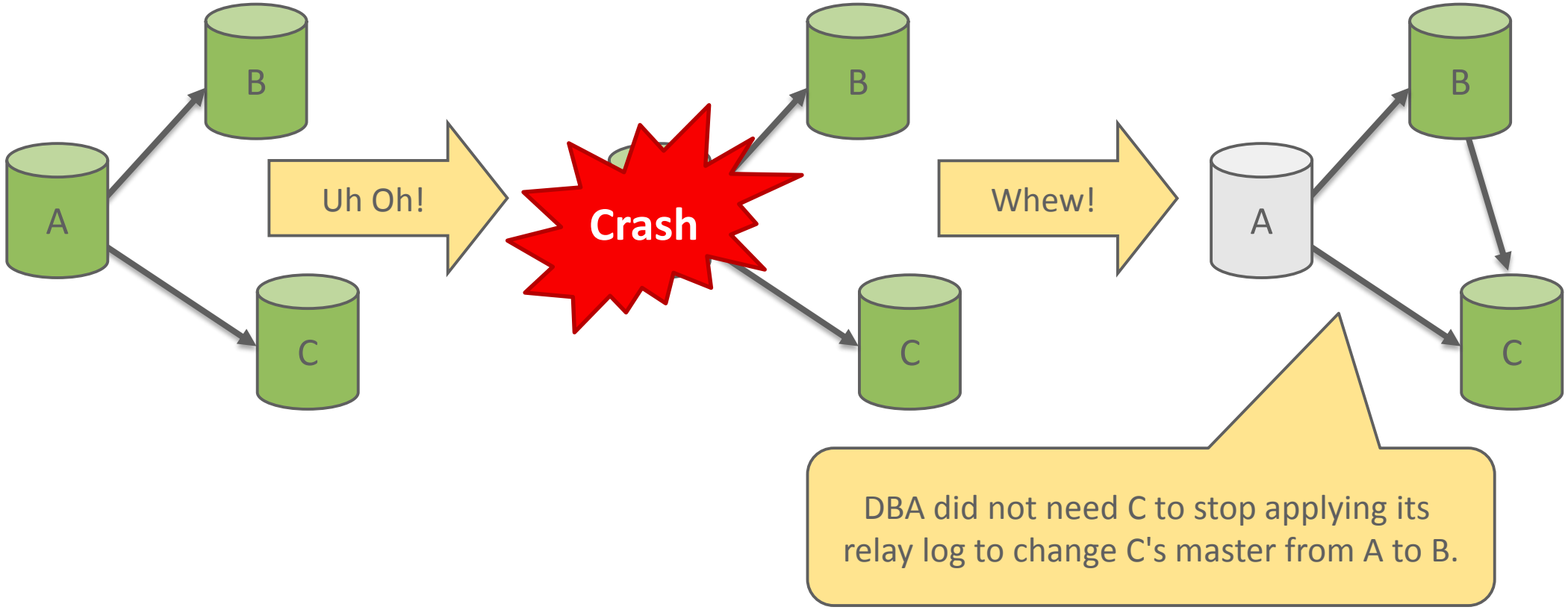
Online Reconfiguration of Replication Receiver/Applier

Change master from A to B without stopping the applier threads.



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Online Reconfiguration of Replication Receiver/Applier

- Enables more online operations during fail-over:

```
mysql> STOP SLAVE IO_THREAD;
mysql> CHANGE MASTER TO MASTER_HOST='master2', …;
mysql> START SLAVE IO_THREAD;
```

- Stopping, changing master and restarting the receiver thread are all done while the applier thread is running.
- Change applier properties while the receiver thread is working:

```
mysql> STOP SLAVE SQL_THREAD;
mysql> CHANGE MASTER TO MASTER_DELAY=3600, …;
mysql> START SLAVE SQL_THREAD;
```


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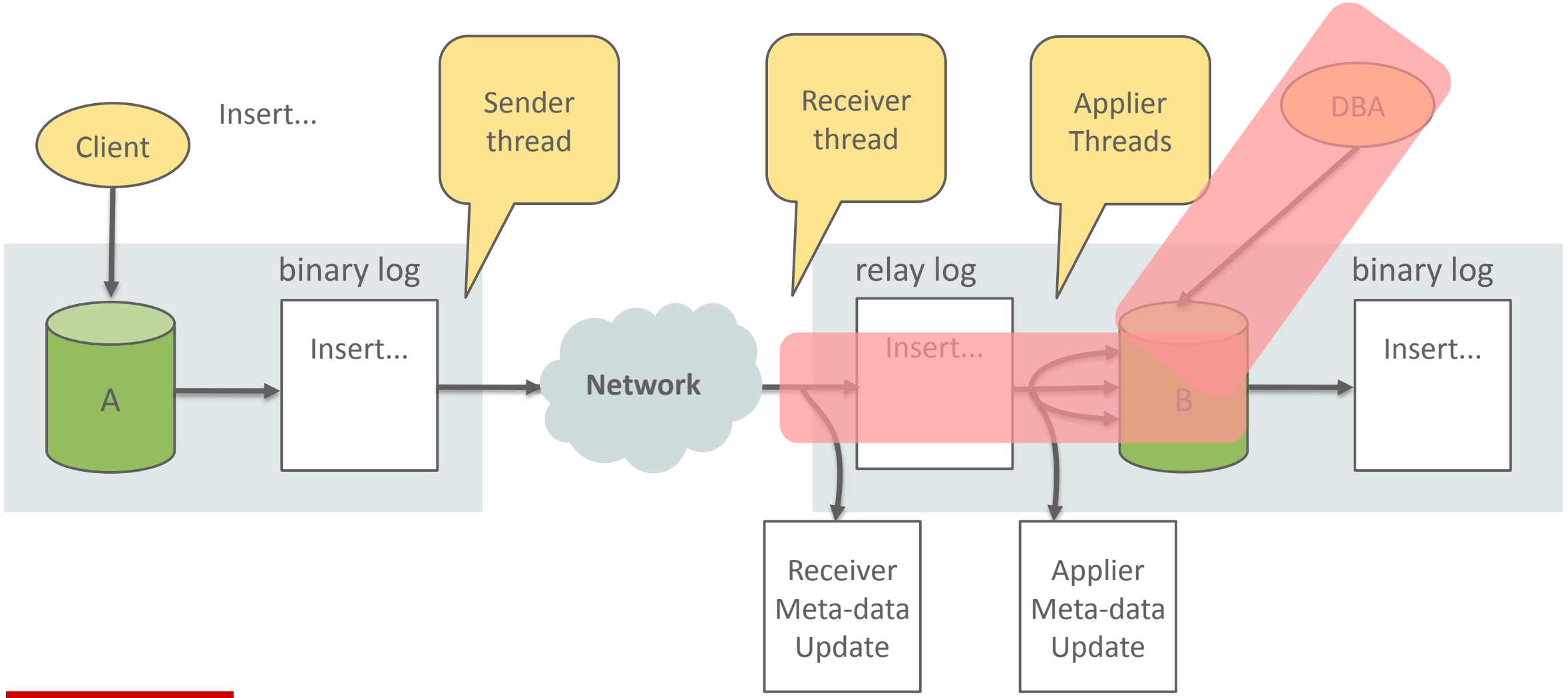
Improved Replication Monitoring



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Improved Replication Monitoring

Performance Schema Replication Tables

- Monitoring through SQL.
- Grouping logically related information.
- Extensible, can be adapted to new features.
- More accurate and consistent identifier names.
- Master-slave, Multi-source, Group Replication support.

