The Future of PostgreSQL High Availability

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Agenda

- Introductions
- Framing the High Availability (HA) Problem
- Hot Standby + Log Streaming
- The PostgreSQL HA Manifesto
- Questions

About Us

- **Simon Riggs -- Key PostgreSQL HA Contributor**
  - PITR, pg_standby, hot standby, etc.
- **Robert Hodges -- Architect of Tungsten Clustering**
  - Tungsten Replicator for MySQL & PostgreSQL, backups, distributed management, etc.
- **Continuent: Cross-platform database clustering**
  - Protect data
  - Improve availability
  - Scale performance
- **2ndQuadrant: PostgreSQL services and core dev**
  - Services
  - Education
  - Support

Framing the Problem: Database High Availability

DBMS High Availability Made Simple

Availability: Degree to which a system is up and running.

Keys to High Availability

1. **Minimize failures**
2. **Keep downtime including repairs as short as possible**
3. **Don't lose more data than you absolutely have to**

What Are Key Causes of Downtime?

- Crashes -- Hardware or software component fails
- Scheduled maintenance – Upgrade/service components
- Migration — Moving between DBMS versions and hardware architectures
- Administrative errors — Accidents that delete data or cause components not to work

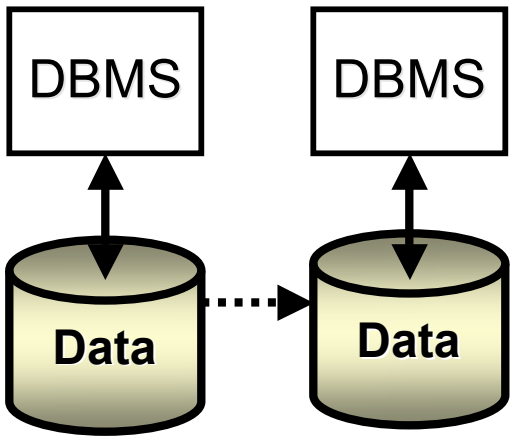
Thought exercise: which accounts for the most down-time?

Who Needs High Availability?

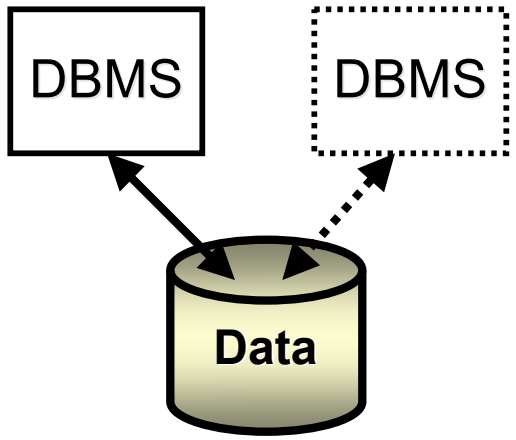
- **Small/medium business applications**
  - Idiot-proof installation and management
- **Embedded medical data processing**
  - Unattended operation
  - Never lose a transaction
- **Hosted website intrusion reporting**
  - Burst updates to 100K INSERTs per second
  - Massive data volumes
- **Hosted CRM (Customer Relationship Management)**
  - Fail-back options for system upgrades
  - Creation of reporting databases
- **Internet Service Provider**
  - Shared DBMS instances
  - Transparent migration of users between instances

Shared vs. Redundant Resources

- **Shared resources create single points of failover (SPOFs)**
- **More redundancy == higher availability**



Redundant data approach covers more use cases with less capable hardware



Shared disk approach requires internal redundancy; limited data protection and fewer use cases

Backups and Point-In-Time-Recovery

- **Backups are first line of defense for availability**
- **Point-in-time-recovery restores database state to a particular:**
  - Point in calendar time, or
  - Transaction ID
- **Provisioning copies directly from one database instance to another**

Physical vs. Logical Replication

- **Databases can update either at disk or logical level, hence two replication approaches**
- **Log records -- Databases apply them automatically during recovery**
- **SQL statements -- Clients send SQL to make changes**

Physical Replication	**Logical Replication**
Replicate log records/events to create bit-for-bit copy	Replicate SQL to create equivalent data
Transparent, high performance, hard to cross architectures and versions, limitations on updates	Flexible, fewer/different restrictions, allow schema differences, replicas allow reads

