ORACLE

MySQL

Disaster Recovery Solutions

MySQL InnoDB ClusterSet

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Safe Harbor Statement

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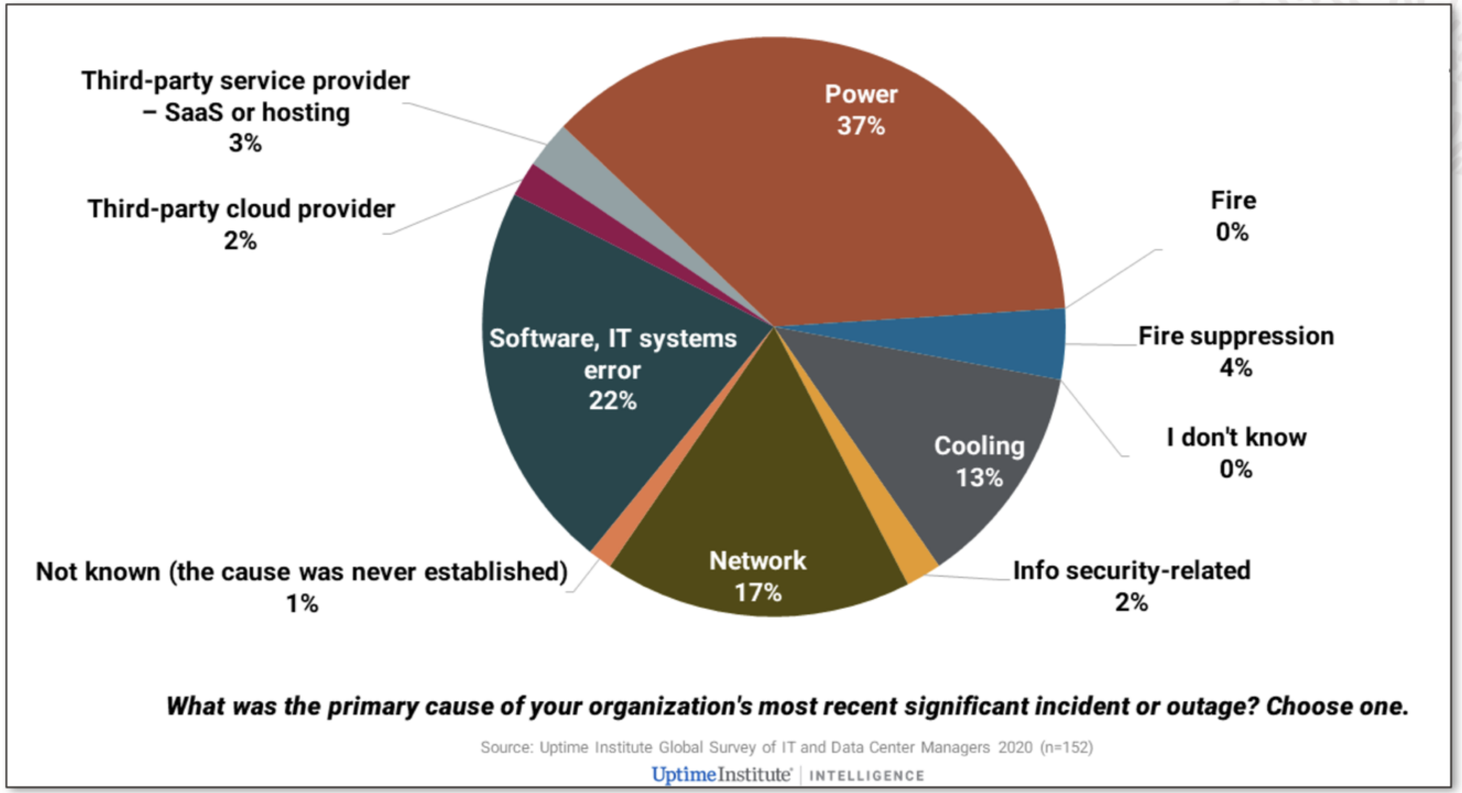
IT Disasters & Outages: Primary Causes



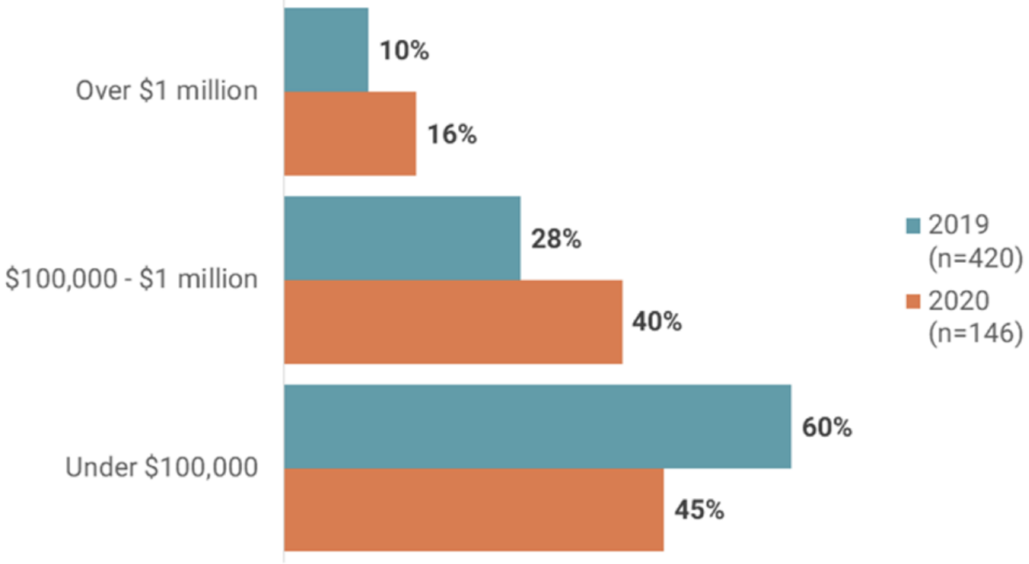
What was the primary cause of your organization's most recent significant incident or outage? Choose one.

Source: Uptime Institute Global Survey of IT and Data Center Managers 2020 (n=152)

UptimeInstitute | INTELLIGENCE

On-site power failure is the biggest cause of significant outages

IT Disasters & Outages: Costs are Rising



Please estimate the total cost of this downtime incident (from outage to full recovery) for your organization, including direct, opportunity and reputation costs using the following options. Choose one.*

** All figures in US dollars*

Source: Uptime Institute Global Survey of IT and Data Center Managers 2019 and 2020

Over half who had experienced an outage costing more than $100,000.

IT Disasters and Outages: Examples

DELTA

5-hour computer outage cost us $150 million. The airline eventually canceled about 1,000 flights on the day of the outage and ground an additional 1,000 flights over the following two days.

OVHcloud

Millions of websites offline after fire at French cloud services firm. The fire is expected to cost the company more than €105 million.

BRITISH AIRWAYS

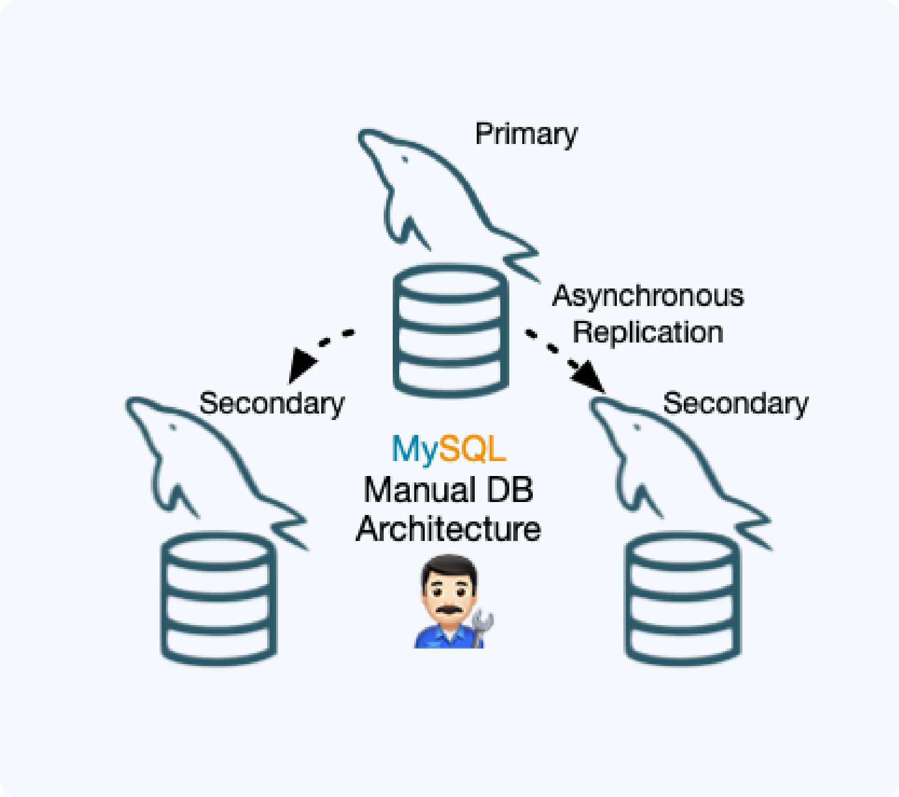
Tens of thousands of passengers were stranded in cities around the world due to cancellation of about 130 flights and the delay of 200.

HSBC

Millions of bank customers were unable to access online accounts. The bank took almost 2 days to recover and get back to normal functioning.

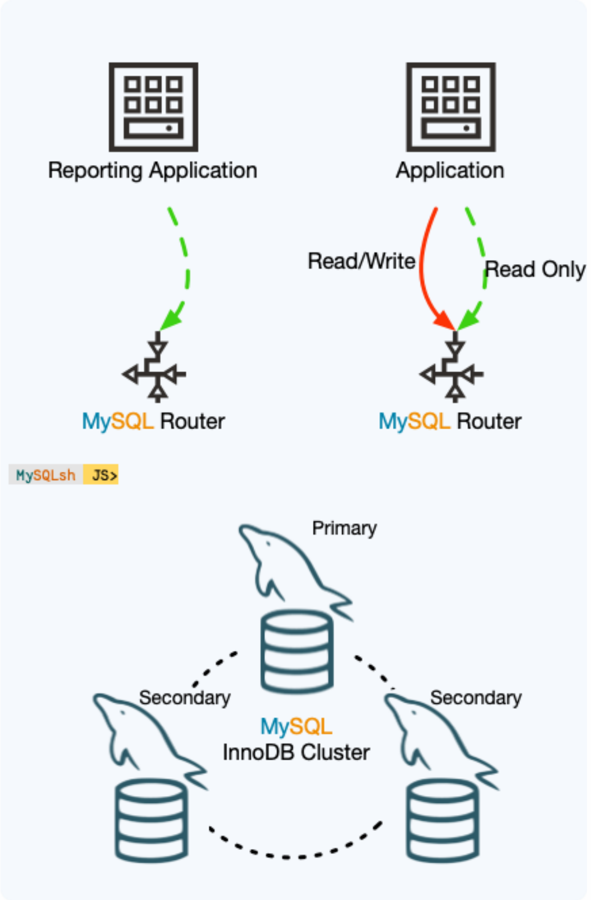
Past, Present & Future

'Past' - Manual



- Setting up Replication topology was usually done manually, taking many steps
  - including user management, restoring backups, configuring replication...
- MySQL only offered the technical pieces, leaving it up to the user to setup an (always customized) architecture
- Even required other software ... bringing lot's of work for DBA's and experts, who spent their time automating and integrating their customized architecture

Present - Solutions!