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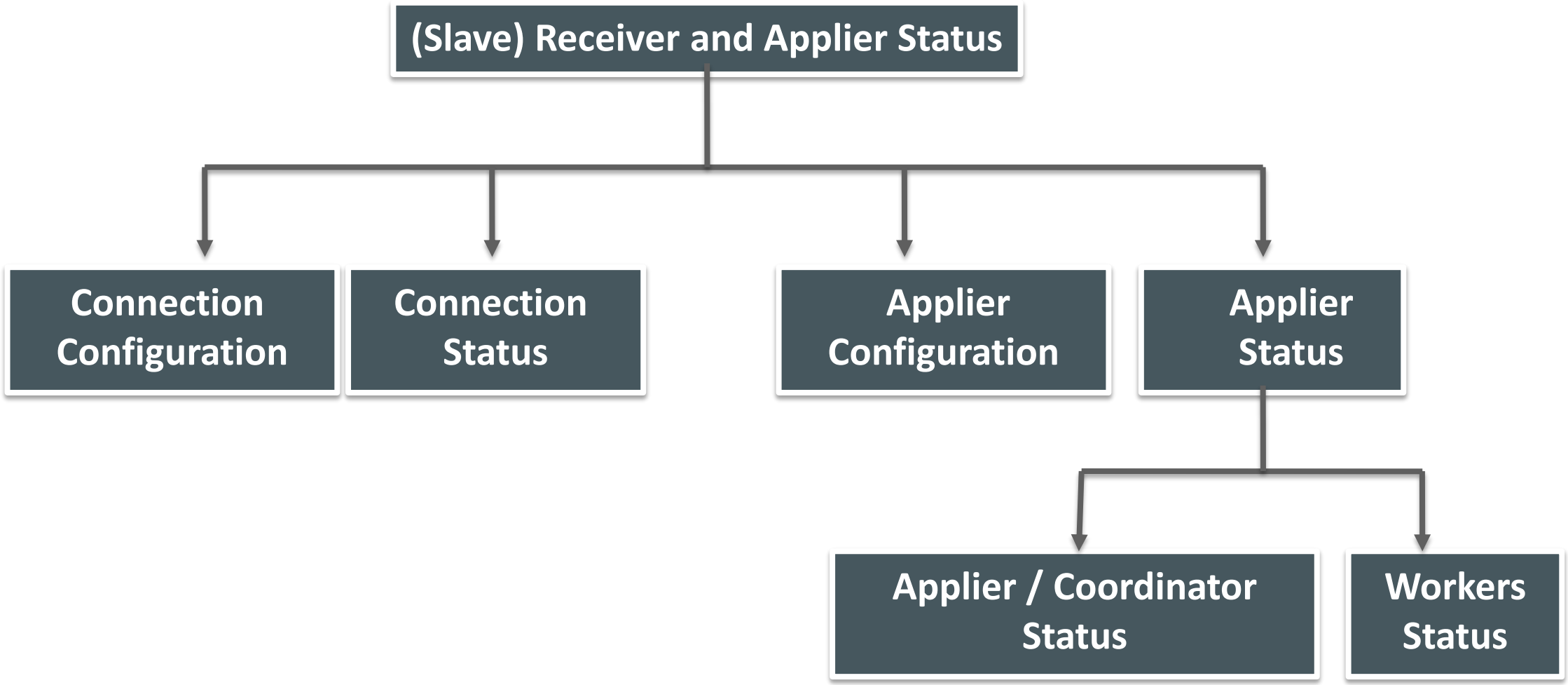
Improved Replication Monitoring



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Improved Replication Monitoring

```
mysql> select * from performance_schema.replication_applier_status_by_worker\G
*************************** 1. row ***************************
        CHANNEL_NAME:
           WORKER_ID: 1
           THREAD_ID: 35
       SERVICE_STATE: ON
LAST_SEEN_TRANSACTION: 4ba0eb86-63c3-11e4-92ba-28b2bd168d07:2368
    LAST_ERROR_NUMBER: 0
   LAST_ERROR_MESSAGE:
 LAST_ERROR_TIMESTAMP: 0000-00-00 00:00:00
*************************** 2. row ***************************
        CHANNEL_NAME:
           WORKER_ID: 2
           THREAD_ID: 36
       SERVICE_STATE: ON
LAST_SEEN_TRANSACTION: 4ba0eb86-63c3-11e4-92ba-28b2bd168d07:2367
    LAST_ERROR_NUMBER: 0
   LAST_ERROR_MESSAGE:
 LAST_ERROR_TIMESTAMP: 0000-00-00 00:00:00
2 rows in set (0,00 sec)
```


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3 The New Replication Features in MySQL 5.7

3.1 Usability / Online

3.2 Performance

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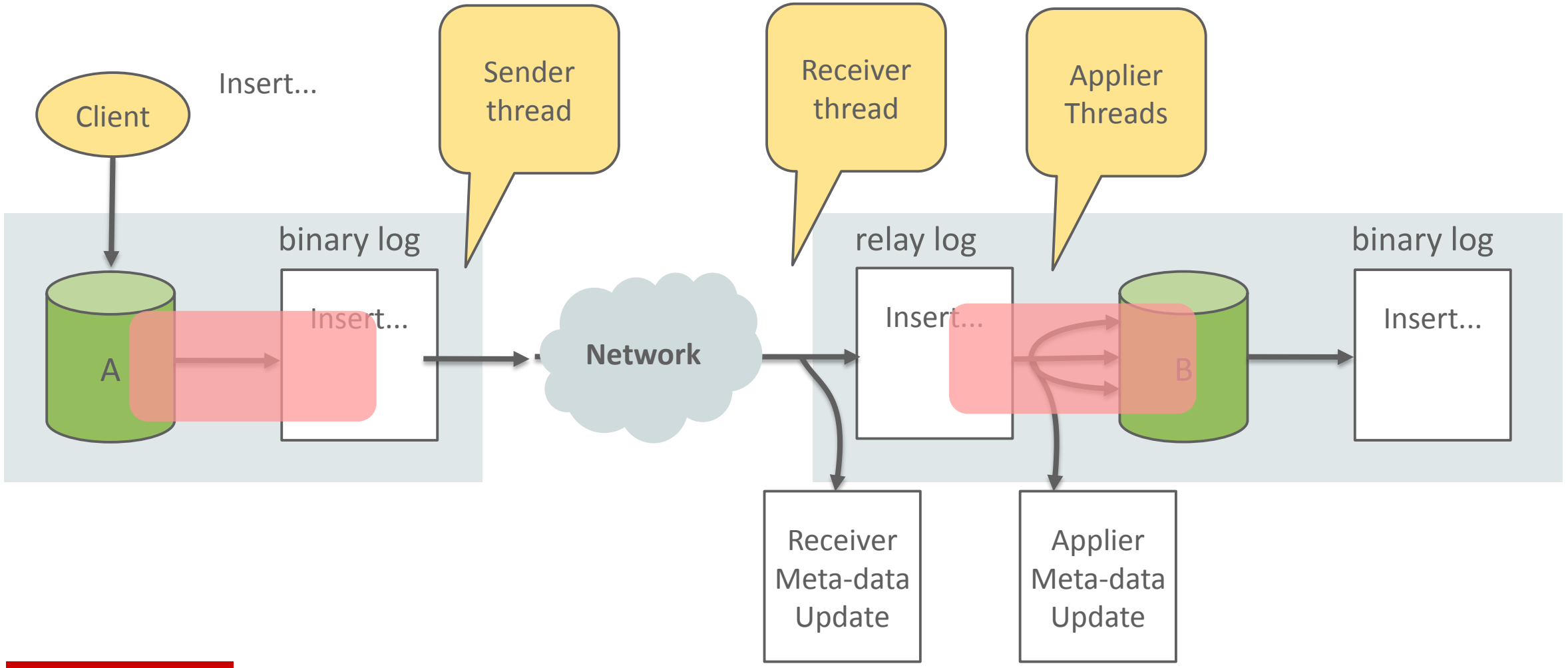
Improved Applier Throughput – Locking-based Parallelism



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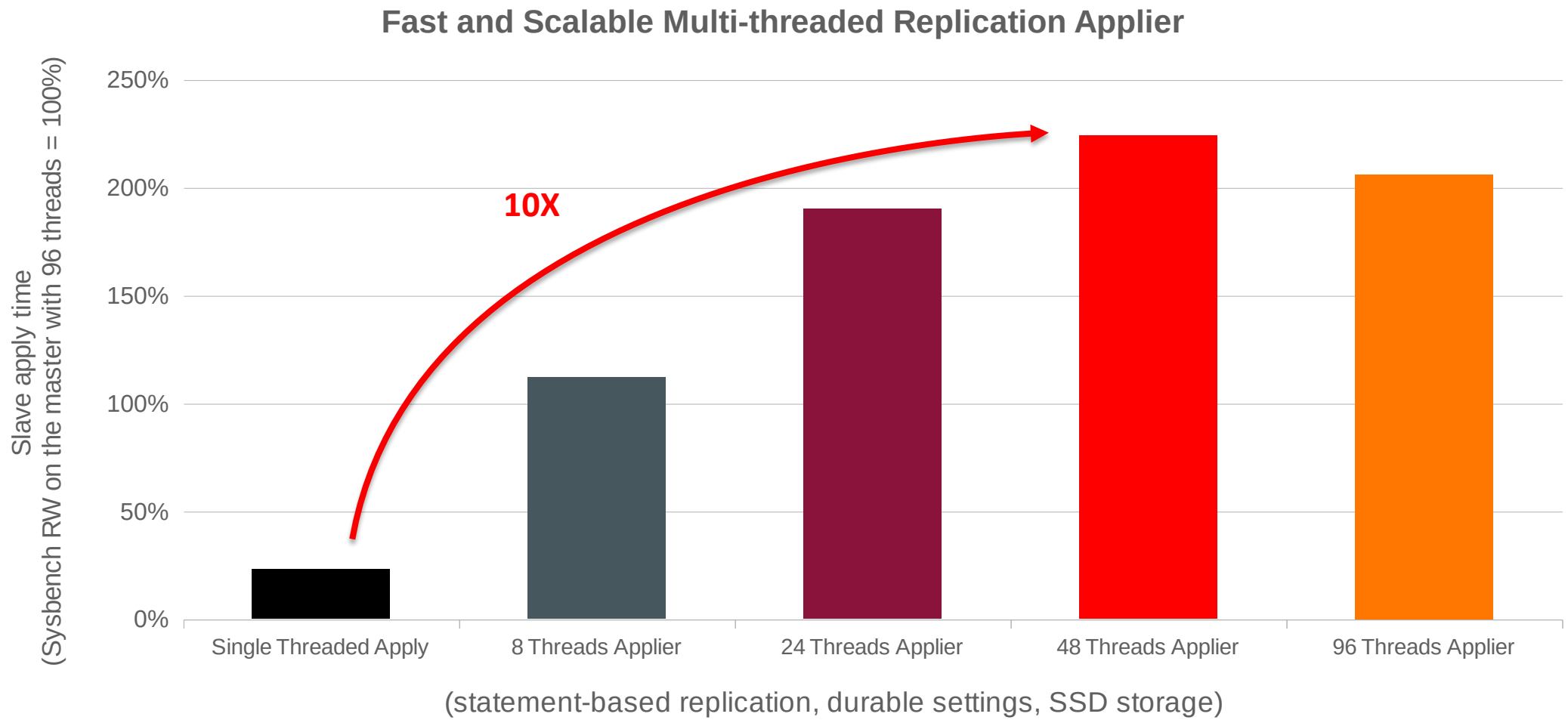
Improved Applier Throughput – Locking-based Parallelism