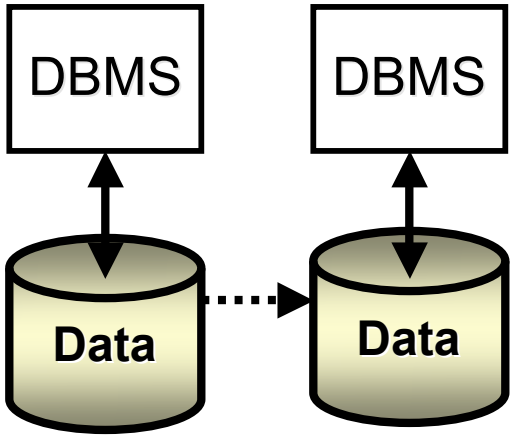
Asynchronous vs. Synchronous

- **Replicating is like buying a car--there are lots of ways to pay for it**
- **$0 down - Pay later; hope nothing goes wrong**
- **Down payment - Pay some so less goes wrong later**
- **Cash - Pay up front and it's yours forever**

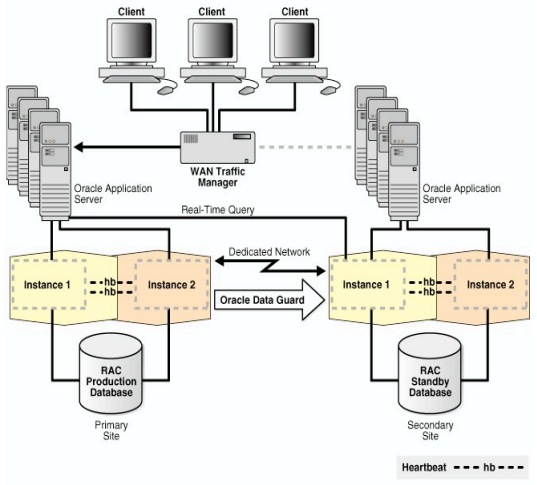
Asynchronous Replication	**Semi-Synchronous Replication**	**Synchronous Replication**
Commit now, replicate later	Replicate to at least one other database	Replicate fully to all other databases
Lose data but robust against network failure	Trade-off data loss vs. partition handling	Network fails --> you stop

Simple vs. Complex

- **Simple systems are almost always more available**
- **Complexity is the #1 enemy of high availability**



Built-in database replication creates simple system with few/no additional ways to fail



Complex combinations are hard to understand, test, and manage; create new failure modes