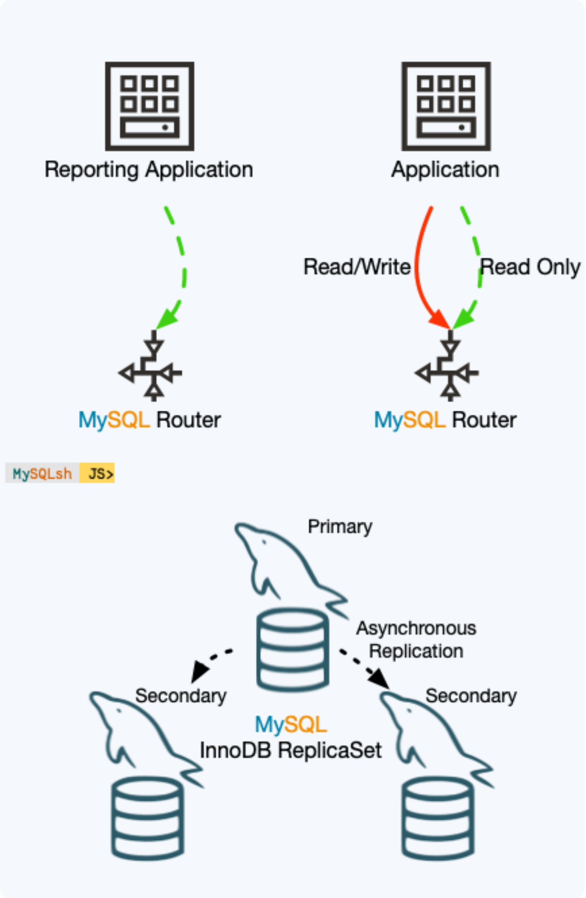


RPO = 0
RTO = seconds (automatic failover)

2016 - MySQL InnoDB Cluster

- MySQL Group Replication: Automatic membership changes, network partition handling, consistency...
- MySQL Shell to provide a powerful interface that helps in automating and integrating all components
- InnoDB `CLONE` to automatically provision members, fully integrated in InnoDB
- MySQL Router
- MySQL Server

Present - Solutions!



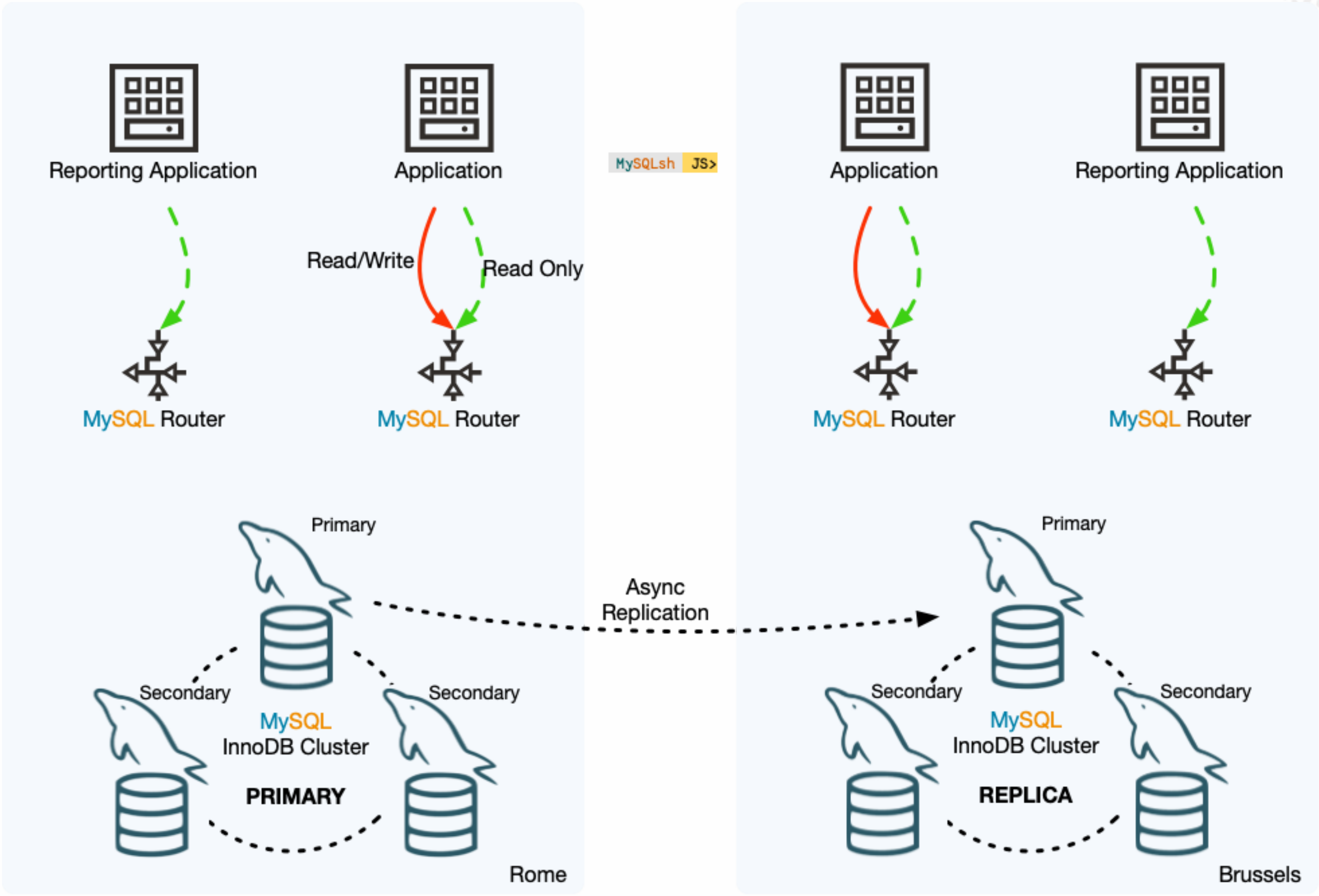
RPO != 0
RTO = minutes (manual failover)

2020 - MySQL InnoDB Replicaset

- 'classic', 'asynchronous' Replication based Solution, fully integrated
- MySQL Shell
- MySQL Router
- MySQL Server

MySQL InnoDB ClusterSet

One or more REPLICA MySQL InnoDB Clusters attached to a PRIMARY MySQL InnoDB Cluster



High Availability (Failure Within a Region)

- RPO = 0
- RTO = seconds (automatic failover)

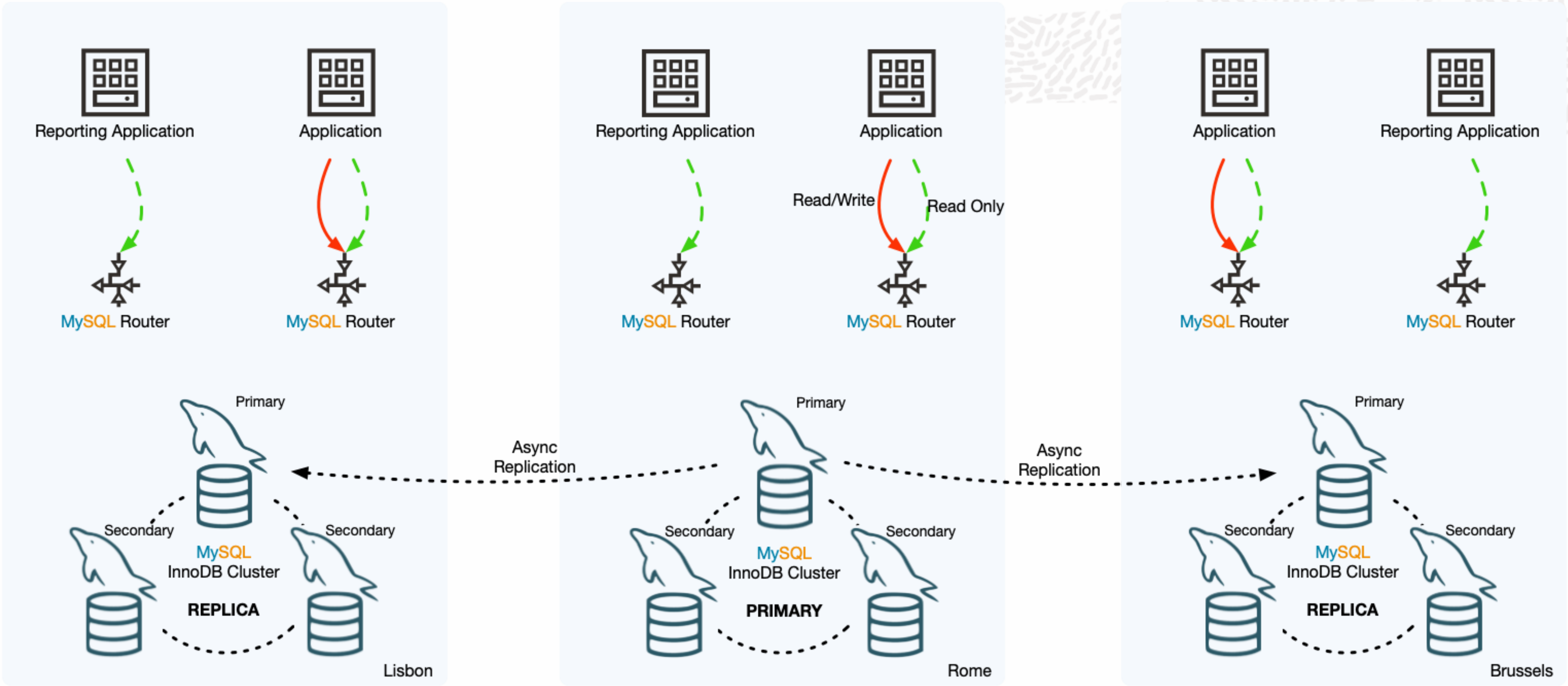
Disaster Recovery (Region Failure)

- RPO != 0
- RTO = minutes or more (manual failover)
- No write performance impact

