# Best practices for MySQL High Availability

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Percona Webminar

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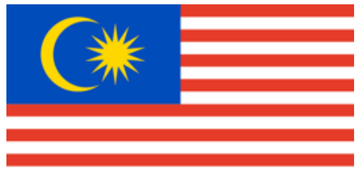
# whoami



- Chief Evangelist (in the CTO office), Percona Inc
- Founding team of MariaDB Server (2009-2016), previously at Monty Program Ab, merged with SkySQL Ab, now MariaDB Corporation
- Formerly MySQL AB (exit: Sun Microsystems)
- Past lives include Fedora Project (FESCO), OpenOffice.org
- MySQL Community Contributor of the Year Award winner 2014

MySQL 5.5 → Percona Server 5.5
→ MariaDB Server 5.5

MySQL 5.6 → Percona Server 5.6

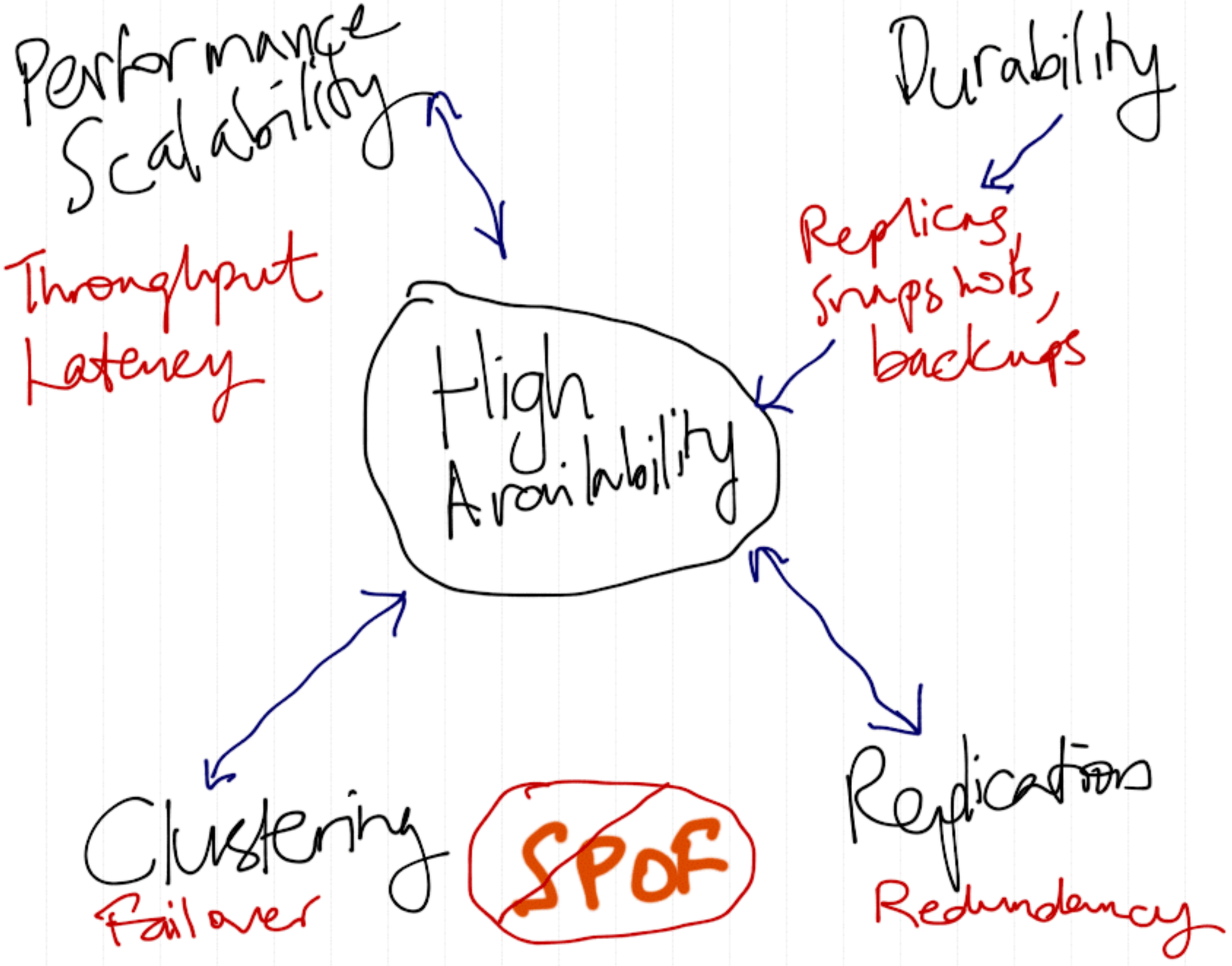
MariaDB 10.0 (5.5 + more)