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Improved Applier Throughput – Locking-based Parallelism

- Leverage parallelization information from master execution:
  - Concurrent transactions, which **have not blocked each other** on the master, are marked as non-contending in the binary log.
- Meanwhile, at the slave:
  - Non-contending transactions are scheduled in **parallel**;
  - Concurrent transactions commit independently, thus **no waiting** involved.

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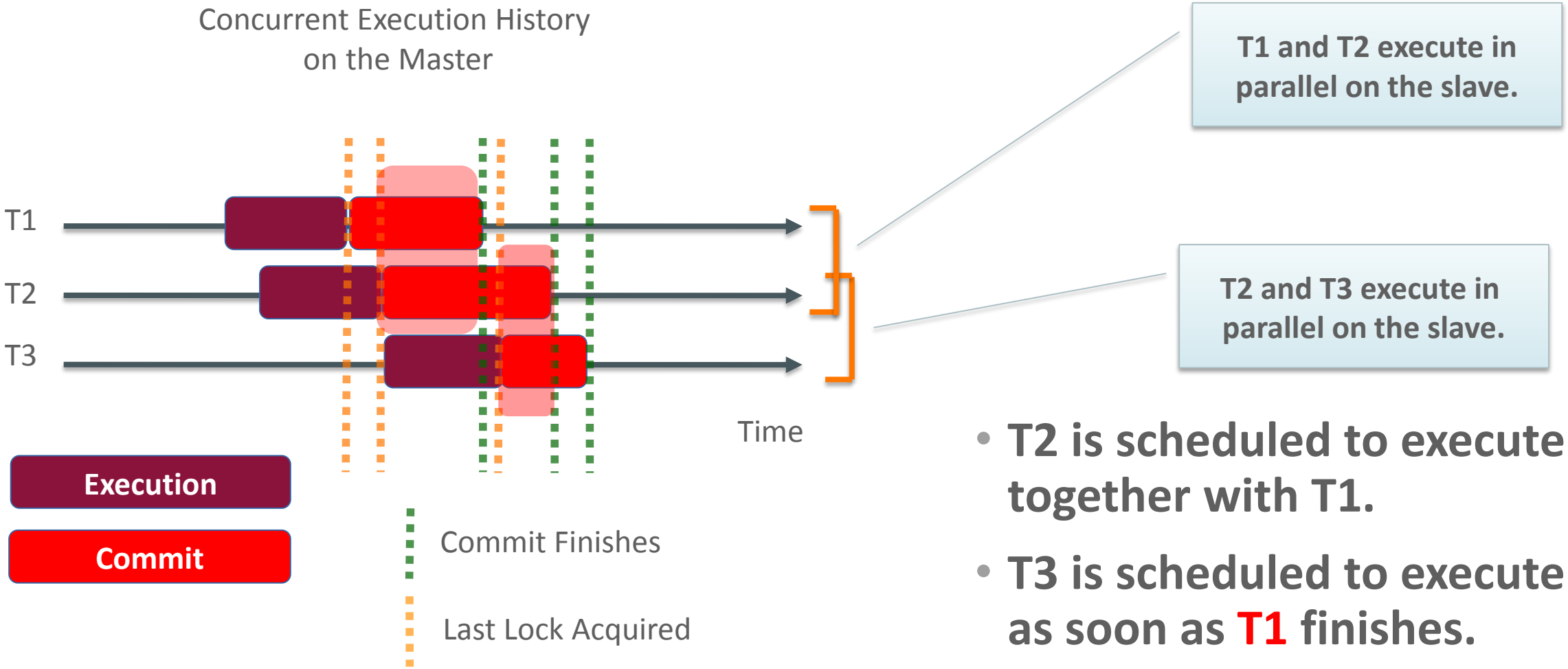
Improved Applier Throughput – Locking-based Parallelism



- **T2 is scheduled to execute together with T1.**
- **T3 is scheduled to execute as soon as T1 finishes.**

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Improved Applier Throughput – Locking-based Parallelism

- Supports statement-based or row-based formats.
- Scheduling policy controlled through:

```
mysql> SET slave_parallel_type= [logical_clock|database]
```

  - ***logical_clock*** - means schedule based on the locking interval timestamps.
  - ***database*** - the scheduling policy from 5.6 (concurrency control done per database).
- Work to improve slave scalability continues, does not stop here.

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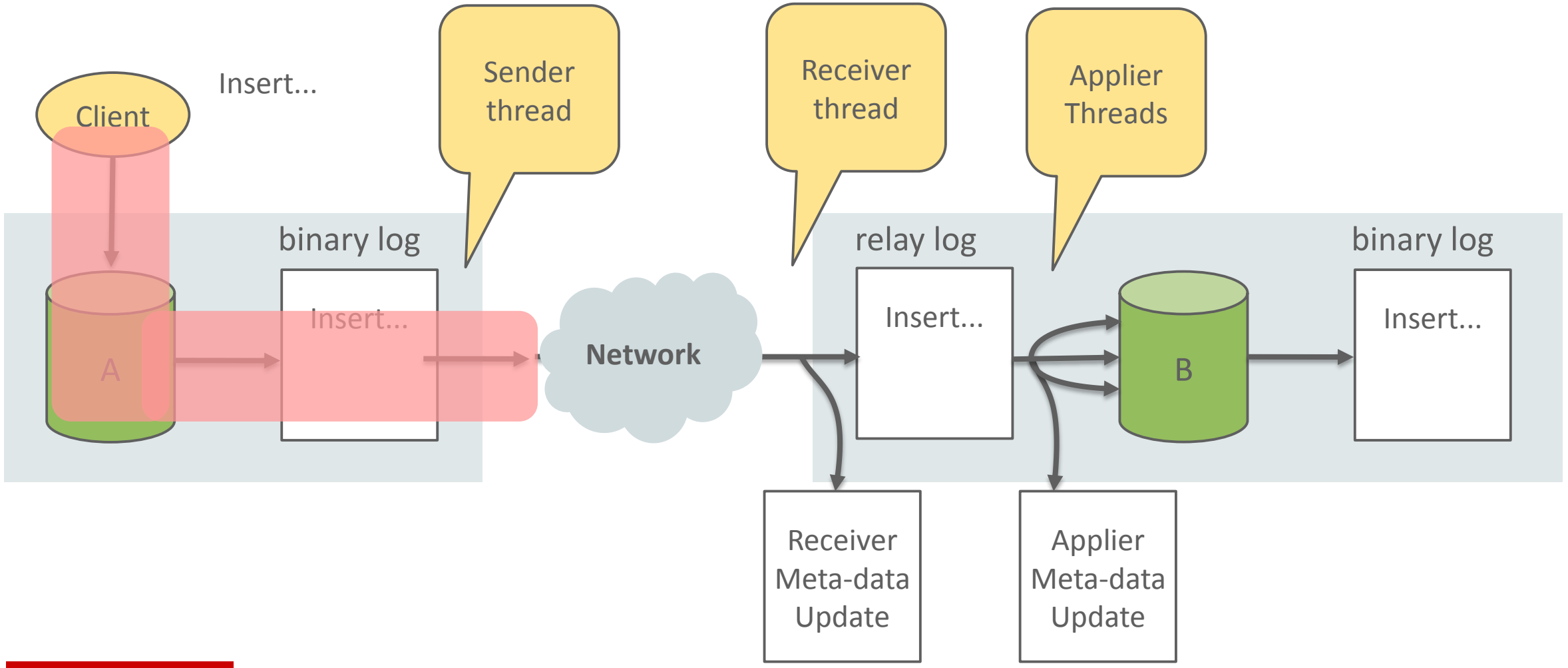
Improved User Threads-Sender Threads Synchronization



