MySQL

ORACLE

MySQL Sharding:

Tools and Best Practices for Horizontal Scaling

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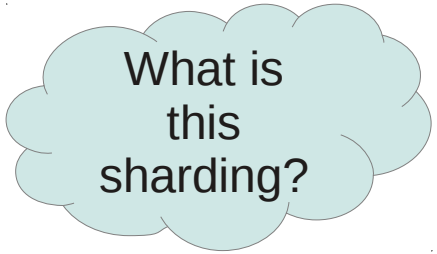
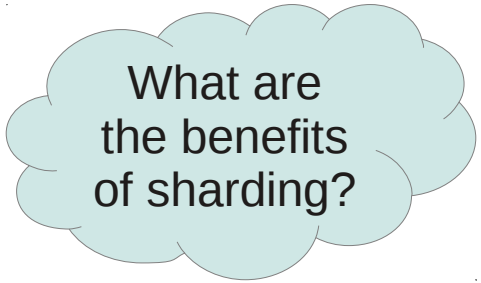
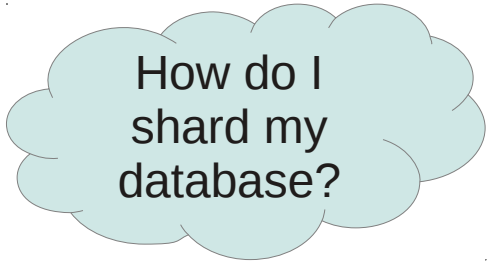
Program Agenda

- Handling Scaling
- What is sharding?
- Managing a Sharded Database
- Working with a Sharded Database



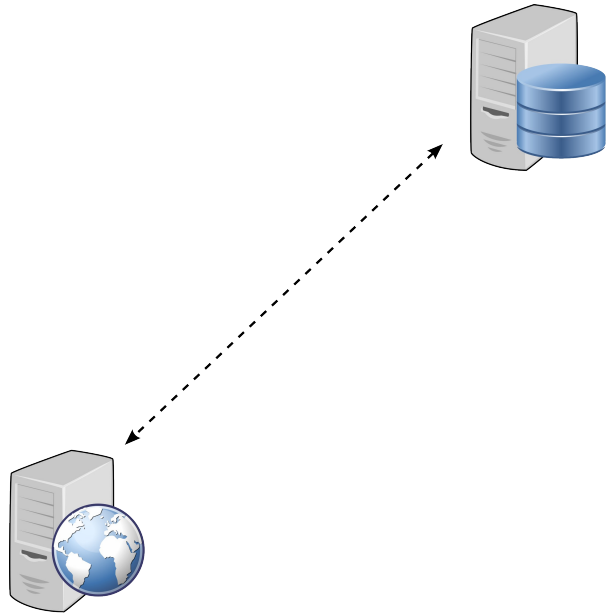




It's all about scaling...

The Growing Enterprise

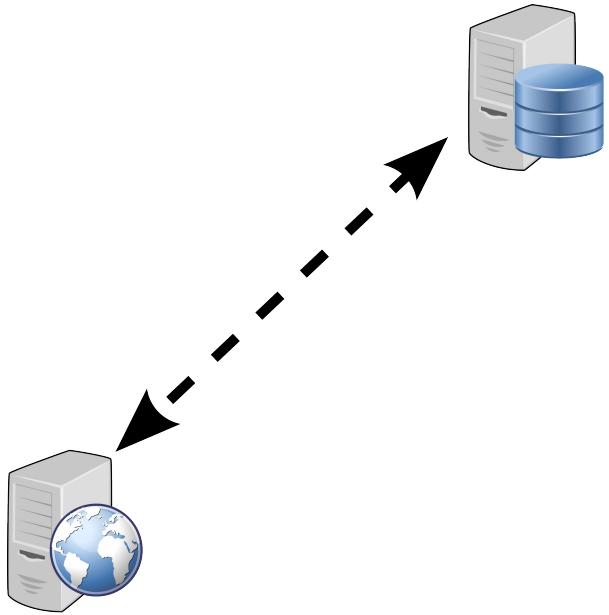
- Start with a single server



It's all about scaling...

The Growing Enterprise

- Start with a single server
- More and more page requests
  - ...more and more reads
- What to do?
  - Scale out!



It's all about scaling...

The Growing Enterprise

- Start with a single server
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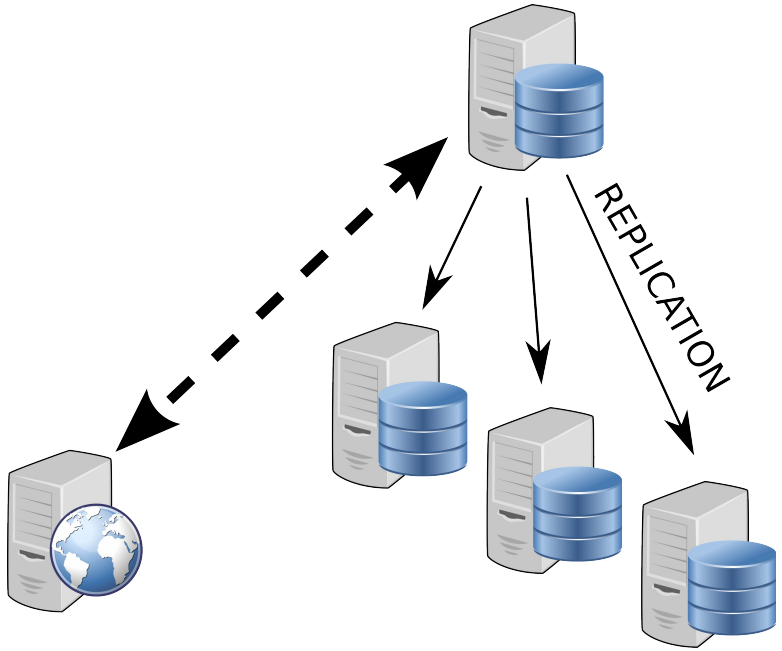
- What to do?
  - Scale out!
- Replicate to read servers



