High Availability Using MySQL Group Replication

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Program Agenda

1. Background
2. MySQL Group Replication
3. Architecture
4. Big Picture
5. Conclusion
1 Background
Background: What is Replication Used For?

Read scale-out

Reads?
More
slaves!
Background: What is Replication Used For?

**Redundancy** as a major building block for high availability: If master crashes, **promote** slave to master
MySQL Group Replication

• **What is MySQL Group Replication?**
  
  “*Update everywhere* replication plugin for MySQL with built-in [automatic distributed recovery, conflict handling, group membership and distributed agreement]*.”

• **What does the MySQL Group Replication plugin do for the user?**
  
  – Removes the need for handling server fail-over.
  – Provides fault tolerance.
  – Enables update everywhere setups.
  – Automates group reconfiguration (handling of crashes, failures, re-connects).
  – Provides a highly available replicated database.
  – Automatic distributed coordination (protects against split-brain and message loss).
  – Less admin overhead, means more fun time!
MySQL Group Replication

Clients

Replication Group

Monday, April 25, 2016
MySQL Innovation Day 2016 - Redwood Shores, CA, US
Some Theory Behind It...

• Implementation based in Replicated Database State Machines
  – Group Communication Primitives resemble properties of Databases.

• Deferred update replication: **propagate atomically, check conflicts, eventually apply**
  – Distributed state machine requires agreed delivery – implies total order;
  – Deterministic certification requires total order delivery.

• Membership Service
  – Which servers are participating in the replication group at a given moment in time?
    (associated with a logical timestamp [ - view identifier]).
MySQL Group Replication

2.1 Multi-Master
Multi-Master update everywhere!

• Any two transactions on different servers can write to the same tuple.
• Conflicts will be detected and dealt with.
  – First committer wins rule.
Multi-Master update everywhere!

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  - First committer wins rule.

```
UPDATE t1 SET a=4 WHERE a=2
UPDATE t1 SET a=3 WHERE a=1
```

OK

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Multi-Master update everywhere!

- Any two transactions on different servers can write to the same tuple.
- Conflicts will be detected and dealt with.
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```
UPDATE t1 SET a=3 WHERE a=1
UPDATE t1 SET a=2 WHERE a=1
```
Multi-Master update everywhere!

- Any two transactions on different servers can write to the same tuple.
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```sql
UPDATE t1 SET a=3 WHERE a=1
UPDATE t1 SET a=2 WHERE a=1
```

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MySQL Group Replication

2.1 Multi-Master

2.2 Automatic distributed server recovery
Automatic distributed server recovery!

- Server that joins the group will automatically synchronize with the others.
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Automatic distributed server recovery!

• If a server leaves the group, the others will automatically be informed.

Each membership configuration is identified by a logical timestamp, i.e., view_id

My machine needs maintenance or a system crash happens

view_id: 4
Automatic distributed server recovery!

• If a server leaves the group, the others will automatically be informed.
Automatic distributed server recovery!

- Server that (re)joins the group will automatically synchronize with the others.
MySQL Group Replication

2.1 Multi-Master
2.2 Automatic distributed server recovery
2.3 MySQL/InnoDB look & feel
MySQL/InnoDB look & feel!

- Load the plugin and start replicating.
- Monitor group replication stats though Performance Schema tables.

```
mysql> SET GLOBAL group_replication_group_name= "9eb07c6d-5e24-11e5-854b-34028662c0cd";
mysql> START GROUP_REPLICATION;

mysql> SELECT * FROM performance_schema.replication_group_members
```

```
*************************** 1. row ***************************
CHANNEL_NAME: group_replication_applier
MEMBER_ID: 597dbb72-3e2c-11e4-9d9d-ecf4bb227f3b
MEMBER_HOST: nightfury
MEMBER_PORT: 13000
MEMBER_STATE: ONLINE
*************************** 2. row ***************************
```

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MySQL/InnoDB look & feel!

• Load the plugin and start replicating.
• Monitor group replication stats through Performance Schema tables.

```sql
mysql> SELECT * FROM performance_schema.replication_group_member_stats
*************************** 1. row ***************************
CHANNEL_NAME: group_replication_applier
VIEW_ID: 1428497631:3
MEMBER_ID: e38fdea8-dded-11e4-b211-e8b1fc3848de
COUNT_TRANSACTIONS_IN_QUEUE: 0
COUNT_TRANSACTIONS_CHECKED: 12
COUNT_CONFLICTS_DETECTED: 5
COUNT_TRANSACTIONS_VALIDATING: 6
TRANSACTIONS_COMMITTED_ALL_MEMBERS: 8a84f397-aaa4-18df-89ab-c70aa9823561:1-7
LAST_CONFLICT_FREE_TRANSACTION: 8a84f397-aaa4-18df-89ab-c70aa9823561:7
```
MySQL/InnoDB look & feel!

• Load the plugin and start replicating.
• Monitor group replication stats though Performance Schema tables.

```sql
mysql> SELECT * FROM performance_schema.replication_connection_status
```

```
*************************** 1. row ***************************
CHANNEL_NAME: group_replication_applier
GROUP_NAME: 8a94f357-aab4-11df-86ab-c80aa9429563
SOURCE_UUID: 8a94f357-aab4-11df-86ab-c80aa9429563
THREAD_ID: NULL
SERVICE_STATE: ON
...
```
MySQL Group Replication

2.1 Multi-Master
2.2 Automatic distributed server recovery
2.3 MySQL/InnoDB look & feel
2.4 Full GTID support
Full GTID support!

• All group members share the same UUID, the group name.

INSERT x;
Will have GTID: group_name:1

INSERT y;
Will have GTID: group_name:2
Full GTID support!