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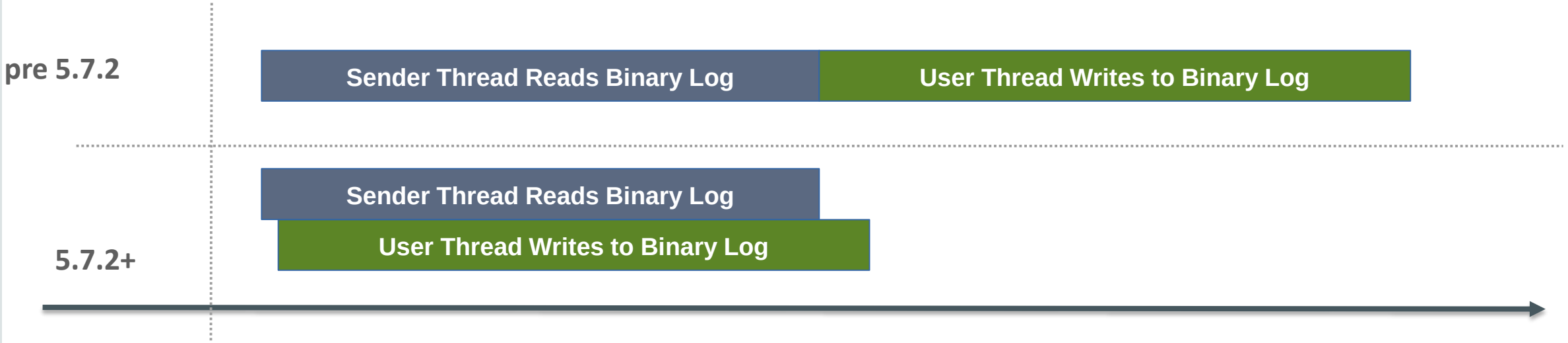
Improved User Threads-Sender Threads Synchronization

- Concurrent reads by the sender thread with ongoing writes from user threads.
  - Sender thread does not block user sessions more than necessary.
  - Higher throughput for both sender threads and user sessions.



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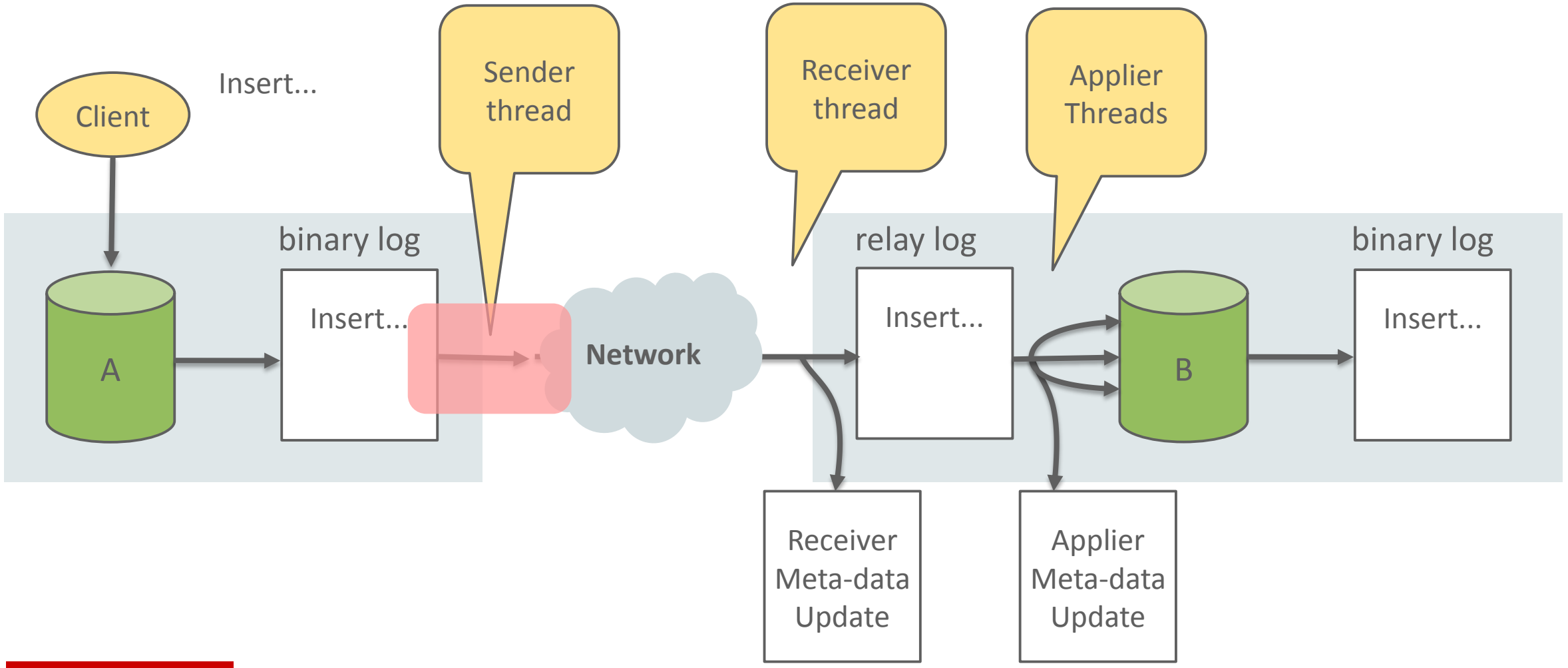
Faster Sender Thread



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Faster Sender Thread

- Send buffer is not allocated and freed every time an event is sent.
- When sender threads require larger send buffer - buffer grows as needed.
- When buffer is larger than needed - buffer shrinks dynamically.
- Together with the sender thread enhancements released on MySQL 5.7.2:
  - increases master scalability;
  - reduces resource consumption (CPU);
  - Master, with dump threads attached, copes better with peak loads.

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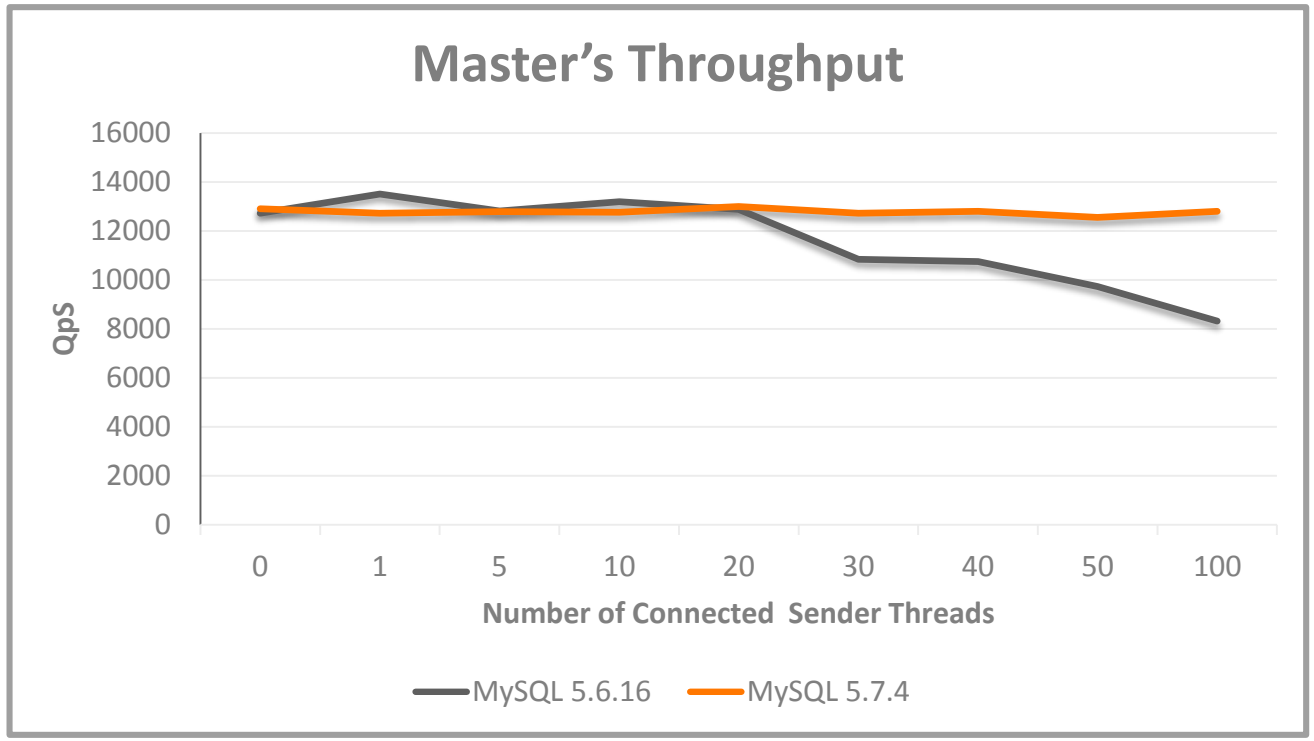
Faster Sender Thread