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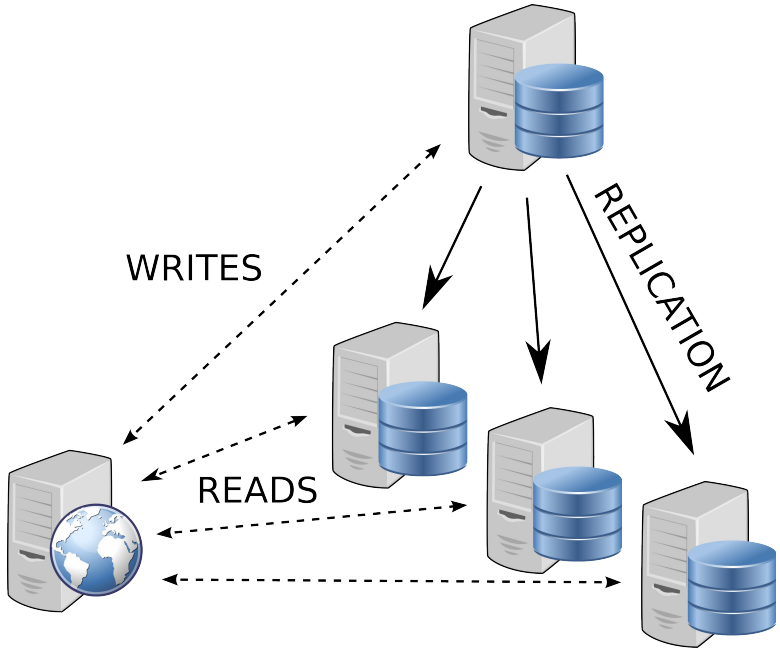
It's all about scaling...

The Growing Enterprise

- Start with a single server
- More and more page requests
  - ...more and more reads
- What to do?
  - Scale out!
- Replicate to read servers
- Perform a *read-write split*
  - Writes go to master
  - Reads go to read servers



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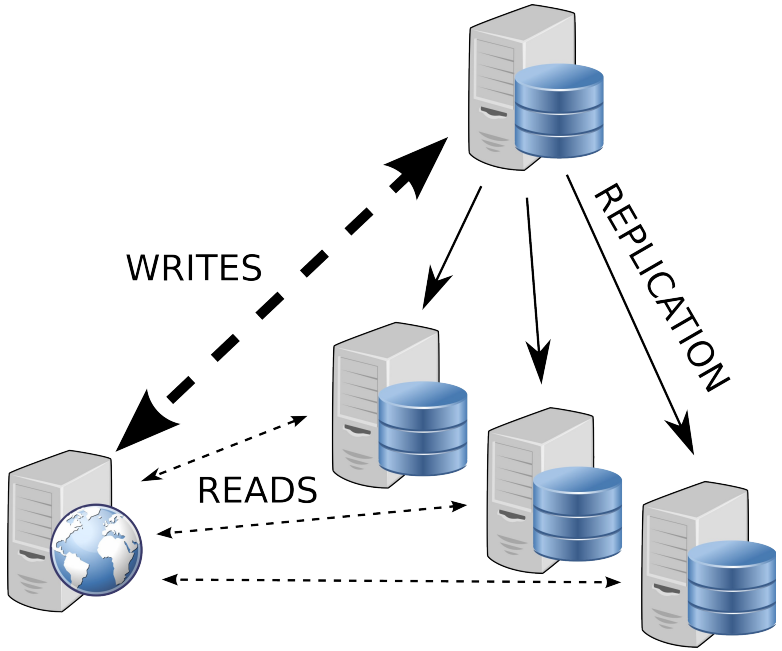
It's all about scaling...

The Growing Enterprise

- More and more updates
  - Write load increases
- What now?



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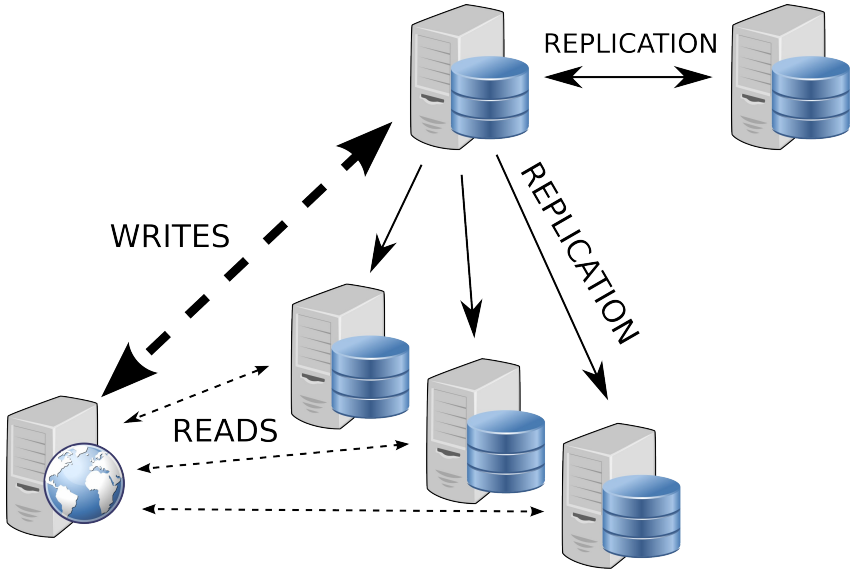
It's all about scaling...