• Users can specify the identifier for the transaction.

SET GTID_NEXT= "UUID:50"
INSERT x;

INSERT y;
Will have GTID: group_name:1
Full GTID support!

- You can even replicate from a outside server to a group, global identifiers will be preserved.
MySQL Group Replication

2.1 Multi-Master

2.2 Automatic distributed server recovery

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2.4 Full GTID support

2.5 Auto-increment configuration/handling
Auto-increment configuration/handling

- Group is configured not to generate the same auto-increment value on all members.

```
INSERT x;
x: 1

INSERT y;
y: 4

INSERT z;
z: 11
```
Auto-increment configuration/handling

- By default, the offset is provided by server_id and increment is 7 [1].

[1]: http://mysqlhighavailability.com/mysql-group-replication-auto-increment-configuration-handling/
Auto-increment configuration/handling

• Users can change the increment size to their needs using `GROUP_REPLICATION_AUTO_INCREMENT_INCREMENT` option.
MySQL Group Replication

2.1 Multi-Master

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2.3 MySQL/InnoDB look & feel

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2.5 Auto-increment configuration/handling

2.6 New distributed agreement and communication engine
New Distributed Agreement and Communications Engine

• Multiple OS support.
  – Linux, but also Windows, OSX, Solaris, FreeBSD...

• No third-party software required.

• No network multicast support required.
  – MySQL Group Replication can now operate on cloud based installations on which multicast is disallowed.

• No message size limit.

• No separate process.
  – MySQL Group Replication is now self-contained on the same software stack.
MySQL Group Replication

2.3 MySQL/InnoDB look & feel
2.4 Full GTID support
2.5 Auto-increment configuration/handling
2.6 New distributed agreement and communication engine
2.7 Requirements
2.8 Limitations
Requirements (by design)

• Support for InnoDB only.
• Primary key is required on every table.
• Requires global transaction identifiers turned on.
• Optimistic execution: transactions may abort on COMMIT due to conflicts with concurrent transactions on other members.
MySQL Group Replication

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2.8 Limitations
Limitations

- Concurrent schema changes are not supported.
Architecture

3.1 Introduction
MySQL Group Replication is

• **Built on top of proven technology!**
  – Shares much of MySQL Replication infrastructure – thence does not feel alien!
  – Multi-Master approach to replication.

• **Built on reusable components!**
  – Layered implementation approach.
  – Interface driven development.
  – Decoupled from the server core.
  – The plugin registers as listener to server events.
  – Reuses the capture procedure from regular replication.
  – Provides further decoupling from the communication infrastructure.
3 Architecture

3.1 Introduction

3.2 Major Building Blocks
Major Building Blocks (1)
Major Building Blocks (2)

- Server calls into the plugin through a generic interface
  - (Most of server) internals are hidden from the plugin.
  - Some of the semi-sync interfaces were reused. Others were deployed.

- Plugin interacts with the server through a generic interface
  - Replication plugin determines the fate of the commit operation through a well defined server interface.
  - The plugin makes use of the relay log infrastructure to inject changes in the receiving server.
Major Building Blocks (3)

- The plugin is responsible for
  - Maintaining distributed execution context.
  - Detecting conflicts.
  - Handling distributed recovery:
    - Detect membership changes;
    - Donate state if needed;
    - Collect state if needed.
  - Receiving and handling transactions from other members.
  - Deciding the fate of on-going transactions.
Major Building Blocks (4)

- The communication API (and bindings) is responsible for:
  - Abstracting the underlaying communication engine from the plugin itself.
  - Mapping the interface to a specific communication engine.
Major Building Blocks (5)

• The communication engine:
  – Variant of Paxos developed at MySQL.
  – Building block to provide distributed agreement between servers.
3 Architecture

3.1 Introduction

3.2 Major Building Blocks

3.3 The Complete Stack
The Complete Stack

MySQL Server

API Replication Plugin

API

Performance Schema Tables: Monitoring

MySQL

APIs: Lifecycle / Capture / Applier

Capture

Conflicts Handler

Applier

Recovery

Replication Protocol

Group Com. API

Group Com. Binding

XCom

Network

Group Com. Engine
Use cases

4.1 Use cases
Use Cases

• **Elastic Replication**
  – Environments that require a very fluid replication infrastructure, where the number of servers has to grow or shrink dynamically and with as little pain as possible.

• **Highly Available Shards**
  – Sharding is a popular approach to achieve write scale-out. Users can use MySQL Group Replication to implement highly available shards. Each shard can map into a Replication Group.

• **Alternative to Master-Slave replication**
  – It may be that a single master server makes it a single point of contention. Writing to an entire group may prove more scalable under certain circumstances.
Use cases

4.1 Use cases

4.2 Big Picture
Dependable and Scalable MySQL Setups

Orchestrate & Manage

Simple Shard Mapping, State and Extra metadata.

Control, Coordinate, Provision

MySQL Router

Group Replication – Shard 1

...  

Group Replication – Shard N

MySQL Router

C, PHP, Perl, ...

Monitoring (MEM)
Conclusion
Summary

• **Cloud Friendly**
  – Great technology for deployments where elasticity is a requirement, such as cloud based infrastructures.

• **Integrated**
  – With server core through a well defined API.
  – With GTIDs, row based replication, performance schema tables.

• **Autonomic and Operations Friendly**
  – It is self-healing: no admin overhead for handling server fail-overs.
  – Provides fault-tolerance, enables multi-master update everywhere and a dependable MySQL service.
Where to go from here?

• Packages
  – http://labs.mysql.com

• Blogs from the Engineers (news, technical information, and much more)
  – http://mysqlhighavailability.com