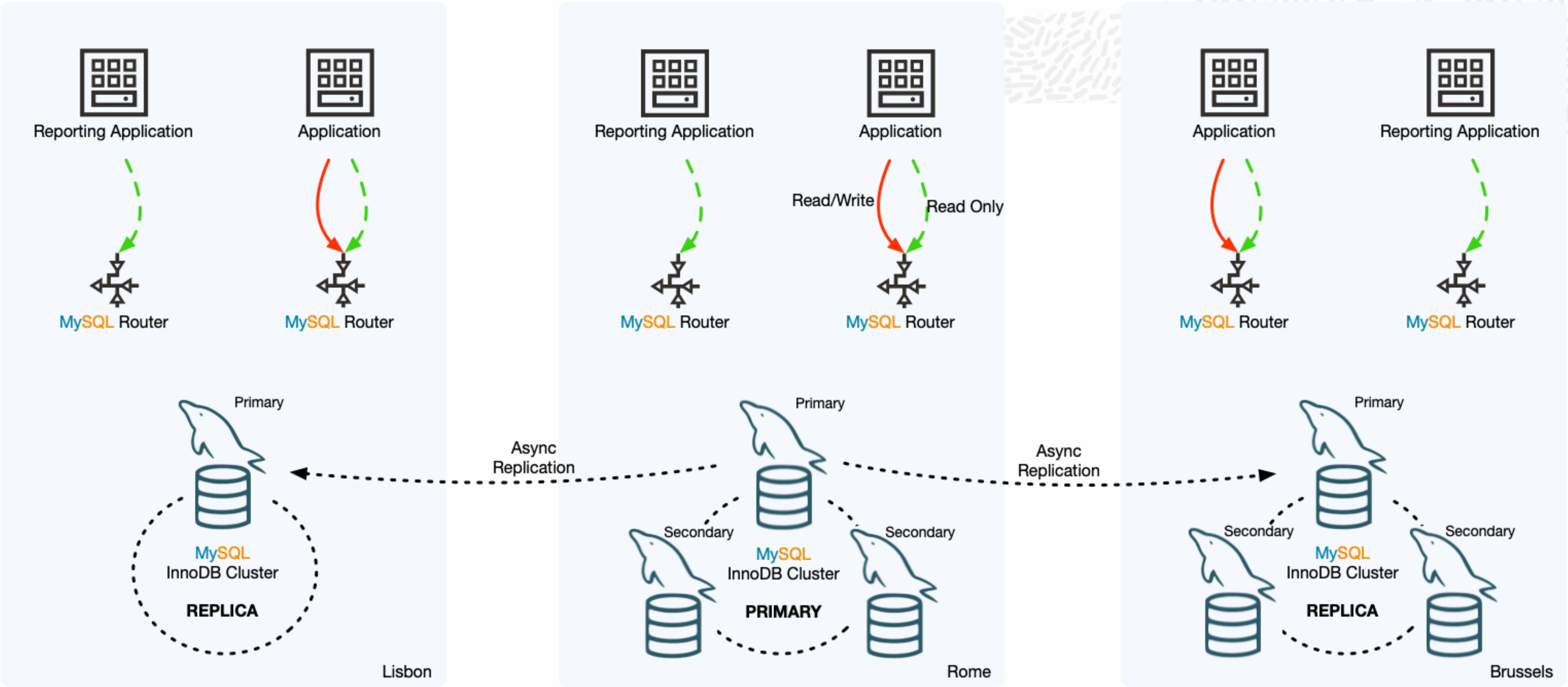
Features

- Easy to use
- Familiar interface and usability `mysqlsh`, `CLONE`, ...
- Add/remove nodes/clusters online
- Router integration, no need to reconfigure application if the topology changes

MySQL InnoDB ClusterSet - 3 Datacenters



MySQL InnoDB ClusterSet - Not every Cluster has to be 3 nodes



Each replica is a MySQL InnoDB Cluster that can have 1-9 members.

Business Requirements

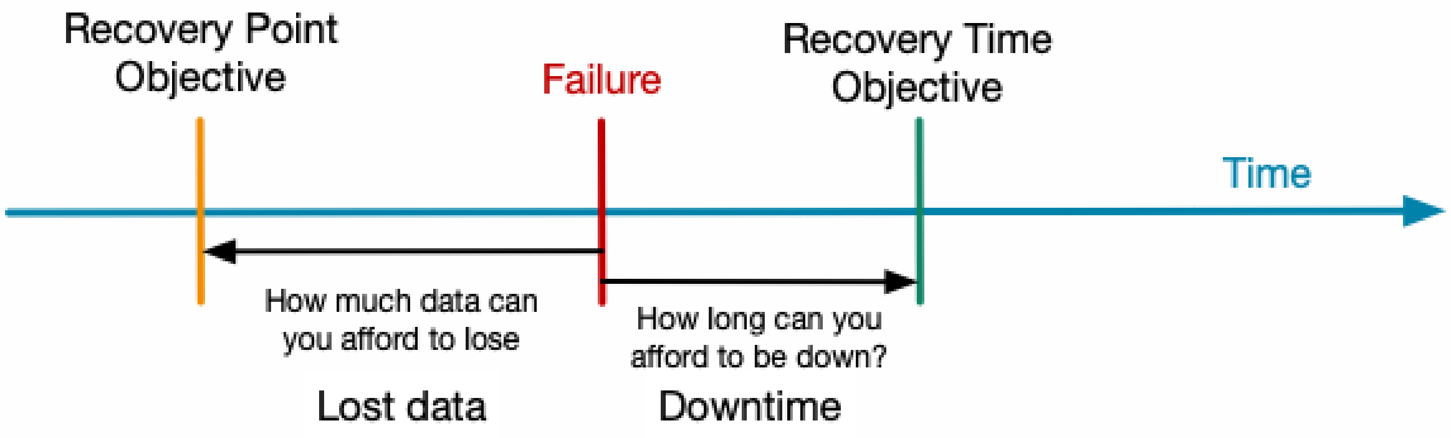
Business Requirements

Concepts - RTO & RPO

- RTO: Recovery Time Objective
  - How long does it take to recover from a single failure
- RPO: Recovery Point Objective
  - How much data can be lost when a failure occurs

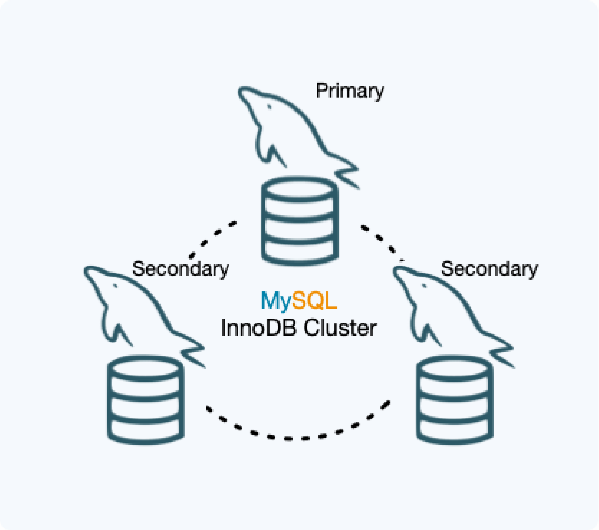
Types of Failure:

High Availability: Single Server Failure, Network Partition
Disaster Recovery: Full Region/Network Failure
Human Error: Little Bobby Tables



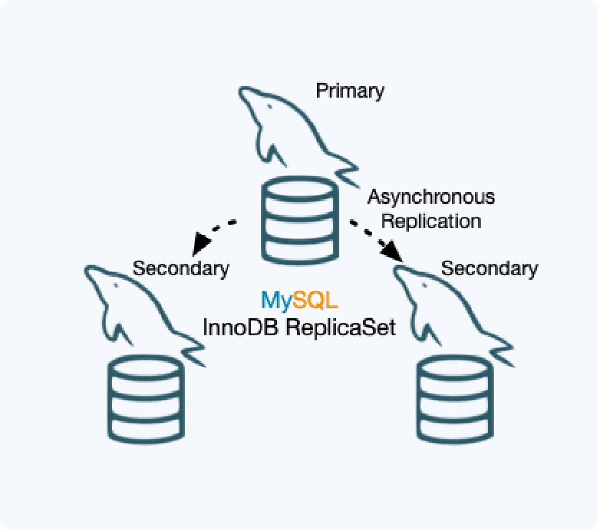
High Availability - Single Region

MySQL InnoDB Cluster



- RPO = 0
- RTO = Seconds

MySQL InnoDB ReplicaSet



- RPO != 0
- RTO = Minutes+ (manual failover)

👍 Best write performance

👎 Manual failover

Disaster Recovery - Multi Region

MySQL InnoDB Cluster

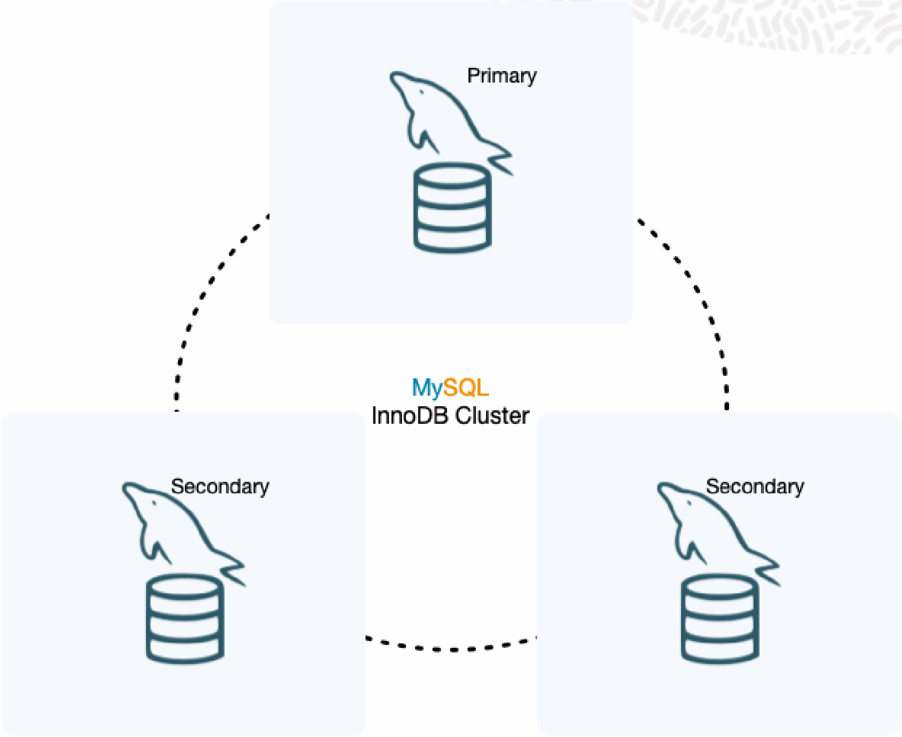
- RPO = 0
- RTO = Seconds

👍 Multi-Region Multi-Primary

👎 3 DC

👎 Requires very stable WAN

👎 Write performance affected by latency between dc's



Disaster Recovery - Multi Region

MySQL InnoDB ClusterSet

- RPO != 0
- RTO = Minutes+ (manual failover)