The Growing Enterprise

- More and more updates
  - Write load increases
- What now?
  - Add another master?



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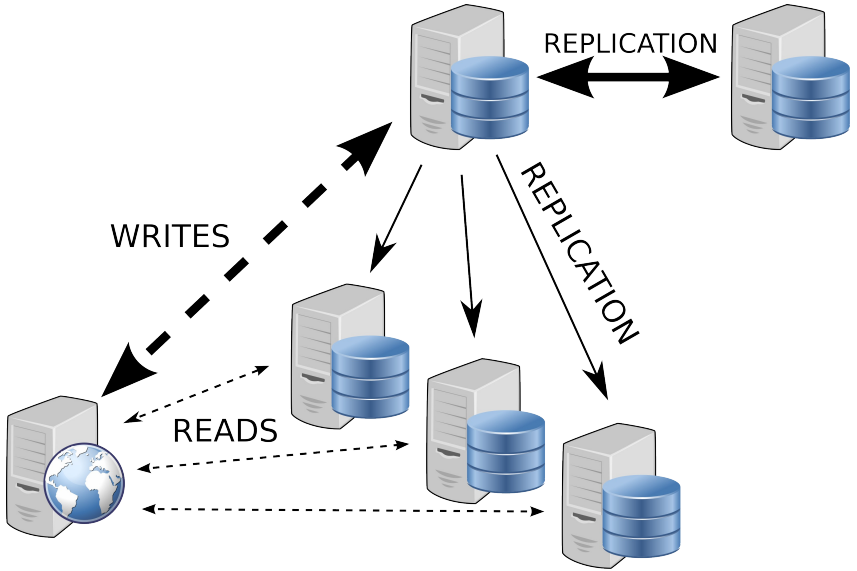
It's all about scaling...

The Growing Enterprise

- More and more updates
  - Write load increases
- What now?
  - Add another master?
- Doesn't work...
  - Write load is replicated



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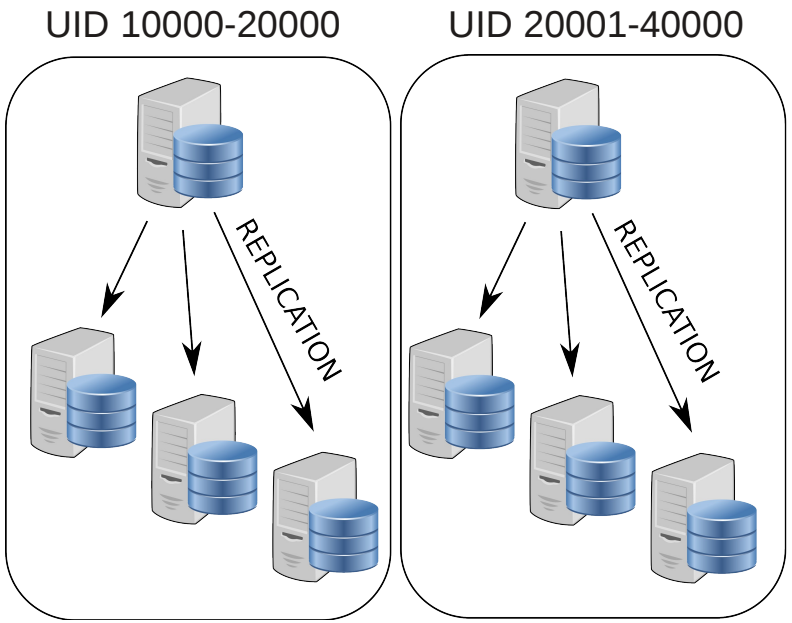
It's all about scaling...

The Growing Enterprise

- More and more updates
  - Write load increases
- What now?
  - Add another master?
- Doesn't work...
  - Write load is replicated
- Partition database
  - Distribute writes
  - Called *sharding*



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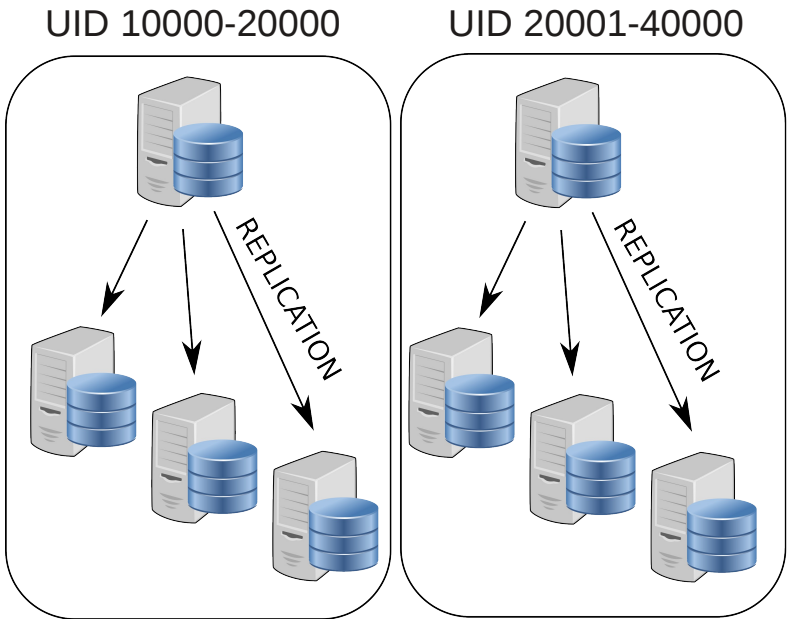
Benefits of Sharding