- Ad hoc microbenchmark using mysqlslap
- 1M queries, concurrency=200, commit=1
- N slaves attached (fake slaves using remote mysqlbinlogs)
- 48 cores HT / 512 GB RAM / HDD

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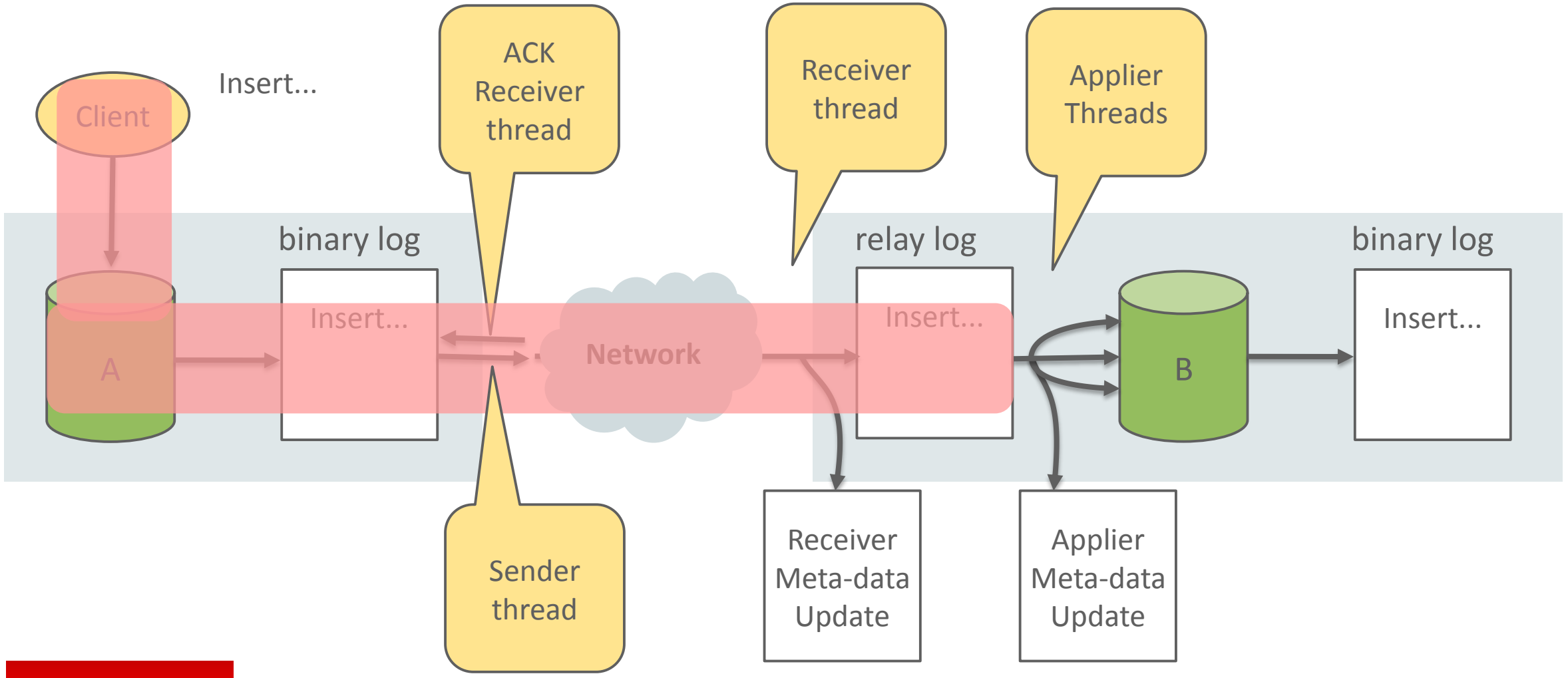
Faster Semi-sync Replication – ACK Receiver Thread



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Faster Semi-sync Replication – ACK Receiver Thread

- Consecutive transactions do not block each other while waiting for ACKs
  - Transaction t1 and t2 are sent immediately to the slave by the sender thread
  - ACKs are received only by a special thread
  - Transaction t2 does not include t1 round trip in its semi-sync overall latency
- Thread starts when semi-sync is activated

```
mysql> SET GLOBAL rpl_semi_sync_master_enabled= ON
```

- Thread stops when semi-sync is deactivated

```
mysql> SET GLOBAL rpl_semi_sync_master_enabled= OFF
```


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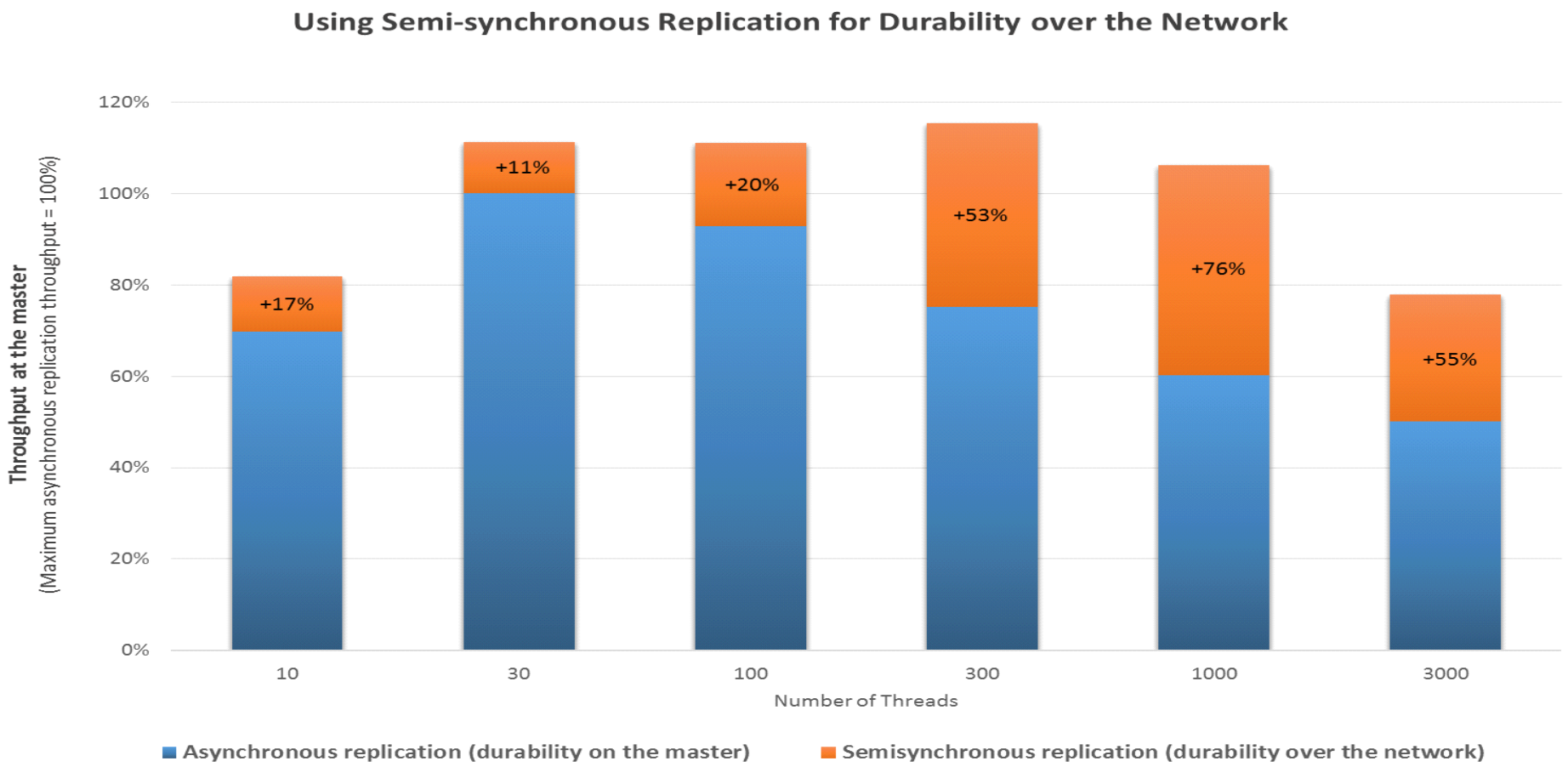
Faster Semi-sync: Durability over the Network



Orange bar **percentage** shows the throughput gain (orange) when compared to the corresponding blue bar. Blue and stacked bars show throughput ratio computed against the best blue bar.