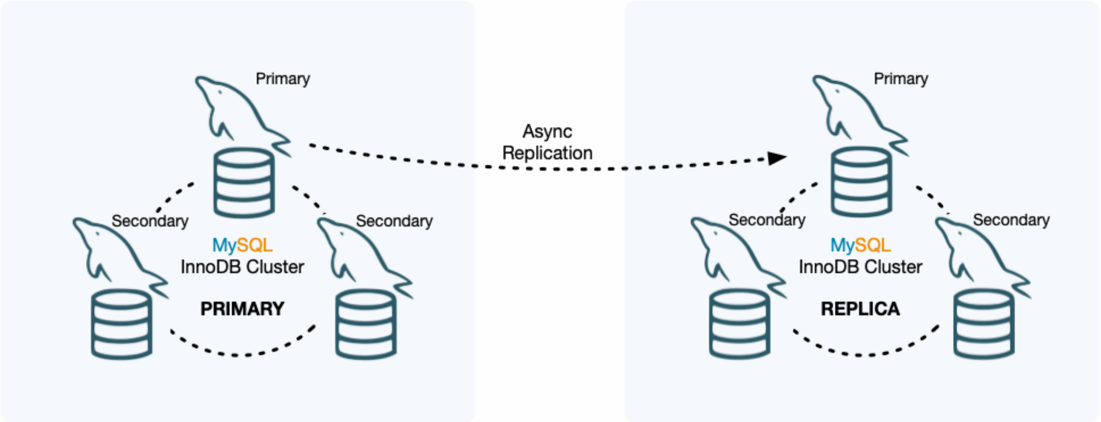
👍 RPO = 0 & RTO = seconds within Region (HA)

👍 Write performance (no sync to other region required)

👎 Higher RTO: Manual failover

👎 RPO != 0 when region fails

MySQL InnoDB ClusterSet



MySQL InnoDB ClusterSet

Demo

ClusterSet Demo

Environment, 3 regions, 3 mysql databases each, listening on different ports:

- ROM:
  - `rome:3331`
  - `rome:3332`
  - `rome:3333`
- BRU:
  - `brussels:4441`
  - `brussels:4442`
  - `brussels:4443`
- LIS:
  - `lisbon:5551`
  - `lisbon:5552`
  - `lisbon:5553`

Commands used in demo available on https://github.com/miguelaraujo/ClusterSet-Demo

Demo

Initial Setup

- Create MySQL InnoDB Cluster
- Create ClusterSet with 3 clusters
- ClusterSet Status
- Router Bootstrap

Change PRIMARYs

- Change `PRIMARY` member in `PRIMARY` cluster
- Change `PRIMARY` member in `REPLICA` cluster
- Change `PRIMARY` Cluster - `setPrimaryCluster()`

Router

- Changing Router Configuration Options
- Router Status with Cluster changes
- Router Logs

Failure Scenarios

- Automatic Handling of `PRIMARY` member in `PRIMARY` cluster
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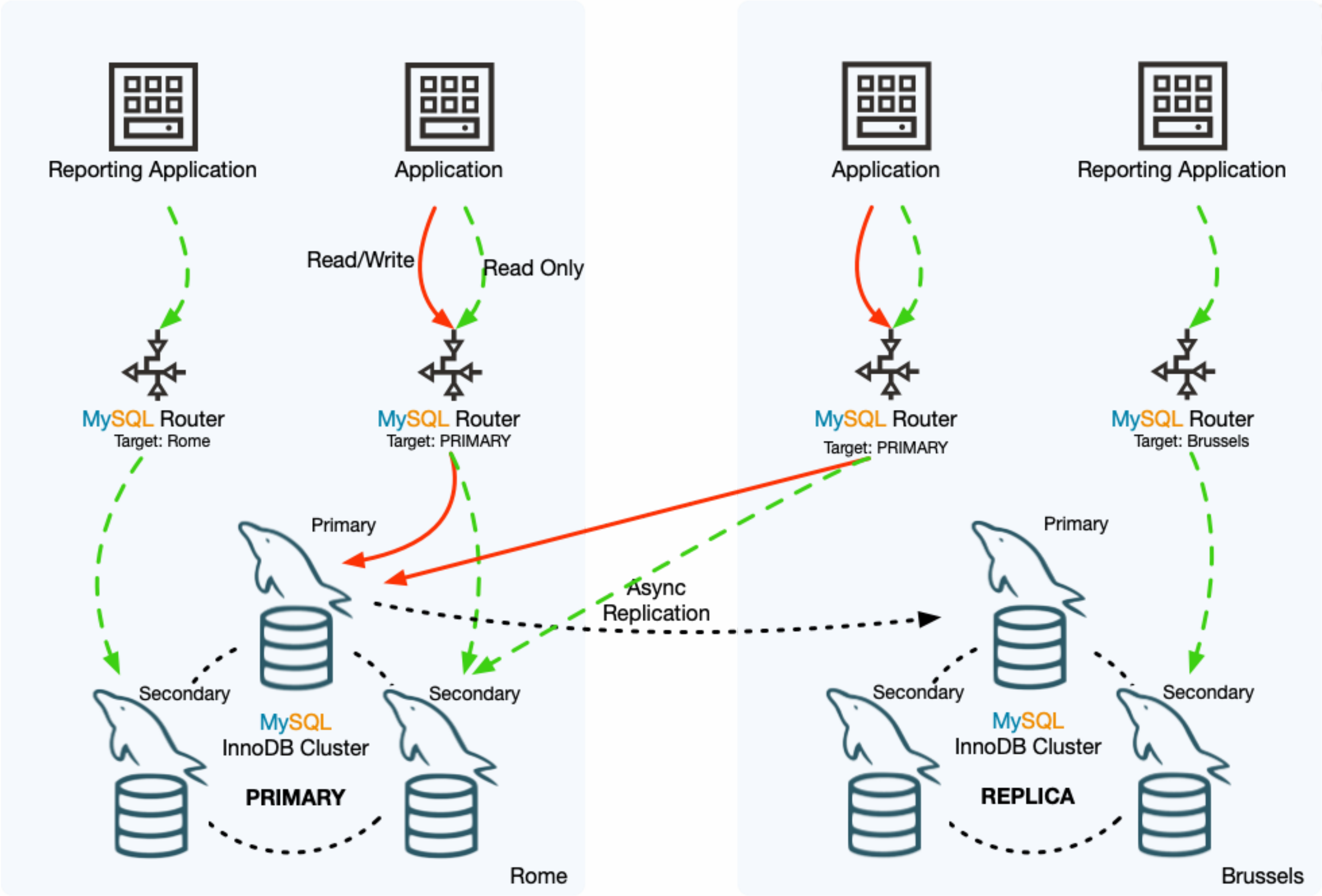
- Disaster - `PRIMARY` Cluster Failure - Failover
- Bring back `INVALIDATED` Cluster
- Rejoin `INVALIDATED` Cluster to ClusterSet

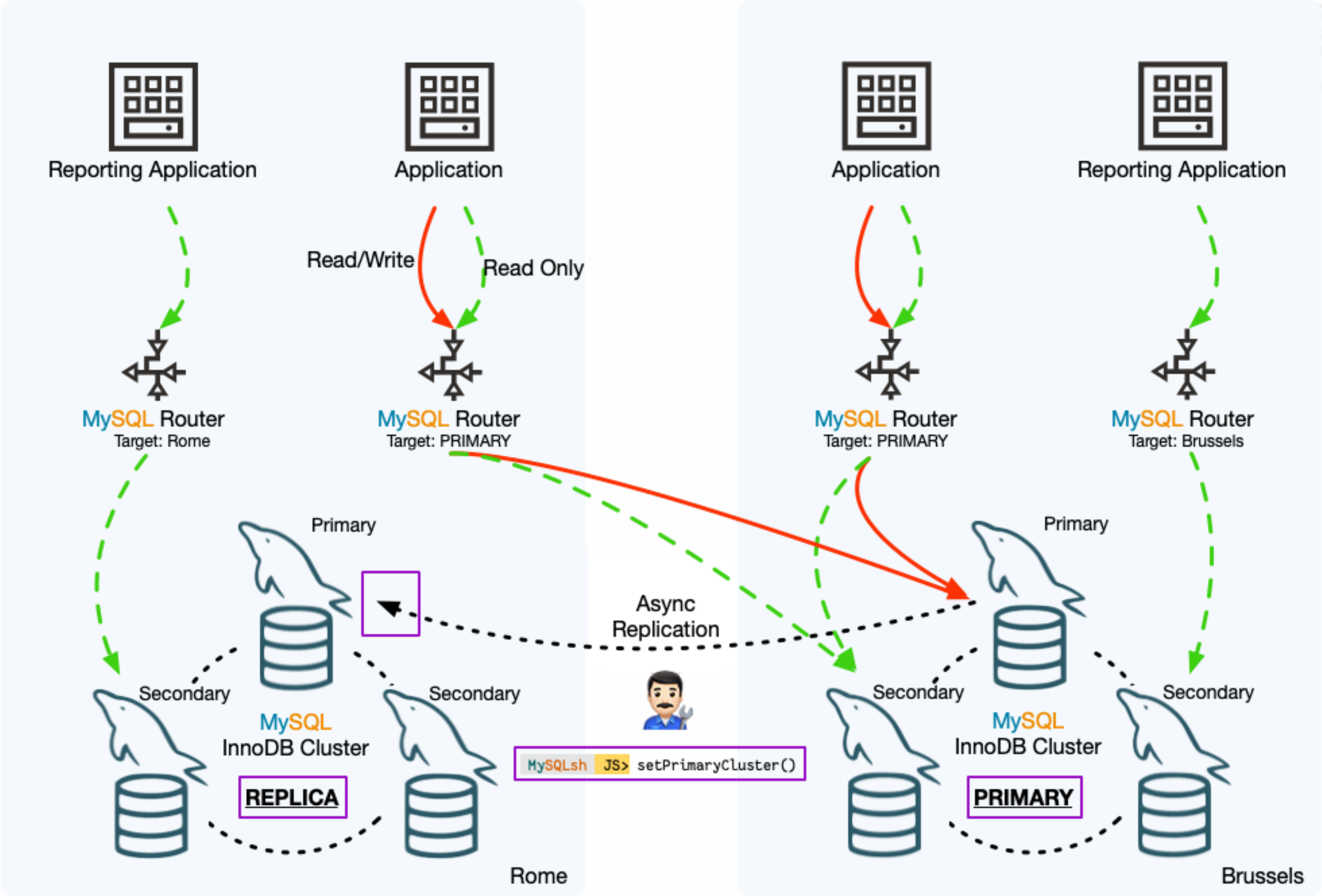
Changing Primary - Change Primary Cluster on Healthy System



Switchover

- one command that does it all: `setPrimaryCluster()`
- Asynchronous replication channels between clusters are automatically reconfigured
- Consistency guaranteed
- All routers will immediately redirect if needed (depending on target mode)