- Write scalability
  - Can handle more writes
- Large data set
  - Database too large
  - Does not fit on single server
- Improved performance
  - Smaller index size
  - Smaller working set
  - Improve performance



Architecture of a Sharding Solution

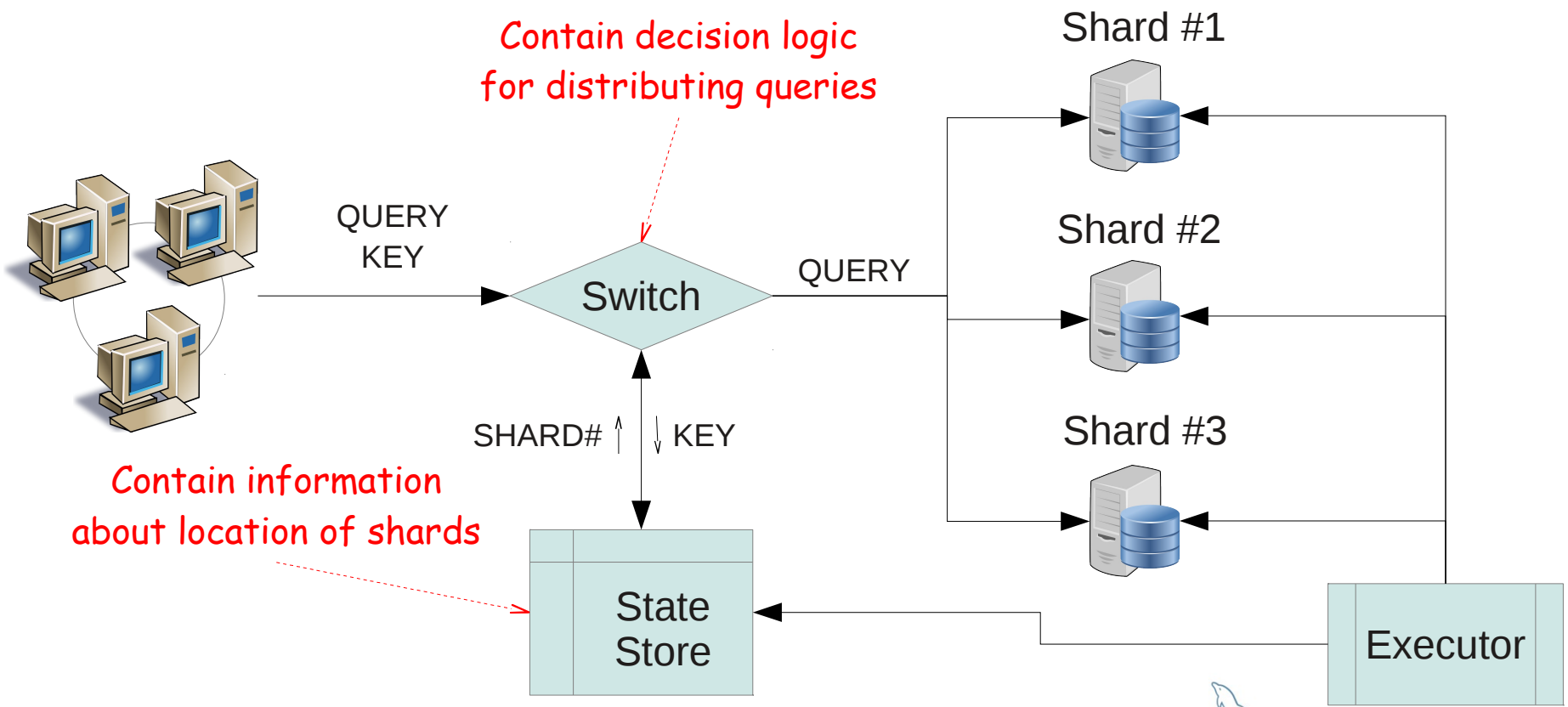
What do you need to consider?

- High level architecture
- Transaction and sharding key handling
- Granularity of sharding

High-level Architecture

- What components do we need?
- How are they deployed?