Hot Standby and Log Streaming

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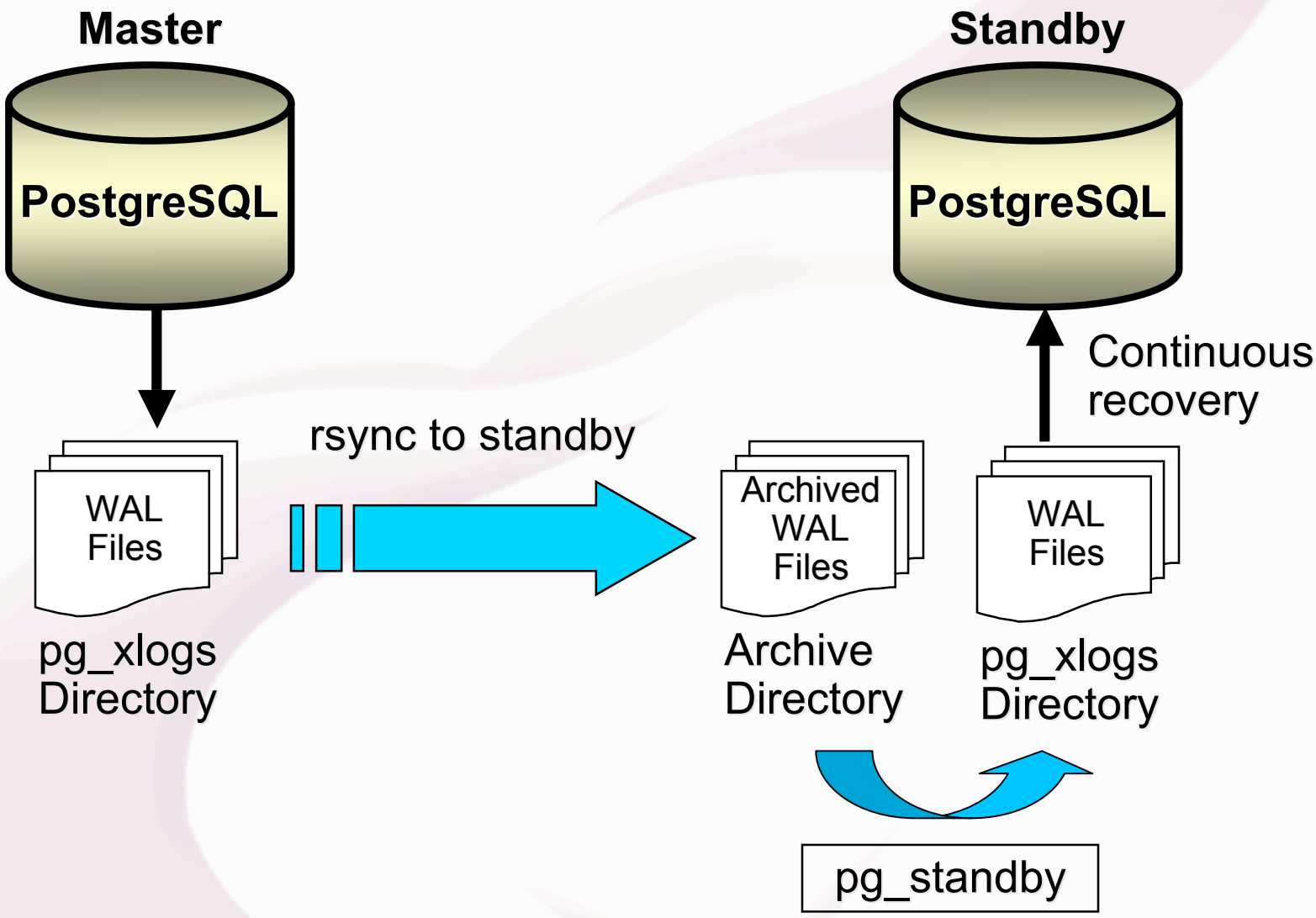
PostgreSQL 8.4 Warm Standby



Advantages of Warm Standby

- **Simple**
- **Completely transparent to applications**
- **Very low performance overhead**
  - E.g. no extra writes from triggers
- **Supports point-in-time recovery**
- **Works over WAN as well as LAN**
- **Has reasonable recovery of master using rsync**
- **Very reliable solution -- if recovery works warm standby works**
- **Requires careful management to use effectively**

Limitations of Warm Standby

1. **Utilization -- Cannot open the standby**
   - To bring up the standby for queries you must end recovery
   - Standby hardware is idle
   - Difficult to track state of recovery since you cannot query log position
2. **Data Loss -- Warm standby transfers only full WAL files**
   - Can bound loss using archive_timeout
   - Low values create large numbers of WAL files; complicate point-in-time recovery
   - Workarounds using DRBD, etc. are complex

Introducing Hot Standby

- **Allows users to connect to standby in read-only mode**
  - Allowed: SELECT, SET, LOAD, COMMIT/ROLLBACK
  - Disallowed: INSERT, UPDATE, DELETE, CREATE, 2PC, SELECT … FOR SHARE/UPDATE, nextval(), LISTEN, LOCK,
  - No admin commands: ANALYZE, VACUUM, REINDEX, GRANT
- **Simple configuration through recovery.conf**