Changing Primary - `setPrimaryCluster()`



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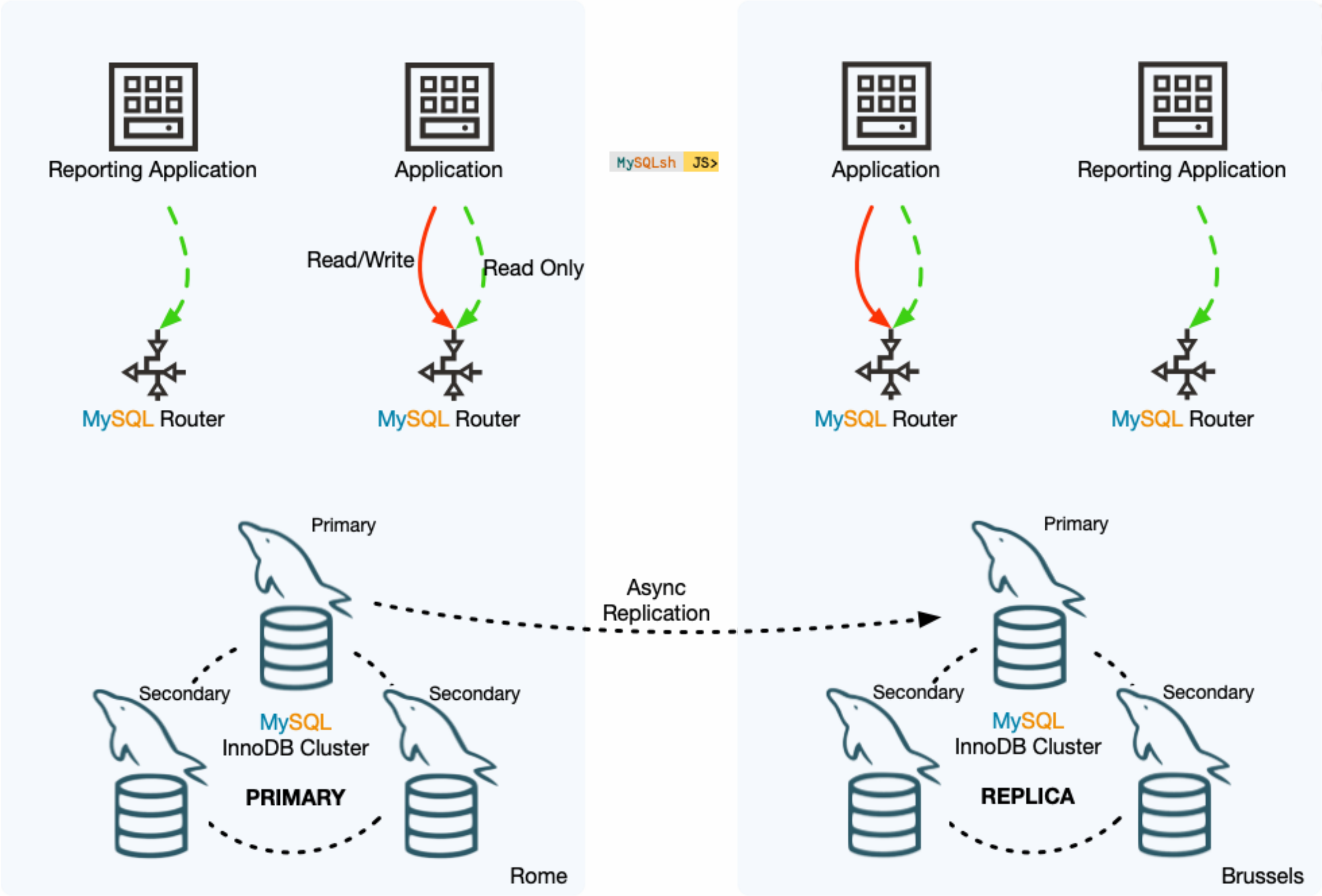
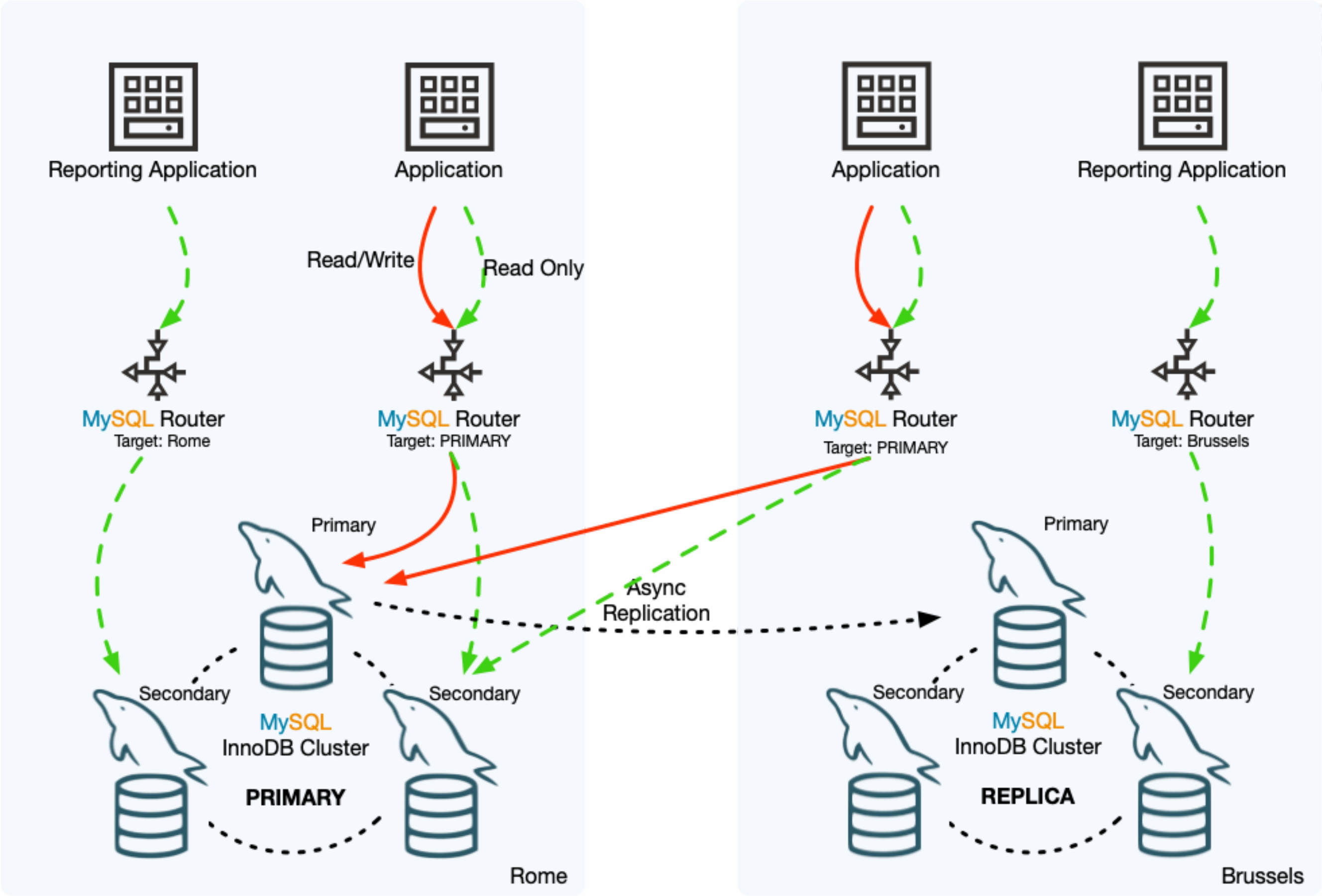
Router Integration



Configure your application to connect to a local MySQL Router to connect to the ClusterSet.

Router Integration



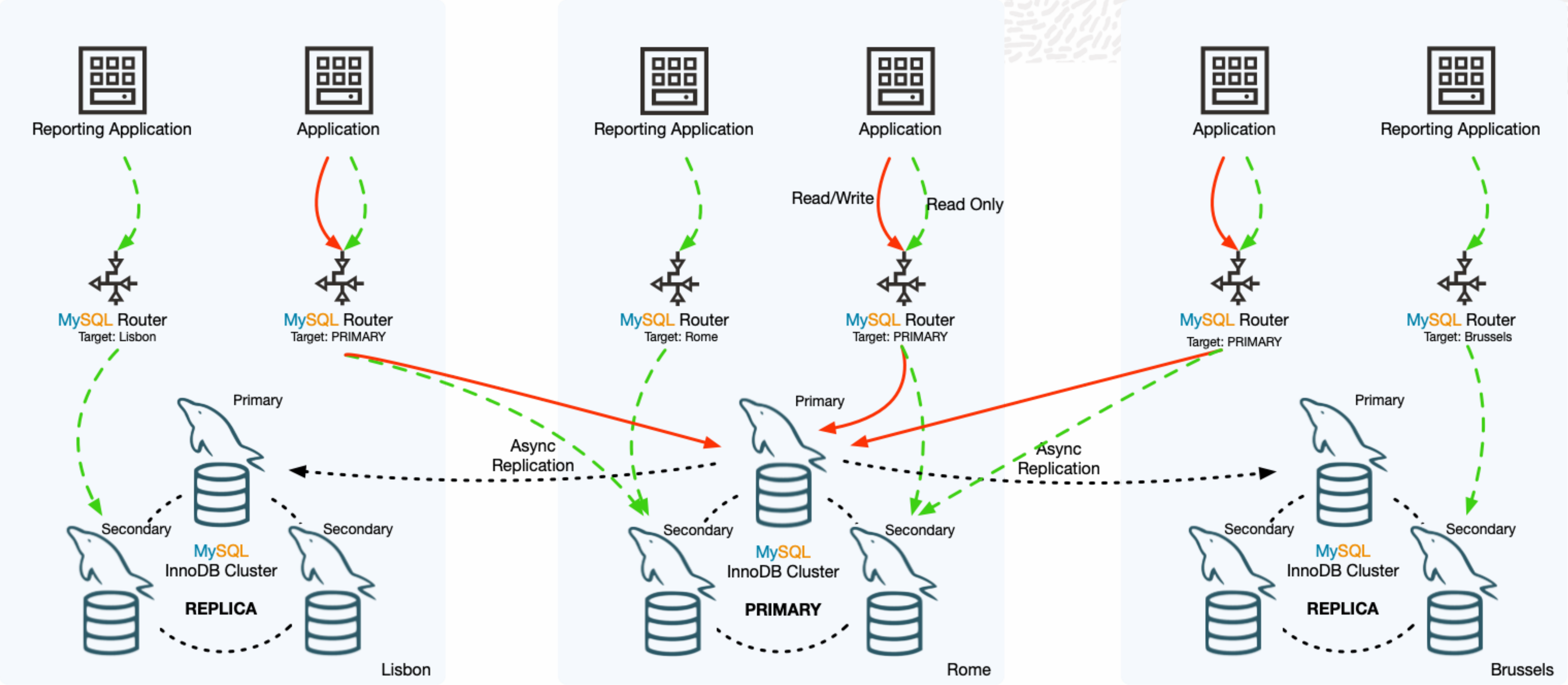
Router Target Modes:

- follow the `PRIMARY` cluster
  - Writes & Reads go to the `PRIMARY` Cluster
- connect to the configured target cluster
  - When target cluster is not `PRIMARY`:
    - only read traffic is open
    - writes will be denied
  - when target cluster is `PRIMARY`
    - write port opens

Features:

- Configurable per Router instance
- Configuration can be changed `ONLINE` in `mysqlsh`
- Deploy 2 types of routers:
  - target `PRIMARY` to send writes to `PRIMARY`
  - define target cluster to keep read traffic local
- `INVALIDATED` clusters can still be used for read traffic (configurable)

Router Integration - 3DC



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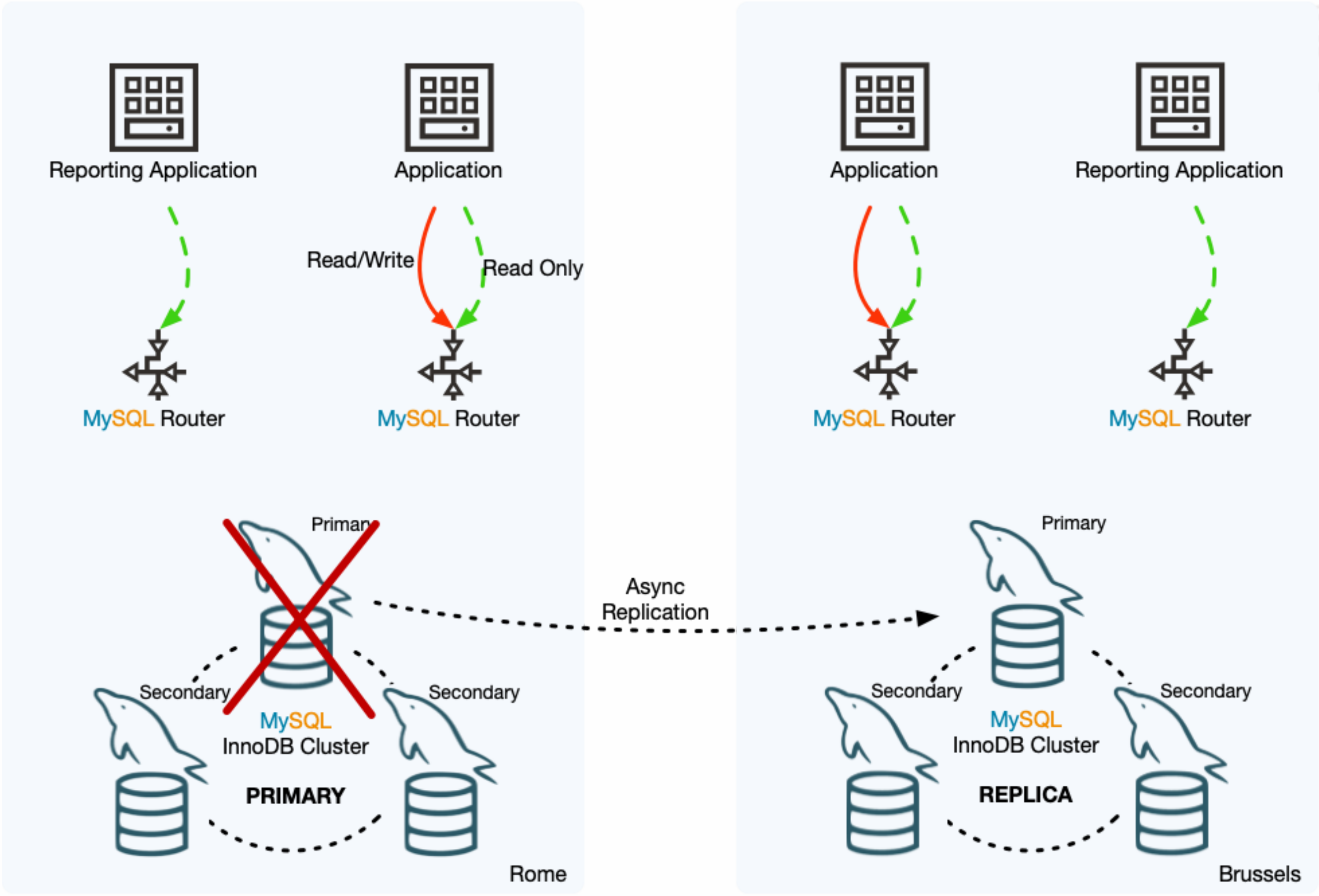
ClusterSet Scenarios

PRIMARY Cluster PRIMARY member Crash/Partition

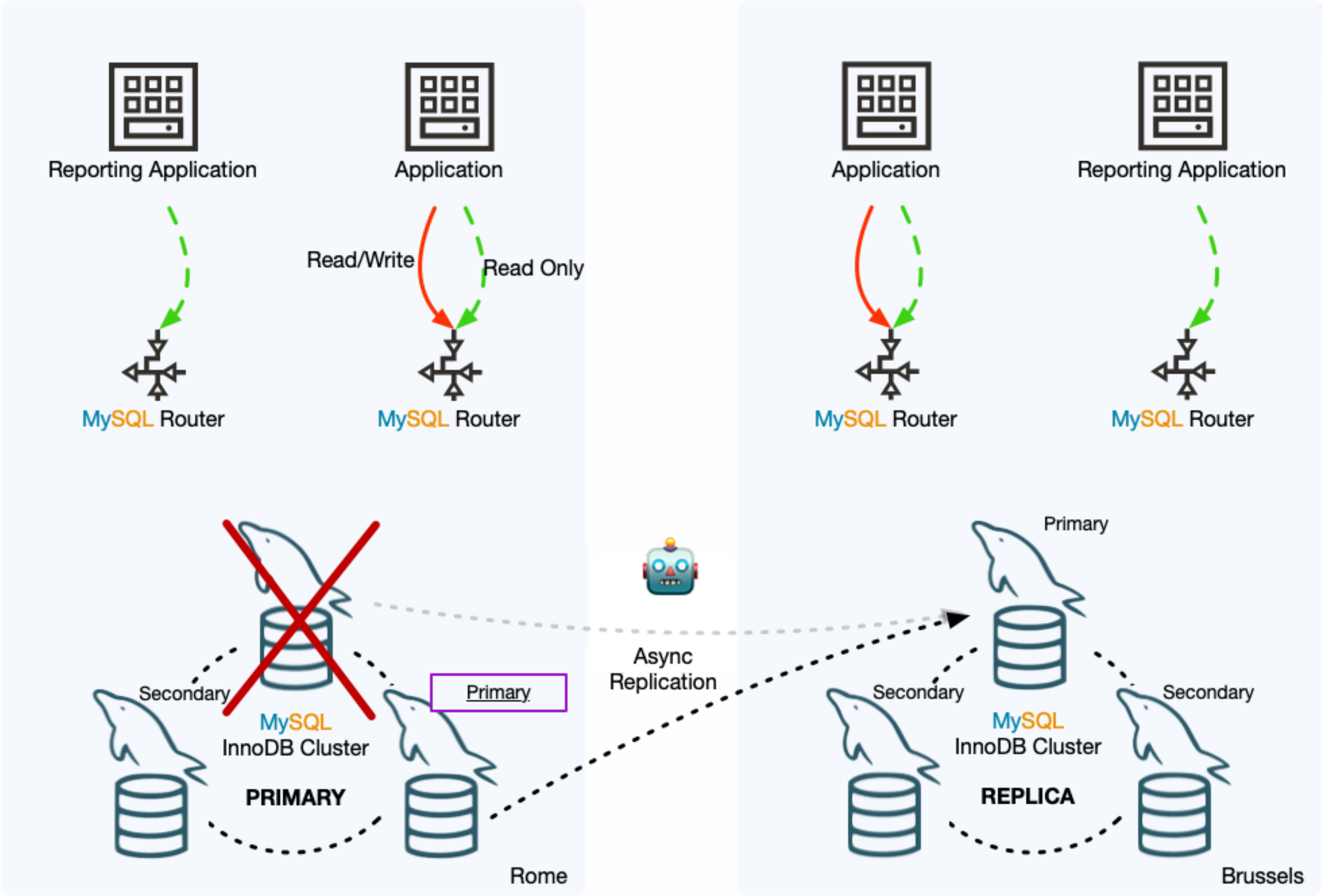


- When there is newly elected PRIMARY member in a cluster
- Works on failures in PRIMARY and REPLICA clusters

Automatic Handling of InnoDB Cluster state changes

- Asynchronous replication is automatically reconfigured after primary change

PRIMARY Cluster PRIMARY member Crash/Partition - Automatic!



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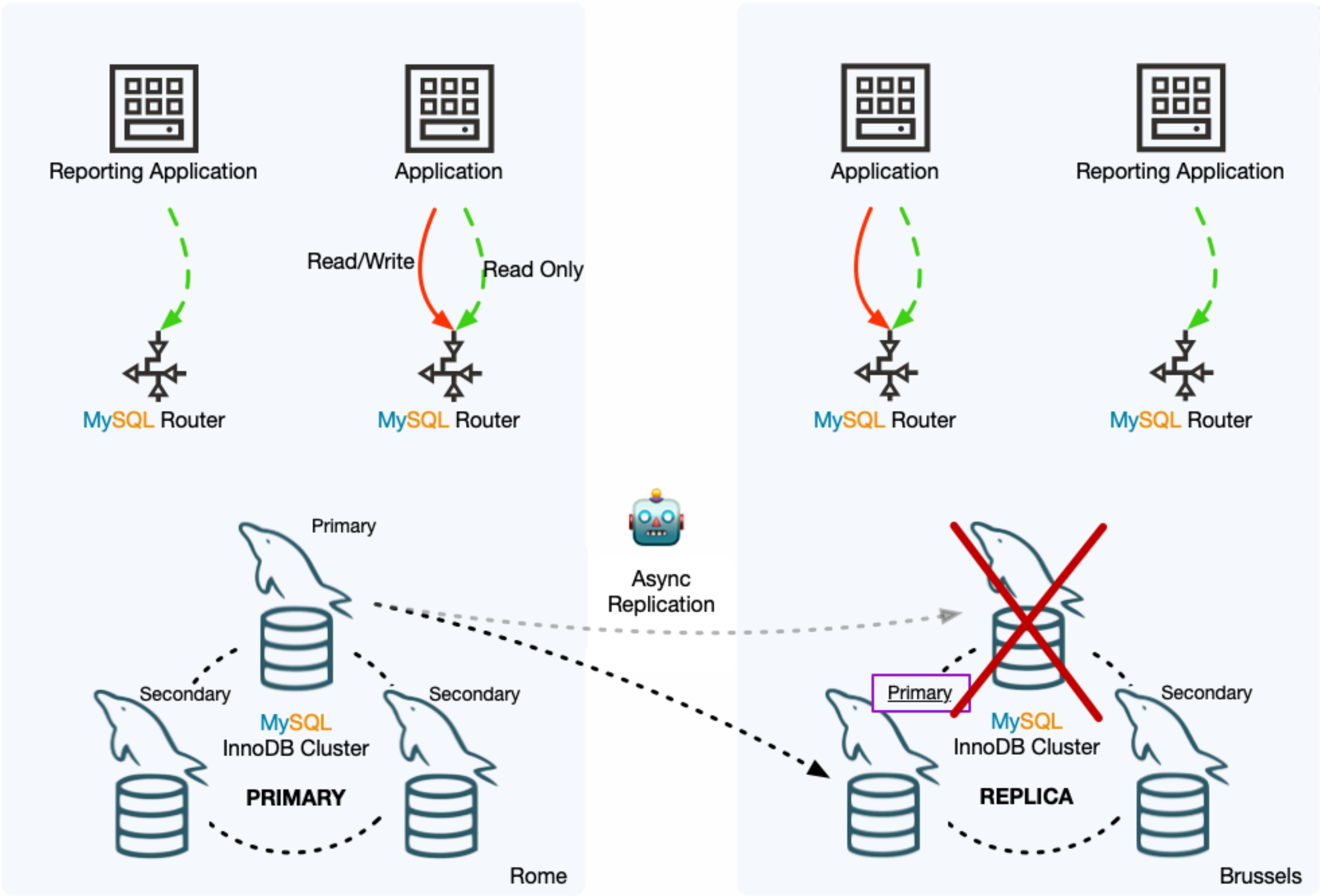
REPLICA Cluster PRIMARY member Crash/Partition - Automatic!