Components for a Sharding Solution



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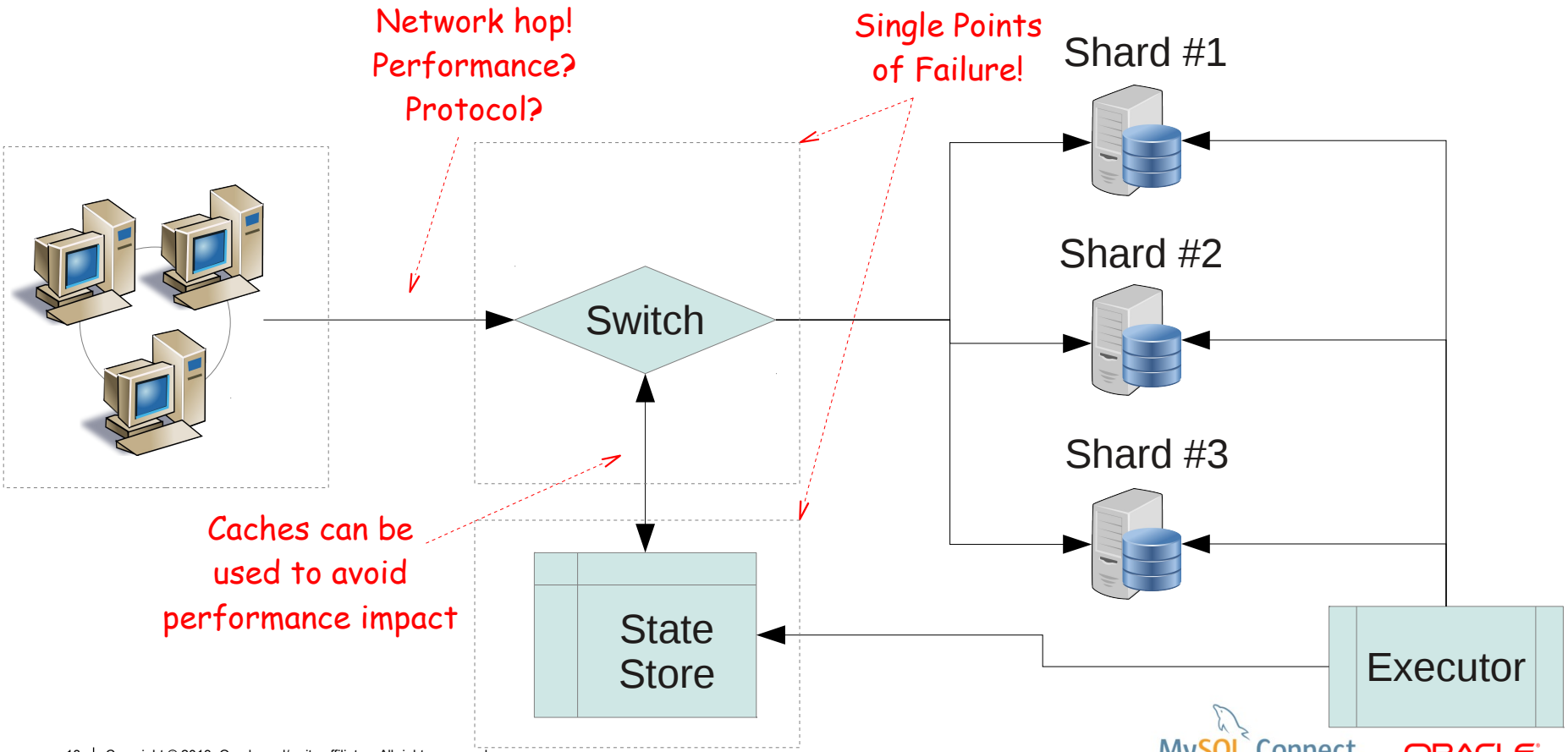
Deployment of the Sharding Solution



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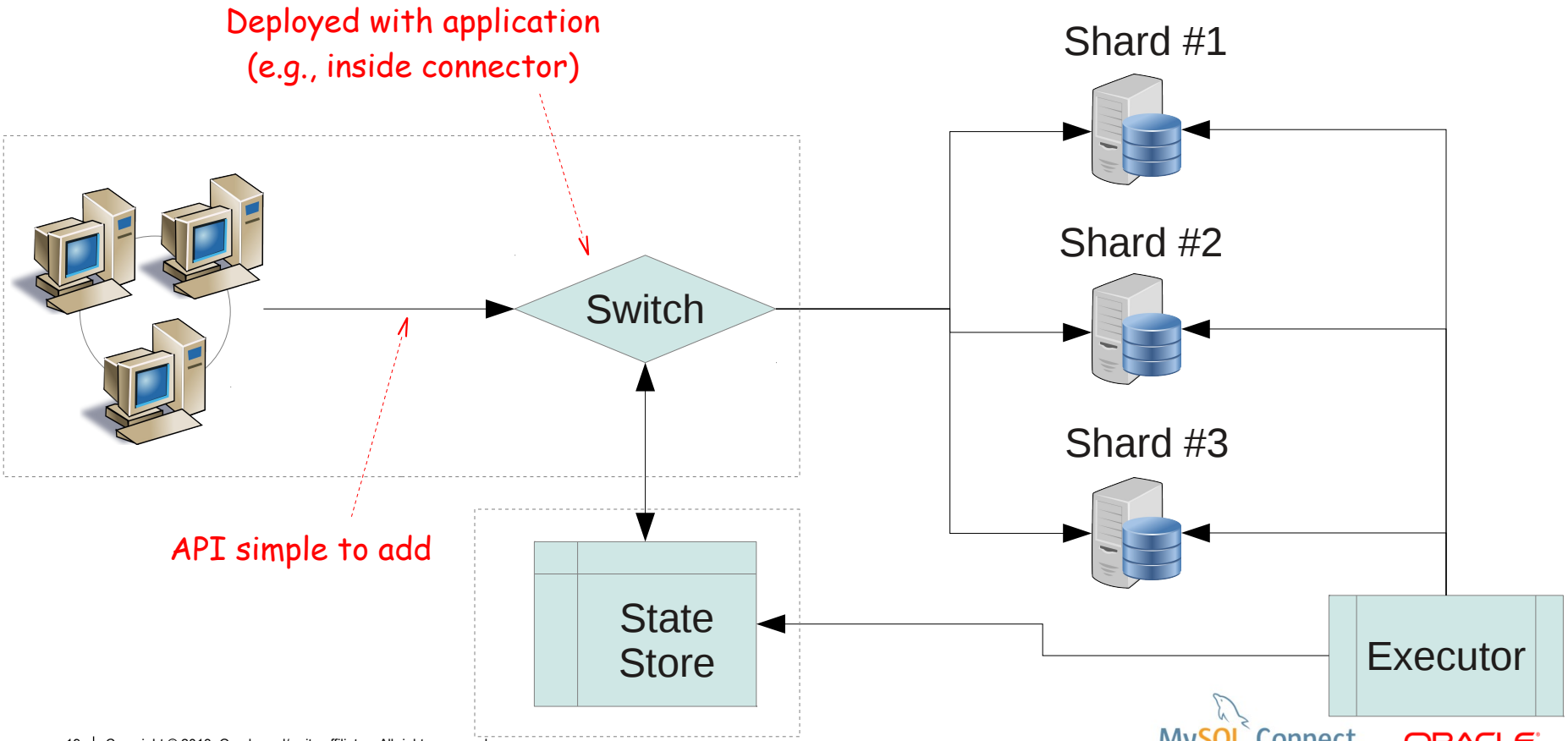
Deployment of the Sharding Solution