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3 The New Replication Features in MySQL 5.7

3.1 Usability / Online

3.2 Performance

3.3 Dependability

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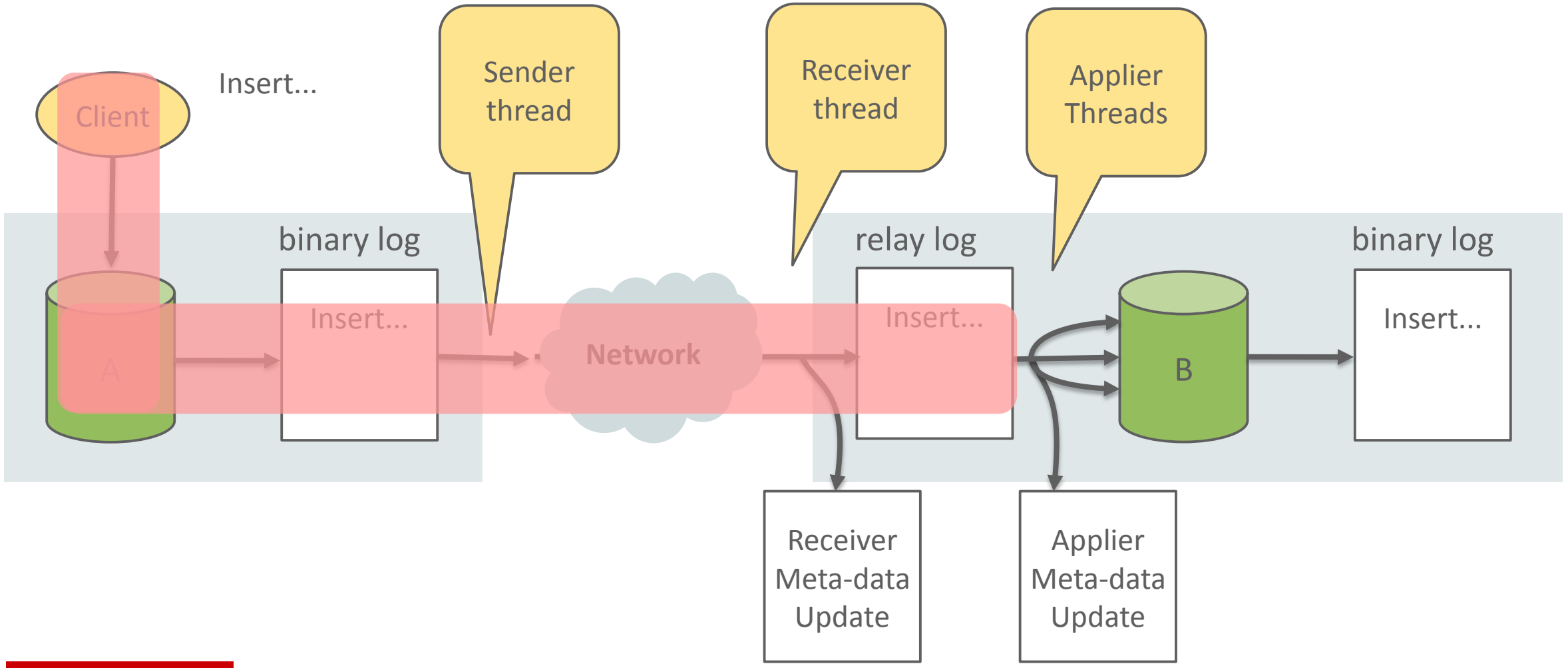
Loss-less Semi-sync Replication



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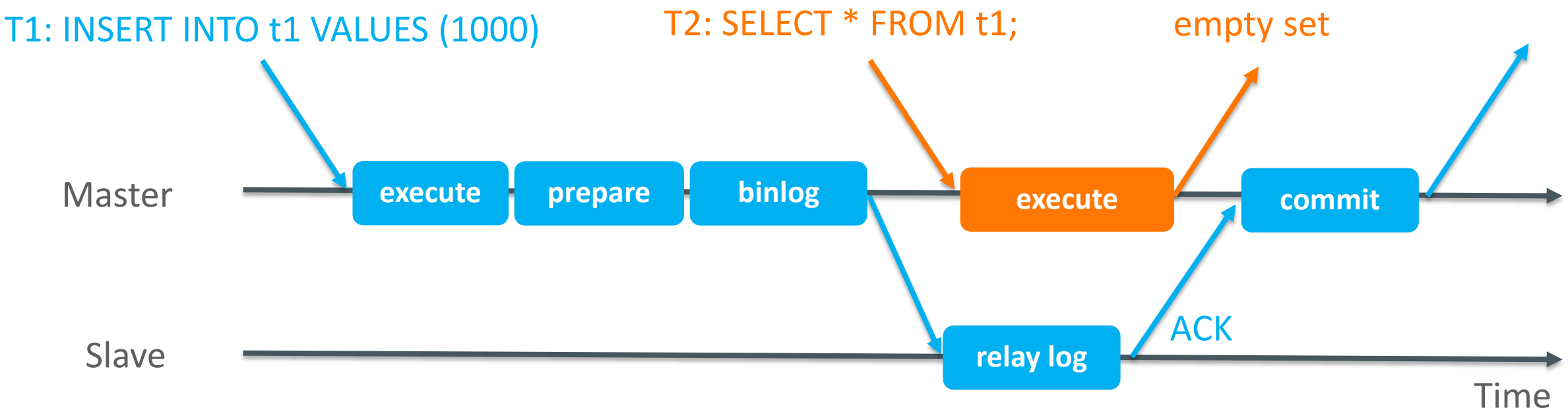
Loss-less Semi-sync Replication



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Loss-less Semi-sync Replication

- Master waits for slave's ACK **before** committing (as opposed to: master waits for slave's ACK **after** committing).
  - Therefore, concurrent transactions do not see changes while this transaction waits for ack.
- Should a master fail, then any transaction that it may have externalized is also persisted on a slave.
- User can choose between the original semi-sync behavior and the new

```
mysql> SET rpl_semi_sync_master_wait_point= [AFTER_SYNC|AFTER_COMMIT]
```


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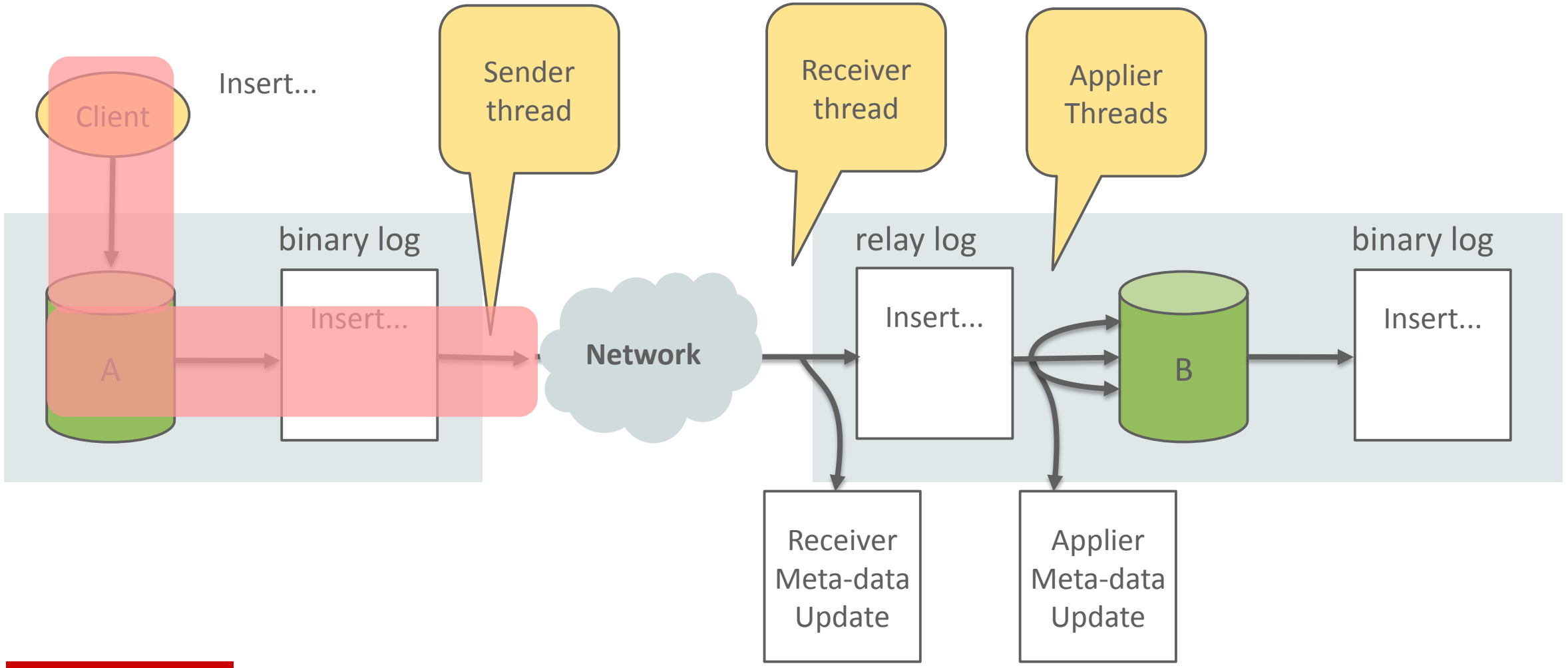
Semi-sync Replication – Wait for Multiple ACKs