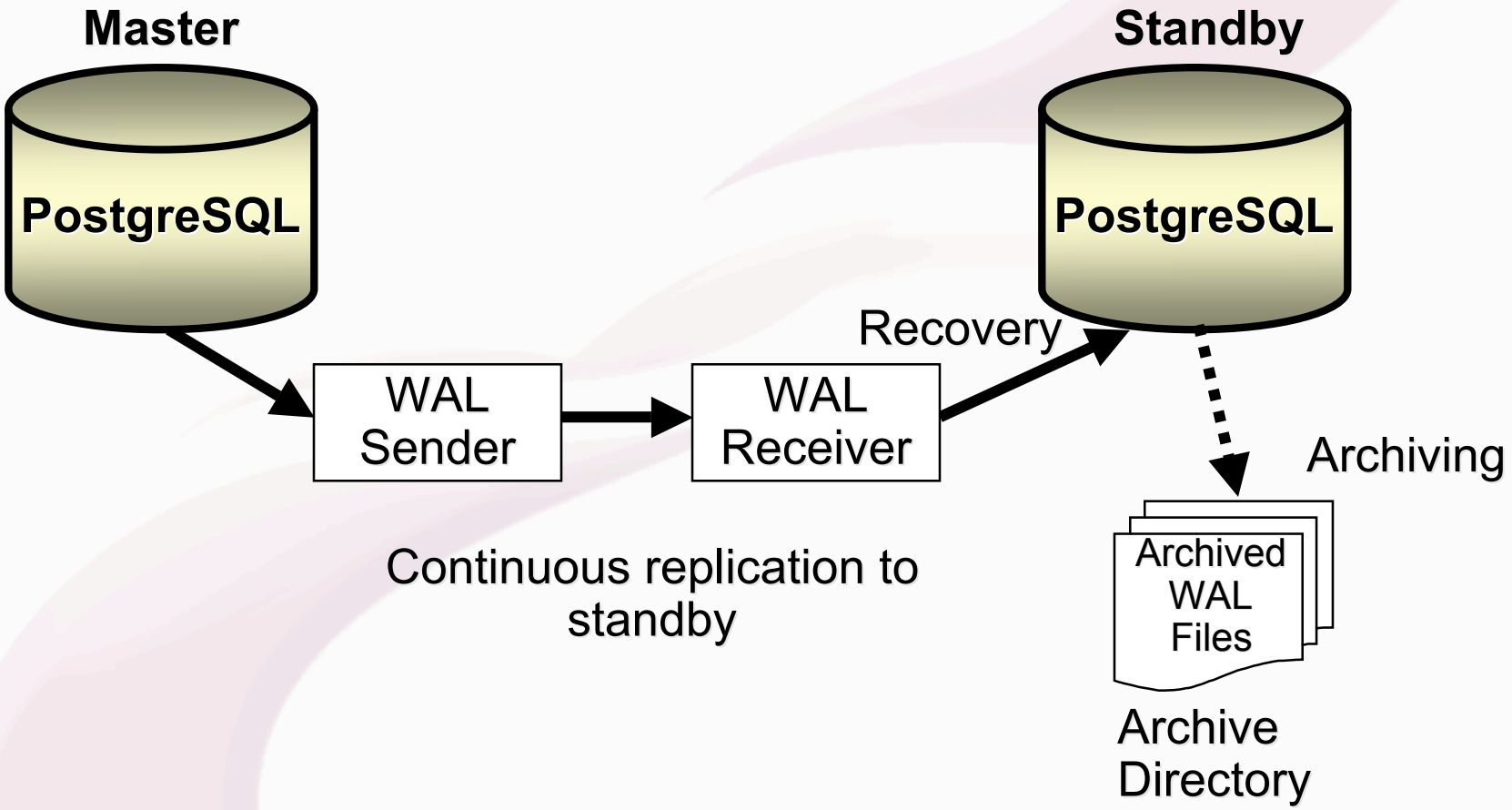
```
# Hot standby
recovery_connections  = 'on'
```

- **Performance Overhead**
  - Master: < 0.1% impact from additional WAL
  - Standby: 2% CPU impact, but we're I/O bound anyway
- **Can come out of recovery while queries are running**

Hot Standby Query Conflicts

- **Master: Connections can interfere and deadlock**
- **Standby: Queries can conflict with recovery**
  - Recovery always wins
- **Causes of conflicts**
  - Cleanup records (HOT/VACUUM)
  - Access exclusive locks
  - DROP DATABASE
  - DROP TABLESPACE
  - Very long queries
- **Conflict resolution**
  - Wait, then Cancel - Controlled by max_standby_delay
  - Avoid - Dblink

Introducing Log Streaming



Configuration and Usage

- Log streaming layers on top of existing warm standby log shipping
- Configuration through postgresql.conf + recovery.conf

```
# Recovery.conf log streaming options
standby_mode          = 'on'
primary_conninfo      = 'host=172.16.238.128
  port=5432 user=postgres'
trigger_file = '/path_to/trigger'
```

- Multiple standby servers allowed
- Failure of one standby does not affect others
- Management is not simple - must coordinate provisioning & WAL shipping to set up/restart

What Does This Get Us?