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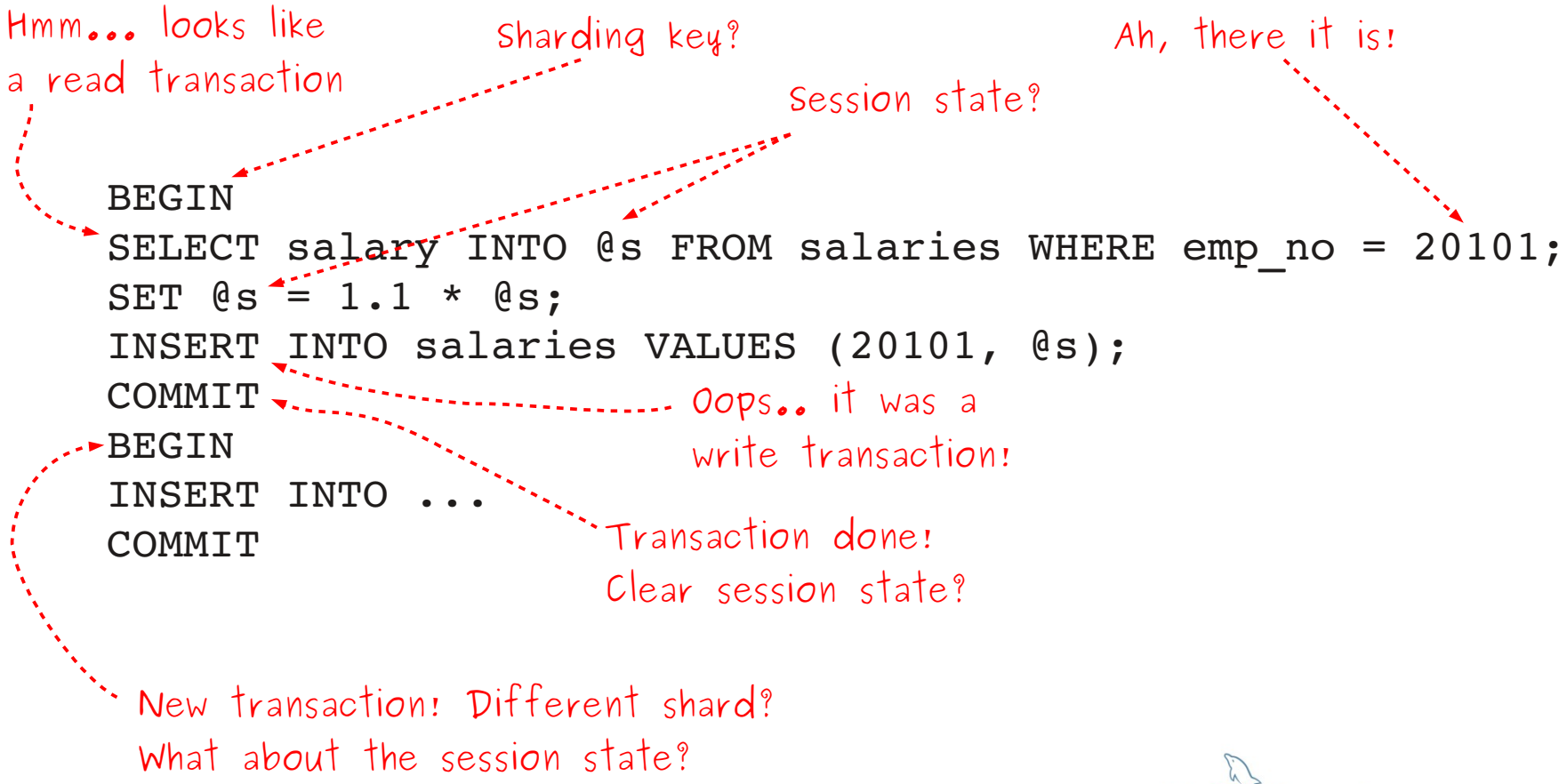
Transaction and Shard Key Handling

- How are the transactions handled?
- How do get the shard key for a transaction?
- How to compute shard from key?

Transaction Handling



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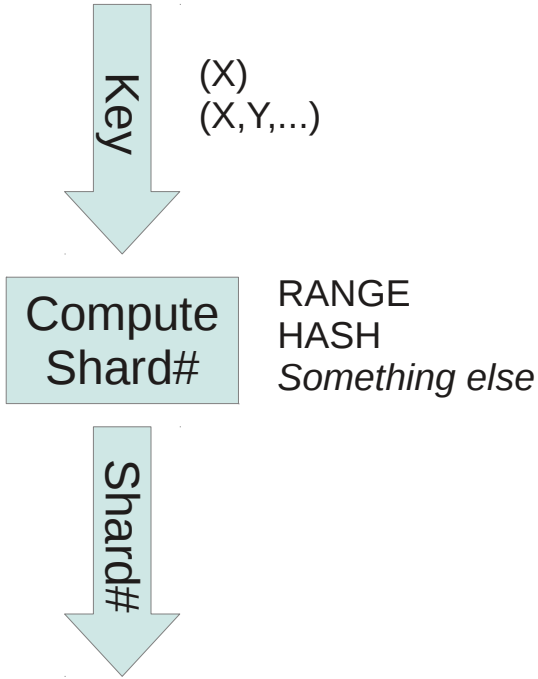
Transaction Handling