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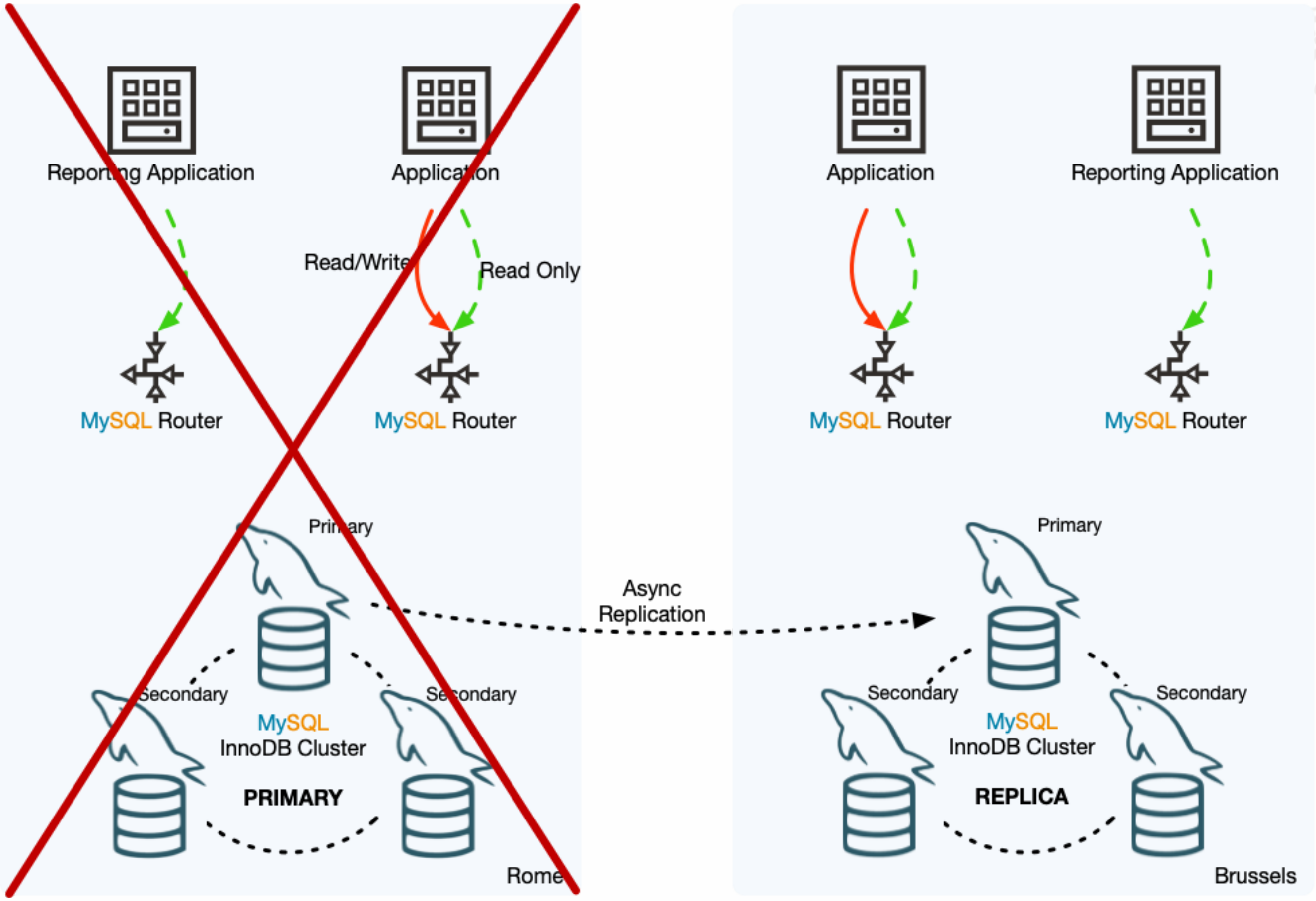
Datacenter Crash/Partition



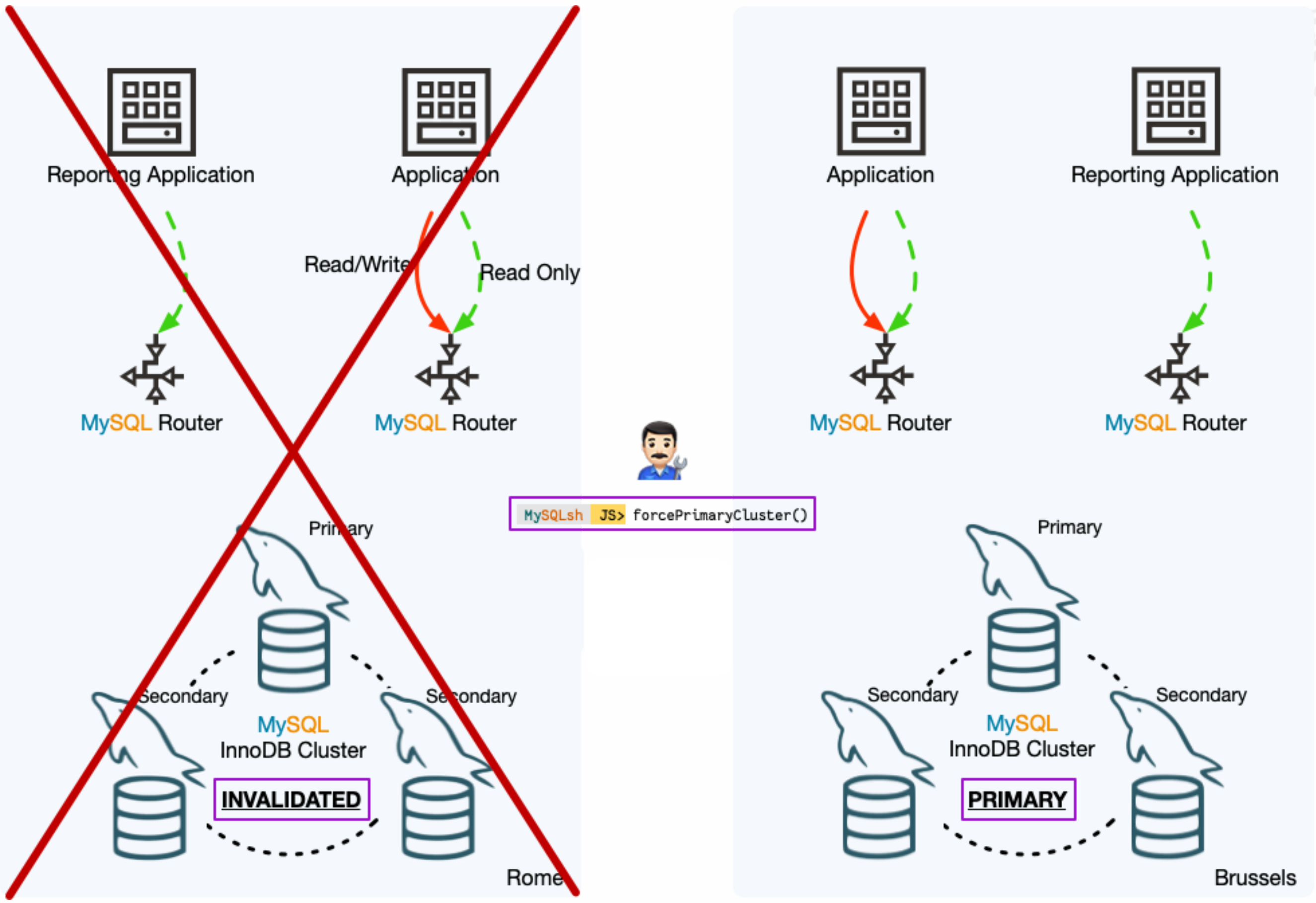
Failover to another Cluster

- one command to invalidate the PRIMARY cluster and promote a new PRIMARY cluster: `forcePrimaryCluster()`
- other REPLICA clusters replication will be reconfigured

Split Brain Warning

- local Routers that cannot connect to other clusters will not learn about new topology
- if datacenter is network partitioned, it will continue to operate as PRIMARY