MariaDB 10.1

MySQL 5.7 → Percona Server 5.7

MariaDB 10.2 (alpha)

MySQL 8.0 (DMR)


Performance
Scalability
Throughput
Latency
Durability
Replicas,
snapshots,
backups
High
Availability
Clustering
Failover
SPOF
Replication
Redundancy


Spider


HA
HighAvailability


3.0


PERCONA
TOOLKIT


severalnines


DRBD
A PRODUCT BY LINBIT


GALERA CLUSTER


PERCONA
XTRADB CLUSTER


MySQL


PERCONA
SERVER


MariaDB

# Uptime

| Percentile target | Max downtime per year |
|---|---|
| 90% | 36 days |
| 99% | 3.65 days |
| 99.5% | 1.83 days |
| 99.9% | 8.76 hours |
| 99.99% | 52.56 minutes |
| 99.999% | 5.25 minutes |
| 99.9999% | 31.5 seconds |

# Estimates of levels of availability

| Method | Level of Availability |
| --- | --- |
| Simple replication | 98-99.9% |
| Master-Master/MMM | 99% |
| SAN | 99.5-99.9% |
| DRBD, MHA, Tungsten Replicator | 99.9% |
| NDBCluster, Galera Cluster | 99.999% |

# HA is Redundancy

- RAID: disk crashes? Another works
- Clustering: server crashes? Another works
- Power: fuse blows? Redundant power supplies
- Network: Switch/NIC crashes? 2nd network route
- Geographical: Datacenter offline/destroyed? Computation to another DC

# Durability

- Data stored on disks
  - Is it really written to the disk?
    - being durable means calling fsync() on each commit
  - Is it written in a transactional way to guarantee atomicity, crash safety, integrity?

# High Availability for databases

- HA is harder for databases
- **Hardware resources** and **data** need to be **redundant**
- Remember, this isn't just data - constantly changing data
- HA means the operation can continue **uninterrupted**, not by restoring a new/backup server
  - uninterrupted: measured in percentiles

# Redundancy through client-side XA transactions

- Client writes to 2 independent but identical databases
  - HA-JDBC (http://ha-jdbc.github.io/)
- No replication anywhere

# InnoDB “recovery” time

- `innodb_log_file_size`
  - larger = longer recovery times
- Percona Server 5.5 (XtraDB) - `innodb_recovery_stats`

# Redundancy through shared storage

- Requires specialist hardware, like a SAN
- Complex to operate
- One set of data is your single point of failure
- Cold standby
  - failover 1-30 minutes
  - this isn't scale-out
- Active/Active solutions: Oracle RAC, ScaleDB

# Redundancy through disk replication

- DRBD
  - Linux administration vs. DBA skills
- Synchronous
- Second set of data inaccessible for use
  - Passive server acting as hot standby
- Failover: 1-30 minutes
- Performance hit: DRBD worst case is ~60% single node performance, with higher average latencies

# Redundancy through MySQL replication

- MySQL replication
- Tungsten Replicator
- Galera Cluster
- MySQL Cluster (NDBCLUSTER)
- Storage requirements are multiplied
- Huge potential for scaling out

# MySQL Replication

- Statement based generally
- Row based became available in 5.1, and the **default** in 5.7
- mixed-mode, resulting in STATEMENT except if calling
  - UUID function, UDF, CURRENT_USER/USER function, LOAD_FILE function
  - 2 or more AUTO_INCREMENT columns updated with same statement
  - server variable used in statement
  - storage engine doesn't allow statement based replication, like NDBCLUSTER

# MySQL Replication II

- **Asynchronous** by default
- Semi-synchronous plugin in 5.5+
- However the holy grail of fully synchronous replication is not part of standard MySQL replication (yet?)
  - MariaDB Galera Cluster is built-in to MariaDB Server 10.1