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Semi-sync Replication – Wait for Multiple ACKs

- Master does **not commit** transaction until it receives **N** ACKs from **N** slaves.
- Dynamically settable:

```
mysql> SET GLOBAL rpl_semi_sync_master_wait_for_slave_count= N
```


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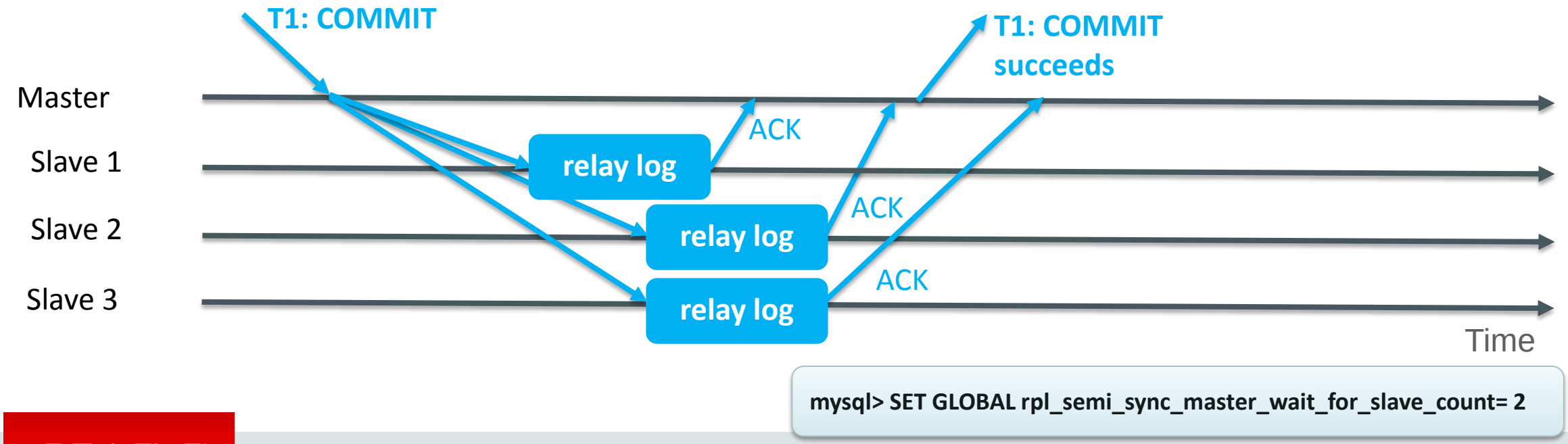
Semi-sync Replication – Wait for Multiple ACKs

- Master does **not commit** transaction until it receives **N** ACKs from **N** slaves.
- Dynamically settable:

```
mysql> SET GLOBAL rpl_semi_sync_master_wait_for_slave_count= N
```



mysql> SET GLOBAL rpl_semi_sync_master_wait_for_slave_count= 2

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3 The New Replication Features in MySQL 5.7

3.1 Usability / Online

3.2 Performance

3.3 Dependability

3.4 Flexibility

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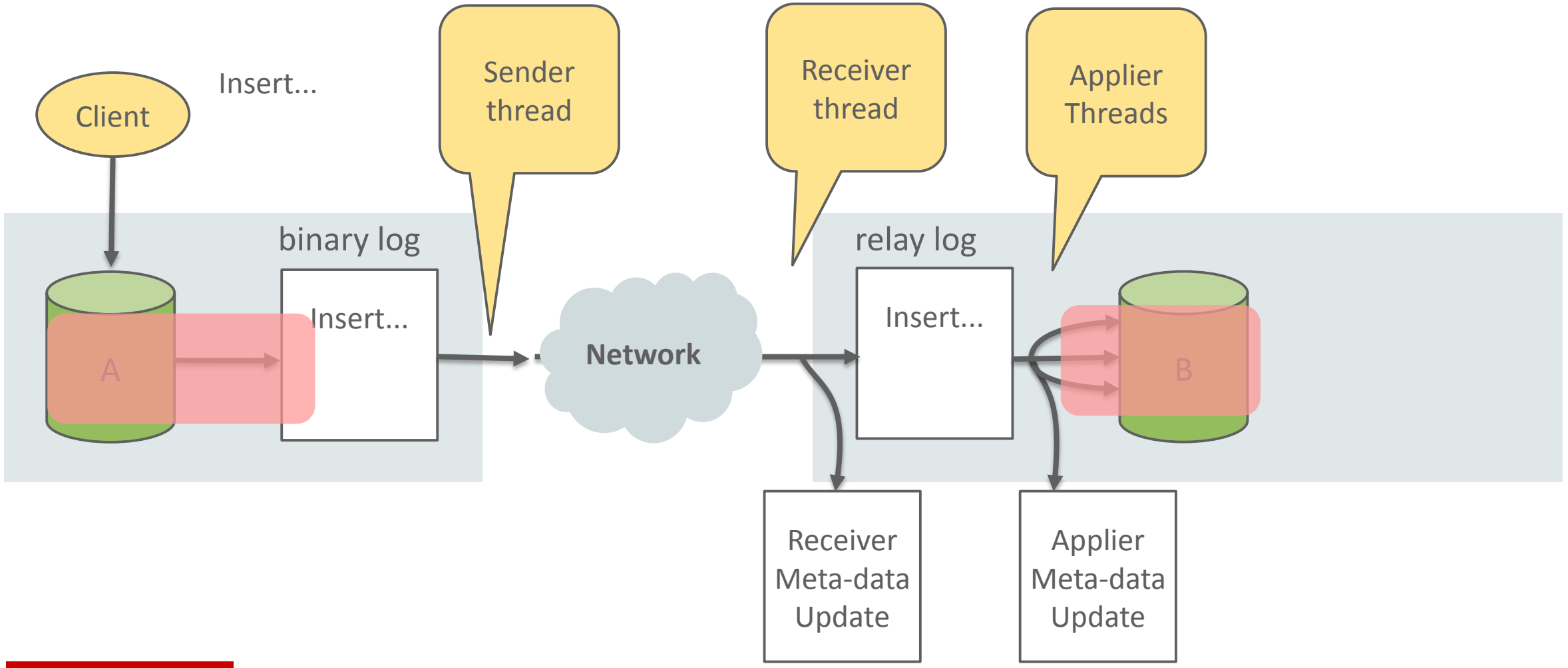
Storing Global Transaction Identifiers in a Table



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Storing Global Transaction Identifiers in a Table

Use Cases

- Slaves can use GTIDs with binary logs disabled.
  - Slaves that are never candidates to become a master can still use GTIDs for auto positioning.

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Storing Global Transaction Identifiers in a Table

Mechanics

- GTIDs are saved into a mysql system table (range-compressed).

```
CREATE TABLE gtid_executed(
   source_uuid CHAR(36) NOT NULL,
   interval_start BIGINT NOT NULL,
   interval_end BIGINT NOT NULL,
   PRIMARY KEY(source_uuid, interval_start)
 );
```

- GTIDs are **inserted** into the table as transactions commit.
- A compression thread runs periodically and compresses the table into ranges.
  - New global variable controls the period: gtid_executed_compression_period.

```
mysql> SET GLOBAL gtid_executed_compression_period= N;(N – number of transactions)
```


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Storing Global Transaction Identifiers in a Table

Mechanics

- Binary Log Enabled
  - Store GTID in binary log (transactionally).
  - Copy GTID set to table on binary log rotation.
- Binary Log Disabled
  - Store GTID in table (transactionally).
  - New transactions do not get an automatic GTID assigned.
- Always store GTIDs transactionally.