Datacenter Crash/Partition - `forcePrimaryCluster()`



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MySQLsh JS> forcePrimaryCluster()
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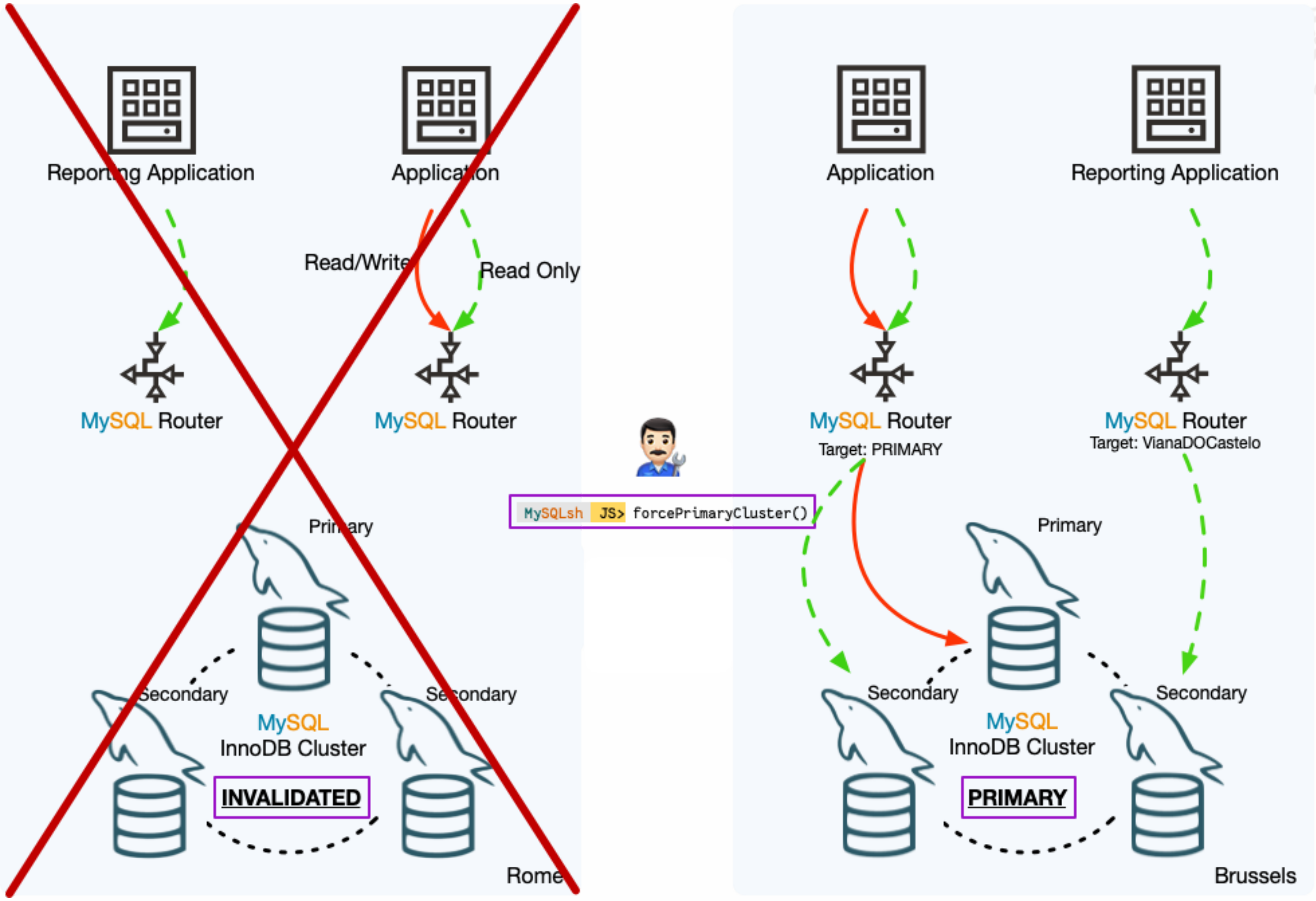
Datacenter Crash/Partition - Router Integration



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MySQLsh JS> forcePrimaryCluster()
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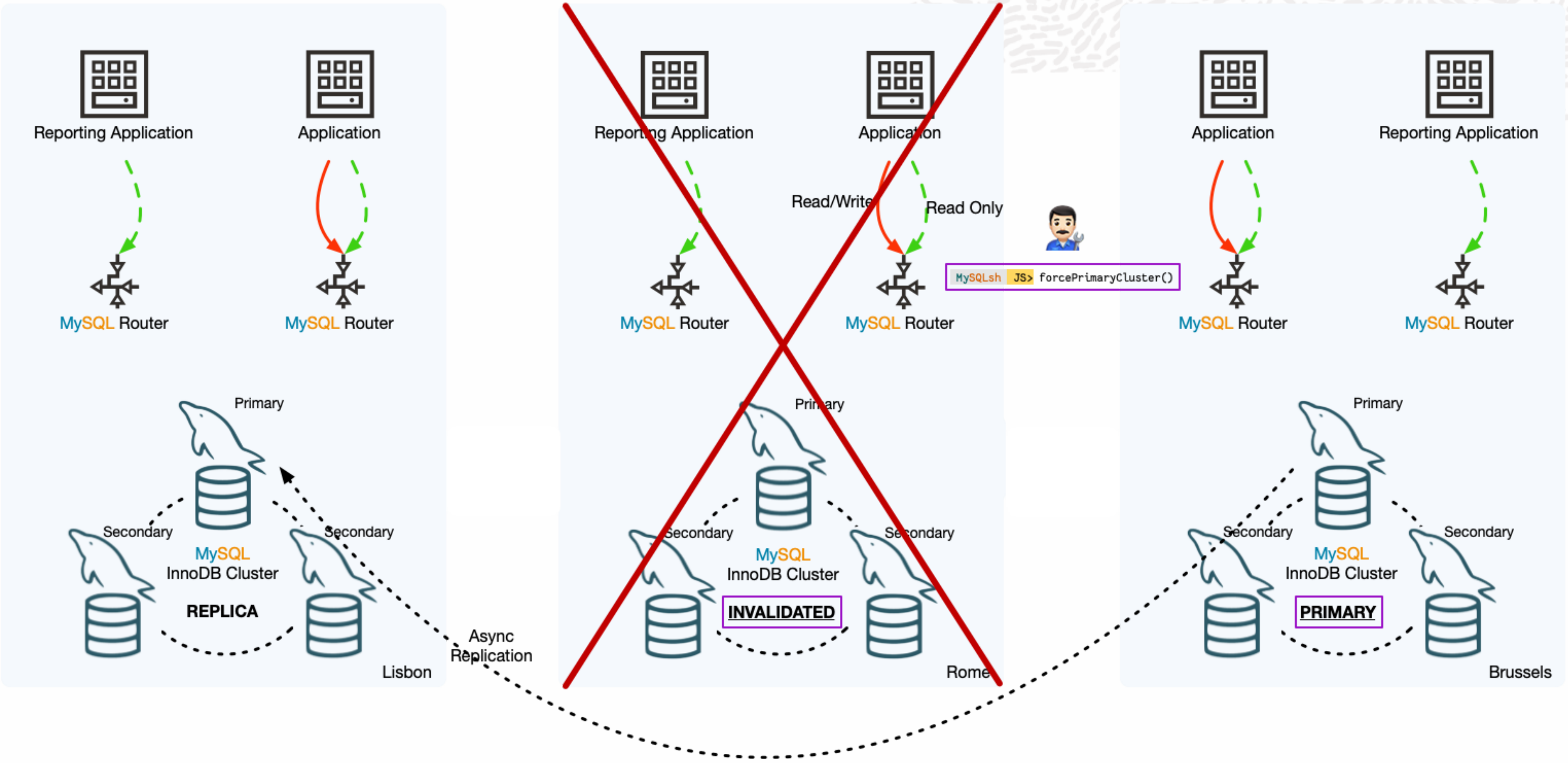
Router Integration

- Routers will learn about new topology and redirect traffic
- Routers that come back, will learn about new topology and abandon the old PRIMARY Cluster (e.g failed DC comes back online)

Datacenter Crash/Partition - Multiple REPLICA clusters Support



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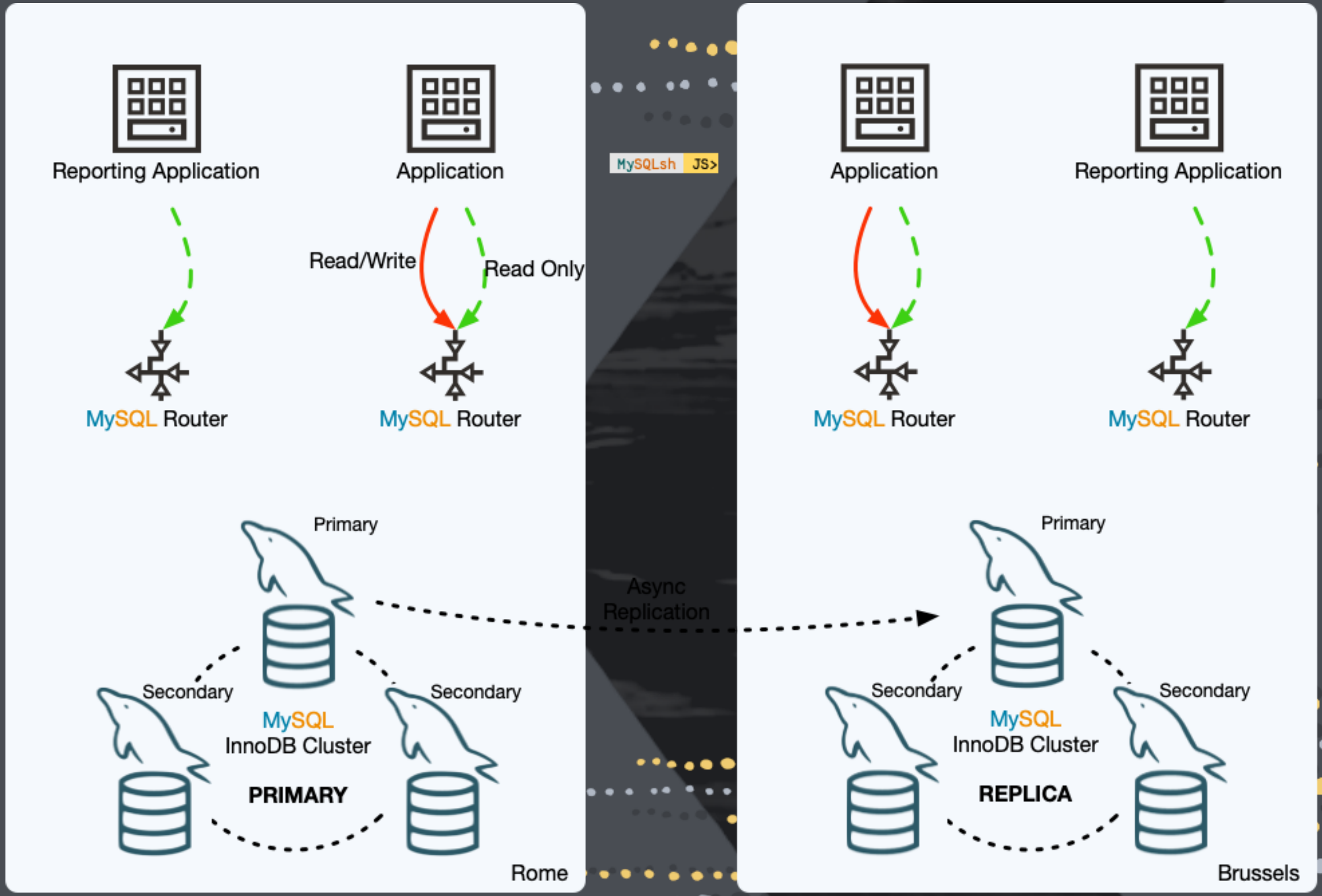
MySQL



MySQL InnoDB ClusterSet