# The logs

- Binary log (binlog) - events that describe database changes
- Relay log - events read from binlog on master, written by slave i/o thread
- master_info_log - status/config info for slave's connection to master
- relay_log_info_log - status info about execution point in slave's relay log

# Semi-synchronous replication

- semi-sync capable slave acknowledges transaction event only after written to relay log & flushed to disk
  - timeout occurs? master reverts to async replication; resumes when slaves catch up
- at scale, Facebook runs semi-sync: http://yoshinorimatsunobu.blogspot.com/2014/04/semi-synchronous-replication-at-facebook.html

# MySQL Replication in 5.6

- Global Transaction ID (GTID)
- Server UUID
- Ignore (master) server IDs (filtering)
- Per-schema multi-threaded slave
- Group commit in the binary log
- Binary log (binlog) checksums
- Crash safe binlog and relay logs
- Time delayed replication
- Parallel replication (per database)

# Replication: START TRANSACTION WITH CONSISTENT SNAPSHOT

- Works with the binlog, possible to obtain the binlog position corresponding to a transactional snapshot of the database without blocking any other queries.
  - by-product of group commit in the binlog to view commit ordering
- Used by the command `mysqldump--single-transaction --master-data` to do a fully non-blocking backup
- Works consistently between transactions involving more than one storage engine
- https://kb.askmonty.org/en/enhancements-for-start-transaction-with-consistent/
- Percona Server made it better, by session ID, and also introducing backup locks

# Multi-source replication

- Multi-source replication - (real-time) analytics, shard provisioning, backups, etc.
- `@@default_master_connection` contains current connection name (used if connection name is not given)
- All master/slave commands take a connection name now (like CHANGE MASTER “connection_name”, SHOW SLAVE “connection_name” STATUS, etc.)

# Global Transaction ID (GTID)

- Supports multi-source replication
- GTID can be enabled or disabled independently and online for masters or slaves
- Slaves using GTID do not have to have binary logging enabled.
- (MariaDB) Supports multiple replication domains (independent binlog streams)
  - Queries in different domains can be run in parallel on the slave.

# Why MariaDB GTID is different compared to 5.6?

- MySQL 5.6 GTID does not support multi-source replication
- Supports —log-slave-updates=0 for efficiency
- Enabled by default
- Turn it on without having to restart the topology

# Parallel replication

- Multi-source replication from different masters executed in parallel
  - Queries from different domains are executed in parallel
- Queries that are run in parallel on the master are run in parallel on the slave (based on group commit).
  - Transactions modifying the same table can be updated in parallel on the slave!
- Supports both statement based and row based replication.