- **Hot standby enhances utilization**
- **Hot standby makes standby monitoring very simple**
- **Hot standby heats up FS cache and shared buffers**
- **Log streaming reduces the data loss window and shortens failover**
- **Hot standby + log streaming will be the favored basic availability solution and will largely replace:**
  - Master/slave availability using SLONY/Londiste/PG Replicator
  - Disk block replication
  - Shared disk failover
- **So are we there yet??**

The PostgreSQL HA Manifesto

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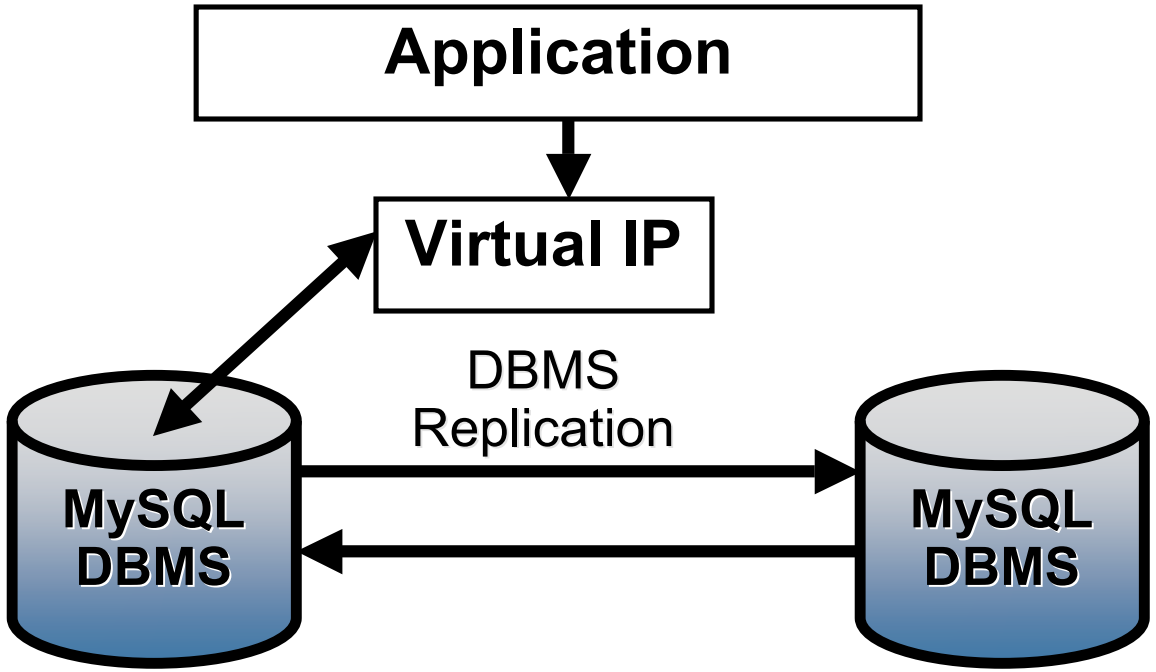
Developing the PostgreSQL HA Roadmap

- What can we learn from the neighbors?
- Four features to round out PostgreSQL HA