- Detecting transaction boundaries
- Managing session state
  - Move session state between servers
    - Easy to use
    - Expensive and error prone
  - Reset state after each transaction
    - Transactions start with default session state

Mapping the Sharding Key

- What is a sharding key?
  - Single column
  - Multi column
    - Same table?
    - Different tables?
- How is the key transformed?
  - Hash
  - Range
  - User-defined



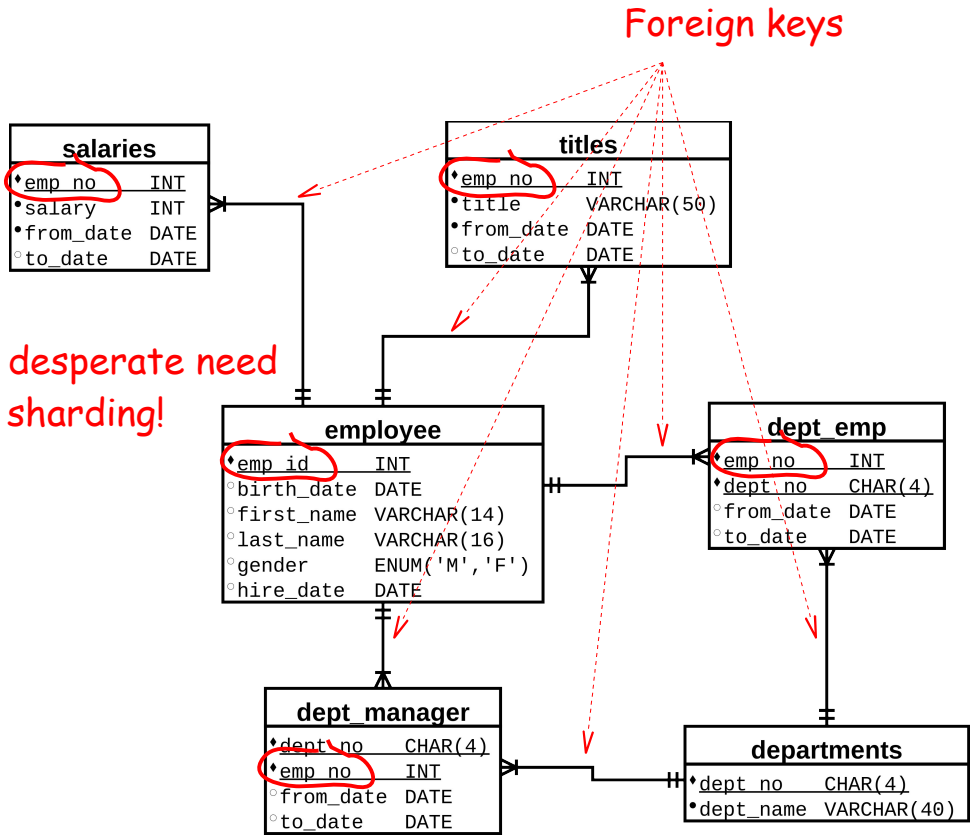
Granularity of Sharding

- Can multiple tables be sharded with the same key?
- Can we shard different tables different ways?
- Do we allow global tables?
- Do we allow cross-database queries?

Sharded Tables

Table	Rows
salaries	284 404 700
titles	44 330 800
employees	30 002 400
dept_emp	33 160 300
dept_manager	2 400
departments	900

In desperate need of sharding!



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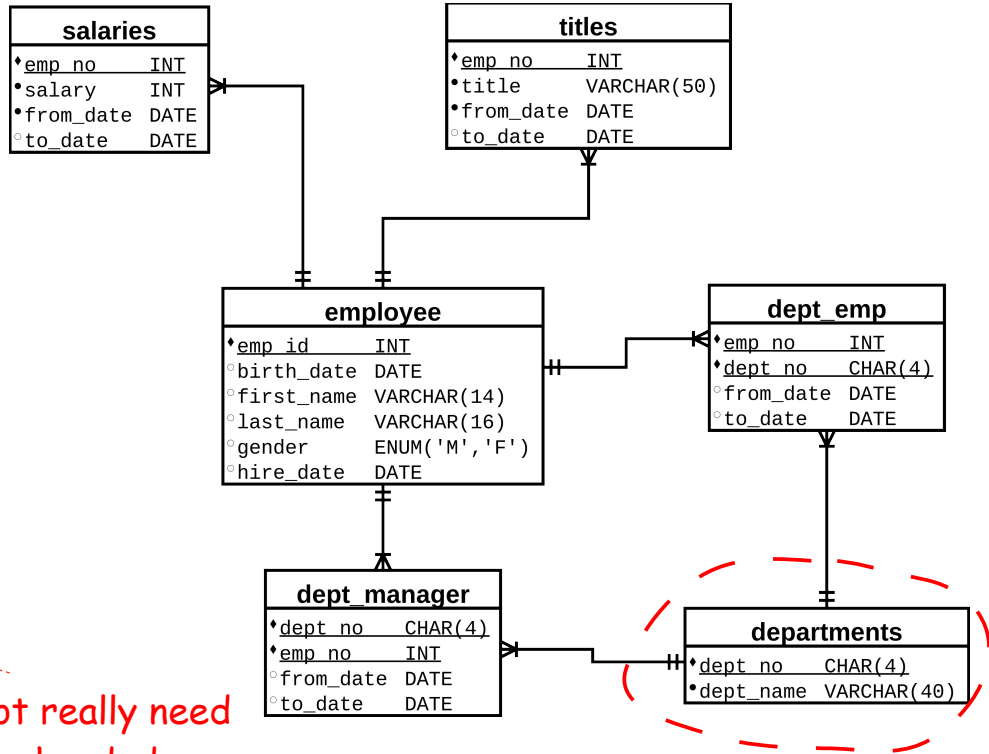
Multi-table Query with Sharded Tables

```
SELECT first_name, last_name, salary
FROM salaries JOIN employees USING (emp_no)
WHERE emp_no = 21012
    AND CURRENT_DATE BETWEEN from_date AND to_date;
```