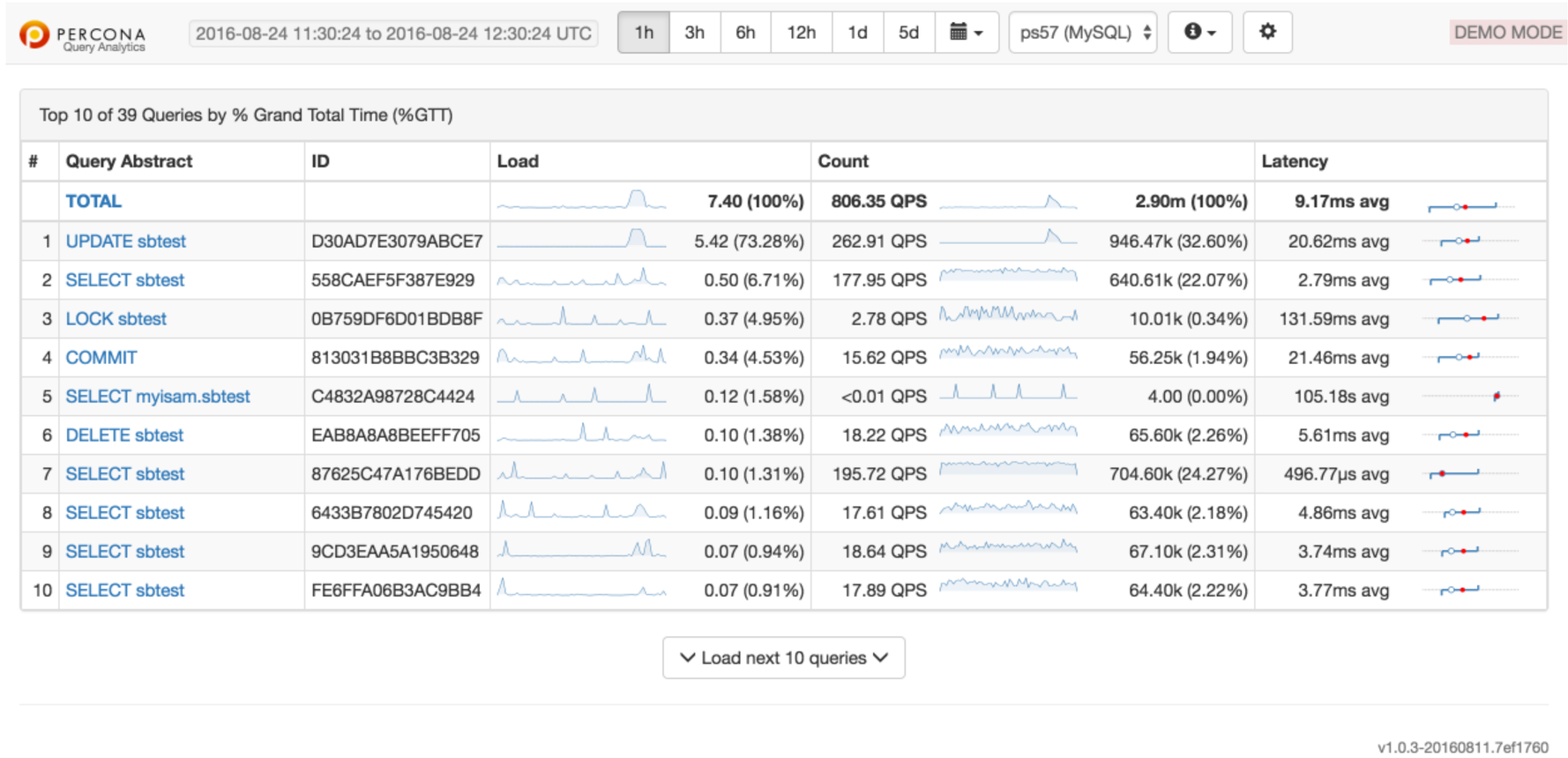
# All in… sometimes it can get out of sync

- Changed information on slave directly
- Statement based replication
  - non-deterministic SQL (UPDATE/DELETE with LIMIT and without ORDER BY)
  - triggers & stored procedures
- Master in MyISAM, slave in InnoDB (deadlocks)
- --replication-ignore-db with fully qualified queries
- Binlog corruption on master
- PURGE BINARY LOGS issued and not enough files to update slave
- read_buffer_size larger than max_allowed_packet
- Bugs?

# Replication Monitoring

- Percona Toolkit is important
- pt-slave-find: find slave information from master
- pt-table-checksum: online replication consistency check
  - executes checksum queries on master
- pt-table-sync: synchronise table data efficiently
  - changes data, so backups important

# Replication Monitoring with PMM




- http://pmmdemo.percona.com/

# mysqlbinlog versions

- ERROR: Error in Log_event::read_log_event(): 'Found invalid event in binary log', data_len: 56, event_type: 30
- 5.6 ships with a “streaming binlog backup server” - v.3.4; MariaDB 10 doesn’t - v.3.3 (fixed in 10.2 - MDEV-8713)
- GTID variances!

# Slave prefetching

- Replication Booster
  - https://github.com/yoshinorim/replication-booster-for-mysql
  - Prefetch MySQL relay logs to make the SQL thread faster
- Tungsten has slave prefetch
- Percona Server till 5.6 + MariaDB till 10.1 have InnoDB fake changes

# What replaces slave prefetching?

- In Percona Server 5.7, slave prefetching has been replaced by doing intra-schema parallel replication
- Feature removed from XtraDB
- MariaDB Server 10.2 will also have this feature removed

# Tungsten Replicator

- Replaces MySQL Replication layer
  - MySQL writes binlog, Tungsten reads it and uses its own replication protocol
- Global Transaction ID
- Per-schema multi-threaded slave
- Heterogeneous replication: MySQL <-> MongoDB <-> PostgreSQL <-> Oracle
- Multi-master replication
  - Multiple masters to single slave (multi-source replication)
  - Many complex topologies
- Continuent Tungsten (Enterprise) vs Tungsten Replicator (Open Source)