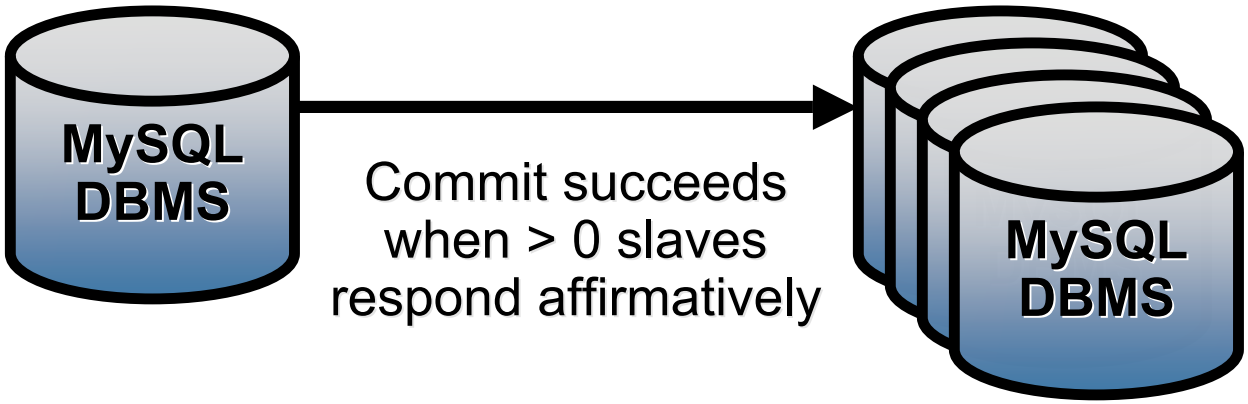
MySQL Master Master Replication

- Logical replication is built in -- no triggers
- Covers all SQL including DDL
- Handles maintenance very well (painless resync, application upgrades, cross architecture/version)



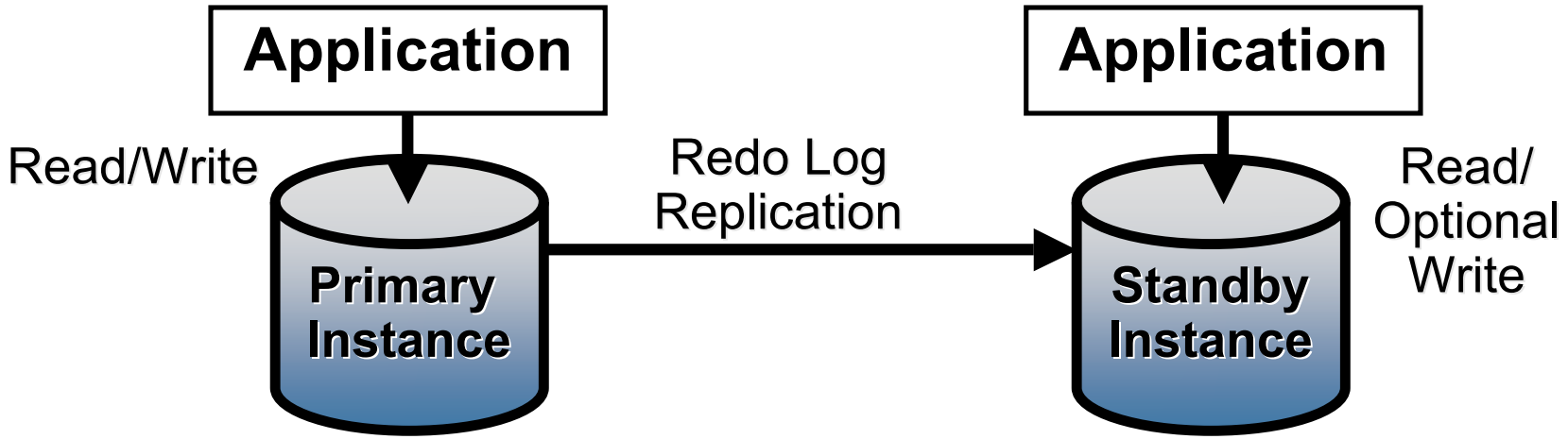
Google Semi-Synchronous Replication

- **Quorum algorithm -- Commits block until at last one slave responds affirmatively**
- **Protects data but avoids system freeze if a slave is unavailable**
- **Released as patch to MySQL; not widely available yet**



Oracle Data Guard

- Oracle Data Guard moves transaction (redo) logs
- Protection modes include async/sync replication
- Physical standby is bit-for-bit copy, readonly
- Logical standby allows readable, updatable copy
- WAY better than RAC or Streams