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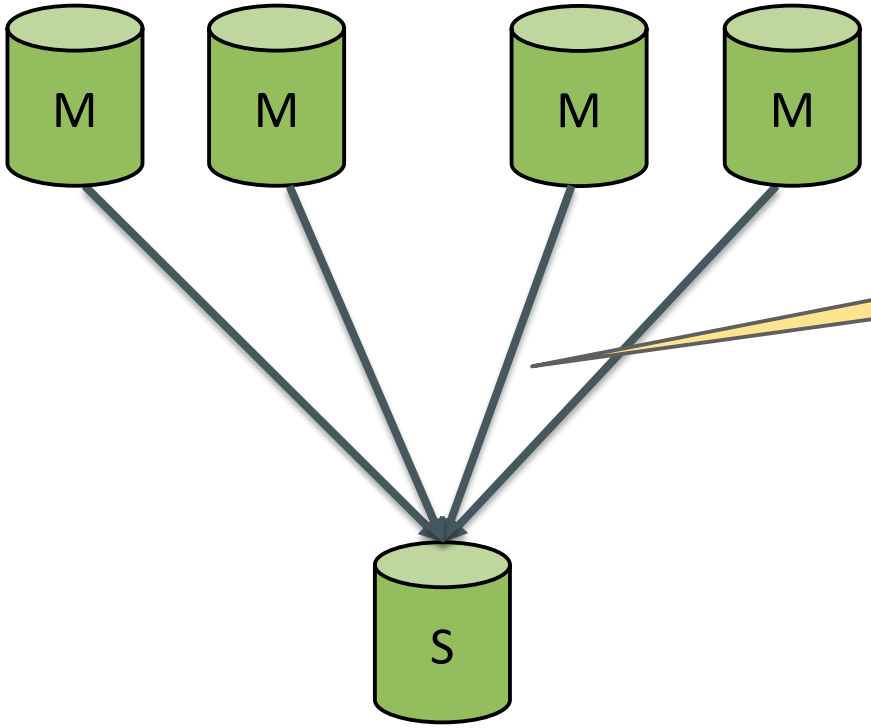
Multi-Source Replication



Slave **can** have more than **one master.**

The need for gathering data in a central server:

- Integrated backup;
- Complex queries for analytics purposes;
- Data HUB for inter-cluster replication.

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Multi-Source Replication

- A server (slave) can replicate from multiple sources (masters).
- Multiple channels (channel: receiver thread, relay logs, applier threads) that can be stopped started individually.
- Integrated with Multi-threaded Slave (each channel has its own multi-threaded applier set of threads).
- Integrated with the new P_S tables.
  - replication_applier_status_by_coordinator shows multiple entries, one per channel/source coordinator.
  - replication_applier_status_by_worker shows multiple entries, multiple entries per channel
  - replication_connection_status shows multiple entries, one per connection to different sources.

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Multi-Source Replication

- Integrated with GTIDs.
- Integrated with crash-safe tables.
  - Progress state is stored in these tables for recoverability purposes.
- Virtually no limit on the number of sources (capped to 256, but can be changed if server binary is rebuilt).
- Able to manage each source separately.

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3 The New Replication Features in MySQL 5.7

- 3.1 Usability / Online
- 3.2 Performance
- 3.3 Dependability
- 3.4 Flexibility
- 3.5 Misc

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“Smaller”, yet interesting, enhancements!

- **Multi-threaded applier** is able to **retry failed transactions**.
- Option to make the **Multi-threaded applier preserve commit order**.
- **SSL** options for **mysqlbinlog** tool.
- **Rewrite DB** rules for the **mysqlbinlog** tool.
- **Function to wait for transactions to be applied**, regardless of the replication stream they come from.
- Options to **track global transaction identifiers** in the **return packet** of the mysql protocol. Useful for tracking GTID session state and enabler for session consistency.
- Support for **XA transactions** when the **binary log is enabled**.
- Change in the defaults. E.g., binlog_format=**ROW** and sync_binlog=**1**.
- Options to **fine tune** the binary log **group commit** procedure.

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4 Development Sneak Peek

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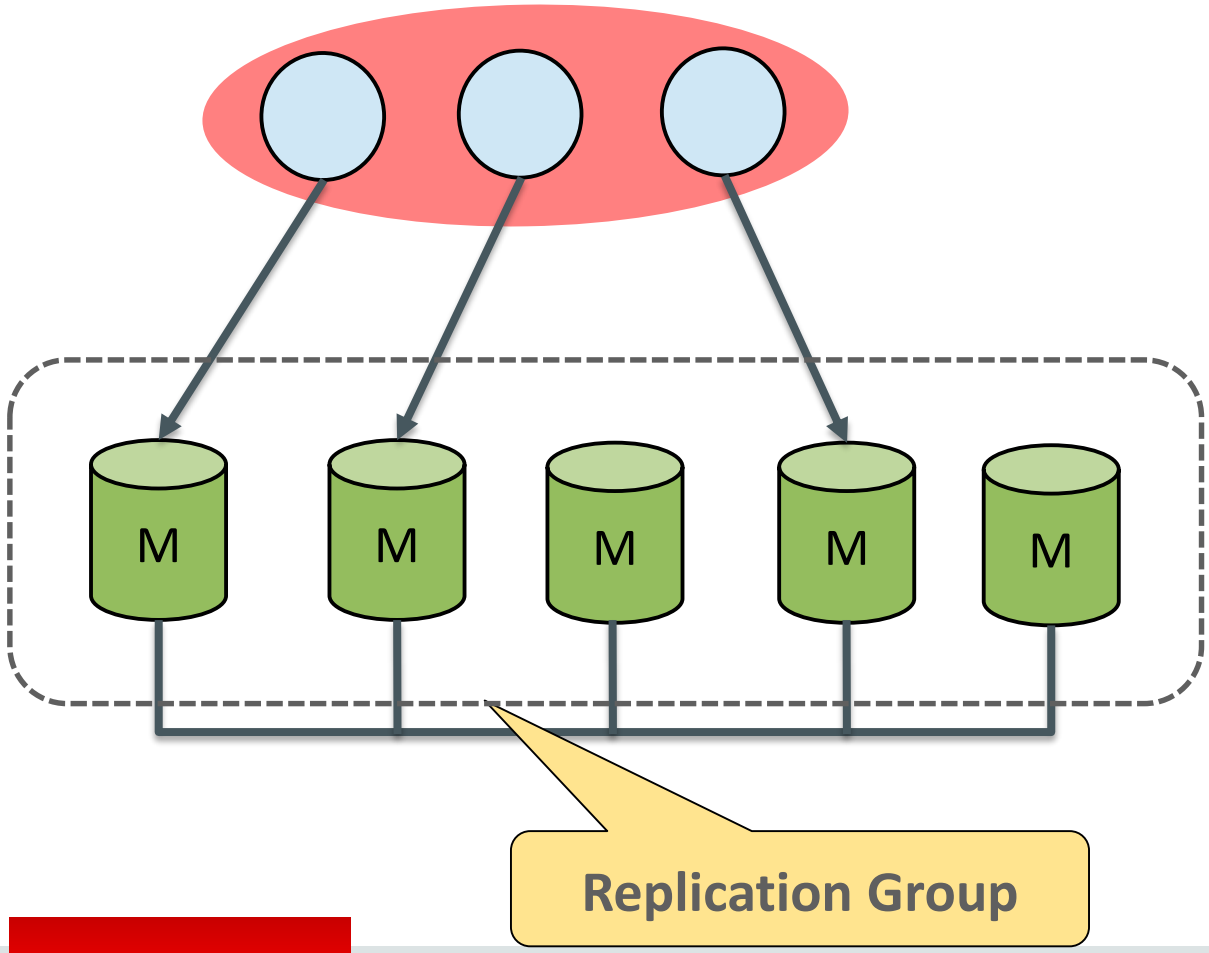
MySQL Group Replication Plugin



- Multi-master update everywhere
- **Automatic group membership management** and **failure detection**.
- **No need for server fail-over.**
- **Automatic reconfiguration.**
- No single point of failure.
- Shared-nothing state machine replication.
- **InnoDB compliant.** Off-the-shelf hardware friendly.

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5 Roadmap

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What is Next?

- MySQL **Group Replication**
  - Rapid releases.
  - Improve performance, stability and usability.
- MySQL Replication **Usability**
  - Instrument even more replication and extend replication P_S tables
  - Simpler administrative commands, more online operations
- MySQL Replication **Performance**
  - Continue to improve replication stream multi-threaded (slave) applier
  - Continue to improve replication stream pipeline performance and efficiency

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6 Summary

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Summary

- Replication feature set in MySQL 5.7 shows many improvements:
  - Semi-sync is more flexible and faster.
  - Less contention on the binary log.
  - Slave is faster and provides an inter-transaction parallelization scheme.
  - More online reconfiguration: Global Transaction Identifiers, filters, configuration.
  - Improved monitoring.
  - Even more flexible replication with multi-source enabling new deployment scenarios.
  - Enhancements all over: transaction retries, sequential commits, XA support, new replication functions, security.

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Where to go from here?

- Packages
  - http://dev.mysql.com
  - http://labs.mysql.com
- Reference Documentation
  - http://dev.mysql.com/doc/refman/5.7/en/replication.html
- Blogs from the Engineers (news, quirks, technical information and much more)
  - http://mysqlhighavailability.com

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