# In today's world, what does it offer?

- **opensource MySQL <-> Oracle replication to aid in your migration**
- automatic failover without MHA
- multi-master with cloud topologies too
- **Oracle <-> Oracle replication (this is Golden Gate for FREE)**
- Replication from MySQL to MongoDB
- Data loading into Hadoop

# Galera Cluster

- Inside MySQL, a replication plugin (wsrep)
- Replaces MySQL replication (but can work alongside it too)
- True multi-master, active-active solution
- Synchronous
- WAN performance: 100-300ms/commit, works in parallel
- No slave lag or integrity issues
- Automatic node provisioning

CODERSHIP - ~3 releases/year

↳ Upstream (galeracluster.com)

Distributions:

1. Percona XtraDB Cluster (PXC)
2. MariaDB Galera Cluster (MGC)

* - #1 - 5.5 + 5.6
  - #2 - 5.5 + 10.0 + 10.1 (integrated)

# Percona XtraDB Cluster 5.7

- Engineering within Percona
- Load balancing with ProxySQL (bundled)
- PMM integration
- Benefits of all the MySQL 5.7 feature-set

# Group replication

- Fully synchronous replication (update everywhere), self-healing, with elasticity, redundancy
- Single primary mode supported
- MySQL InnoDB Cluster - a combination of group replication, Router, to make magic!

# MySQL NDBCLUSTER

- 3 types of nodes: SQL, data and management
- MySQL node provides interface to data. Alternate API's available: LDAP, memcached, native NDBAPI, node.js
- Data nodes (NDB storage)
  - different to InnoDB
  - transactions synchronously written to 2 nodes(ore more) - replicas
  - transparent sharding: partitions = data nodes/replicas
  - automatic node provisioning, online re-partitioning
- High performance: 1 billion updates / minute

# Summary of Replication Performance

- SAN has "some" latency overhead compared to local disk. Can be great for throughput.
- DRBD = 50% performance penalty
- Replication, when implemented correctly, has no performance penalty
  - But MySQL replication with disk bound data set has single-threaded issues!
  - Semi-sync is poorer on WAN compared to async
- Galera & NDB provide read/write scale-out, thus more performance

# Handling failure

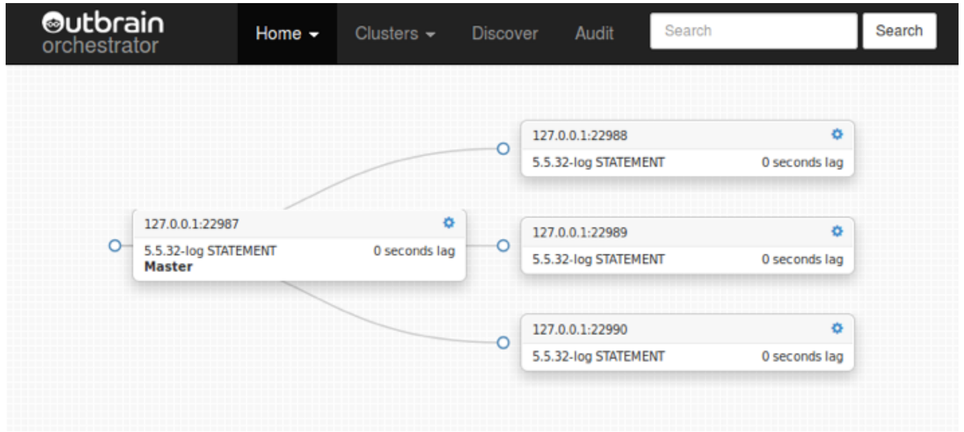
- How do we find out about failure?
  - Polling, monitoring, alerts...
  - Error returned to and handled in client side
- What should we do about it?
  - Direct requests to the spare nodes (or DCs)
- How to protect data integrity?
  - Master-slave is unidirectional: Must ensure there is only one master at all times.
  - DRBD and SAN have cold-standby: Must mount disks and start mysqld.
- In all cases must ensure that 2 disconnected replicas cannot both commit independently. (split brain)

# Frameworks to handle failure

- MySQL-MMM
- Severalnines ClusterControl
- Orchestrator
- MySQL MHA
- Percona Replication Manager
- Tungsten Replicator
- 5.6: mysqlfailover, mysqlrpladmin
- (MariaDB) Replication Manager