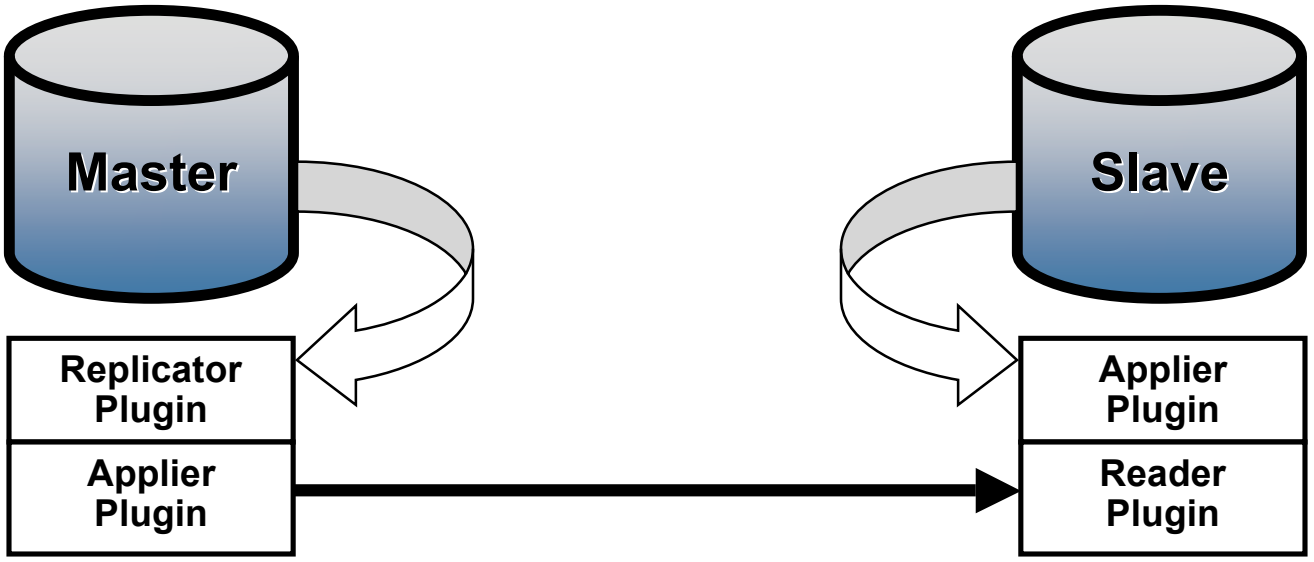


Oracle Flash Back

- **Flash Back Query builds PITR into the DBMS**
- **Select any SCN (System Commit #) for which logs are available**
- **Flash back query to recover deleted data**
- **Flash back instance to convert failed master to slave**
  - Sounds better than rsync, doesn't it?

Drizzle Pluggable Replication

- Public replication protocol (Google Proto Buffers)
- Pluggable replication -- enable new replication types
- Sync/async replication
- Support for all SQL operations, not just DML



PostgreSQL HA: Synchronous Replication

- **Flexible, synchronous replication**
  - Physical replication is the beginning…
- **Selectable apply modes**
  - Submitted to replication
  - Received by slave
  - Applied by slave
- **Selectable quorum semantics**
  - Async
  - Semi-sync
  - Synchronous
- **Enables any application that values data to trade off durability vs. availability**
- **Vendor solution jump off: configuration and management**

PostgreSQL HA: Real-Time PITR

- Implement Flash Back for PostgreSQL
- Implementations range from straightforward to very hard
- Use zoned snapshots to pick points in past where data remain visible to R/O transactions
- Extra credit: Let PostgreSQL revert to a snapshot

- Usage: Allow users to recover data from specific point in time--like built-in time delay replication. Snapshot reversion simplifies master recovery
- Vendor jump-off point: Set up and manage snapshots

PostgreSQL HA: VLDB High Availability

- **Multiple simultaneous backups (only one now supported)**
  - Backup ref counts to allow more than one customer at a time
- **Incremental backup with WAL synchronization**
- **Efficient recovery of large masters after failover**

- **Vendor solution jump-off -- Management, fast backup/restore utilities, incremental backup solutions**

PostgreSQL HA: Logical Replication

- **Supplement WAL to allow SQL generation**
  - Keys
  - Schema definitions
  - Recover DDL statements in “actionable” form (e.g., XML)
- **Extensible replication plug-ins a la Drizzle**
  - Intercept data as they are written to log
  - Ability to hold commits to mark transactions (e.g., global IDs) and implement synchronous replication
  - Handle two-phase commit issues
  - Loadable through SQL without weird syntax extensions
- **Provide built-in reference implementation**
- **Open source/vendor jump-off: Migration, multi-master, filtering, data consistency checking and repair**

Summary and Questions

Summary

- Hot standby + log streaming provide sound built-in “simple” HA
- PostgreSQL HA manifesto = roadmap to a complete solution for high availability with jump-offs to vendor solutions
- Tell us what features you need!

Information/Contact

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http://www.continuent.com

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http://www.2ndquadrant.com