# Orchestrator

- Reads replication topologies, keeps state, continuous polling
- Modify your topology — move slaves around
- Nice GUI, JSON API, CLI



# MySQL MHA

- Like MMM, specialized solution for MySQL replication
- Developed by Yoshinori Matsunobu at DeNA
- Automated and manual failover options
- Topology: 1 master, many slaves
  - Choose new master by comparing slave binlog positions
- Can be used in conjunction with other solutions
- http://code.google.com/p/mysql-master-ha/

# Pacemaker

- Heartbeat, Corosync, Pacemaker
- Resource Agents, Percona-PRM
- Percona Replication Manager - cluster, geographical disaster recovery options
  - Pacemaker agent specialised on MySQL replication
  - https://github.com/percona/percona-pacemaker-agents/
  - Pacemaker Resource Agents 3.9.3+ include Percona Replication Manager (PRM)

# Load Balancers for multi-master clusters

- Synchronous multi-master clusters like Galera require load balancers
- HAProxy
- Galera Load Balancer (GLB)
- MaxScale
- ProxySQL

# MySQL Router

- Routing between applications and any backend MySQL servers
- Failover
- Load Balancing
- Pluggable architecture (connection routing, Fabric cache)

# MaxScale

- “Pluggable router” that offers connection & statement based load balancing
- Possibilities are endless - use it for logging, writing to other databases (besides MySQL), preventing SQL injections via regex filtering, route via hints, query rewriting, have a binlog relay, etc.
- Load balance your Galera clusters today!

# ProxySQL

- High Performance MySQL proxy with a GPL license
- Performance is a priority - the numbers prove it
- Can query rewrite
- Sharding by host/schema or both, with rule engine + modification to SQL + application logic

# JDBC/PHP drivers

- JDBC - multi-host failover feature (just specify master/slave hosts in the properties)
  - true for MariaDB Java Connector too
- PHP handles this too - mysqlnd_ms
- Can handle read-write splitting, round robin or random host selection, and more

# Clustering: solution or part of problem?

- "Causes of Downtime in Production MySQL Servers" whitepaper, Baron Schwartz VividCortex
  - Human error
  - SAN
- Clustering framework + SAN = more problems
- Galera is replication based, has no false positives as there's no "failover" moment, you don't need a clustering framework (JDBC or PHP can load balance), and is relatively elegant overall

# InnoDB based?

- Use InnoDB, continue using InnoDB, know workarounds to InnoDB
- All solutions but NDB are InnoDB. NDB is great for telco/ session management for high bandwidth sites, but setup, maintenance, etc. is complex

# Replication type

- Competence choices
  - Replication: MySQL DBA manages
  - DRBD: Linux admin manages
  - SAN: requires domain controller
- Operations
  - DRBD (disk level) = cold standby = longer failover
  - Replication = hot standby = shorter failover
  - GTID helps tremendously
- Performance
  - SAN has higher latency than local disk
  - DRBD has higher latency than local disk
  - Replication has little overhead
- Redundancy
  - Shared disk = SPoF
  - Shared nothing = redundant

# SBR vs RBR? Async vs sync?

- row based: deterministic
- statement based: dangerous
- GTID: easier setup & failover of complex topologies
- async: data loss in failover
- sync: best
- multi-threaded slaves: scalability (hello 5.6+, Tungsten)

# Conclusions for choice

- Simpler is better
- MySQL replication > DRBD > SAN
- Sync replication = no data loss
- Async replication = no latency (WAN)
- Sync multi-master = no failover required
- Multi-threaded slaves help in disk-bound workloads
- GTID increases operational usability
- Galera provides all this with good performance & stability

# Conclusion

- MySQL replication is amazing if you know it (and monitor it) well enough
- Large sites run just fine with semi-sync + tooling for automated failover
- Galera Cluster is great for fully synchronous replication
- Don’t forget the need for a load balancer: ProxySQL is nifty

# At Percona, we care about your High Availability

- Percona XtraDB Cluster 5.7 with support for ProxySQL and Percona Monitoring & Management (PMM)
- Percona Monitoring & Management (PMM) with Orchestrator
- Percona Toolkit
- Percona Server for MySQL 5.7
- Percona XtraBackup

# Q&A / Thanks

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