- Referential Integrity Constraint
  - Example query joining salaries and employees
  - Same key, same shard: co-locate rows for same user
- JOIN normally based on equality
  - Using non-equality defeats purpose of foreign key

Global Tables

Table	Rows
salaries	284 404 700
titles	44 330 800
employees	30 002 400
dept_emp	33 160 300
dept_manager	2 400
departments	900



Do not really need to be sharded

 |

Multi-table Query with Global Tables

```
SELECT first_name, last_name, GROUP_CONCAT(dept_name)
  FROM employees JOIN dept_emp USING (emp_no)
                 JOIN departments USING (dept_no)
WHERE emp_no = 21012 GROUP BY emp_no;
```

- JOIN with **departments** table
  - Has no employee number, hence no sharding key
  - Table need to be present on all shards
- How do we update global tables?

Managing a Sharded Database

MySQL Fabric

An extensible and easy-to-use framework for managing a farm of MySQL server supporting high-availability and sharding

MySQL Fabric: What is it?

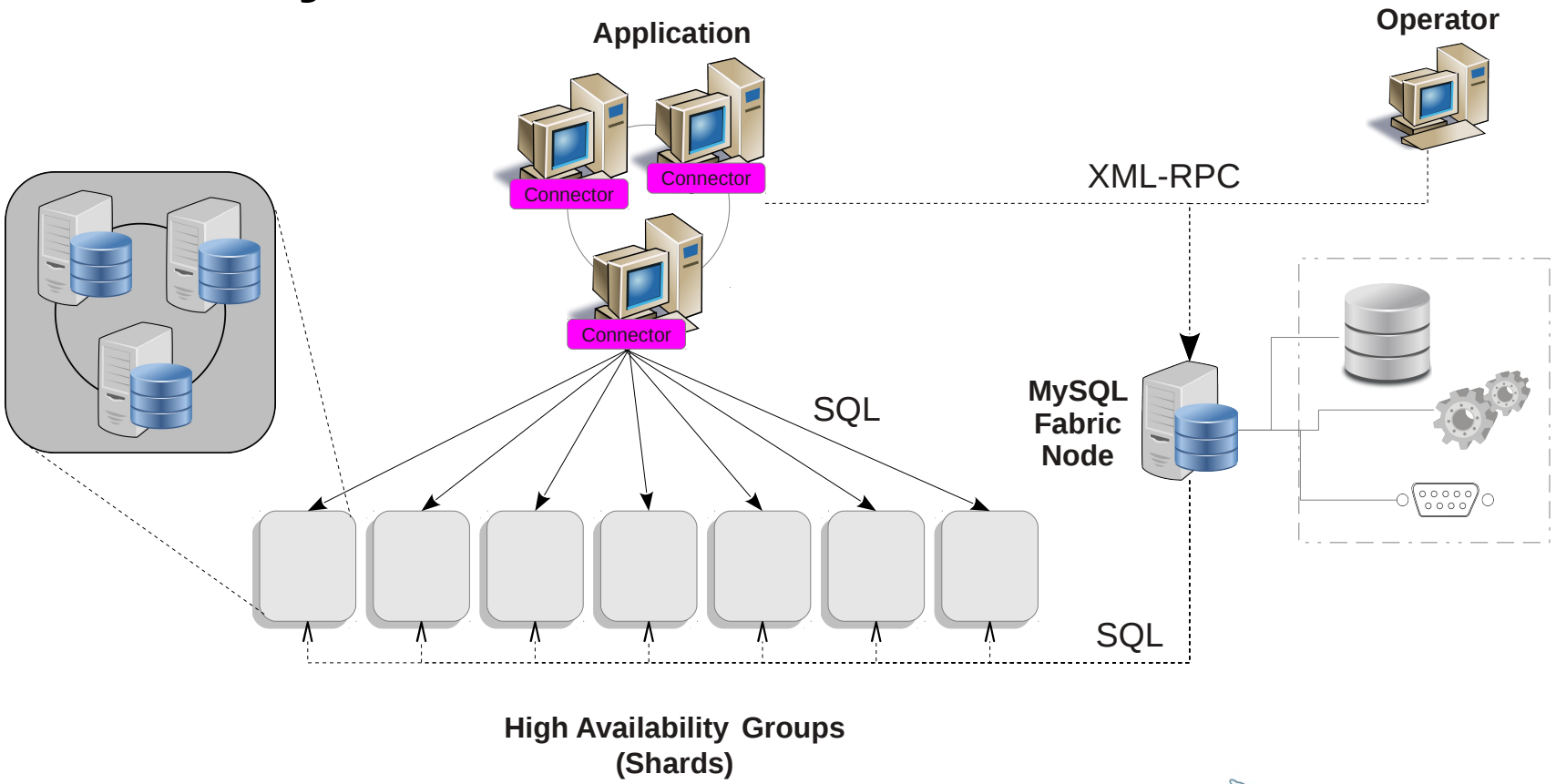
- "Farm" Management System
  - High-Availability
  - Sharding
- Distributed
- Procedure Execution
- Extensible

- Written in Python
- Early alpha
  - Long road ahead
- Open Source
  - You can participate
  - Suggest features
  - Report bugs
  - Contribute patches
- MySQL 5.6 is focus

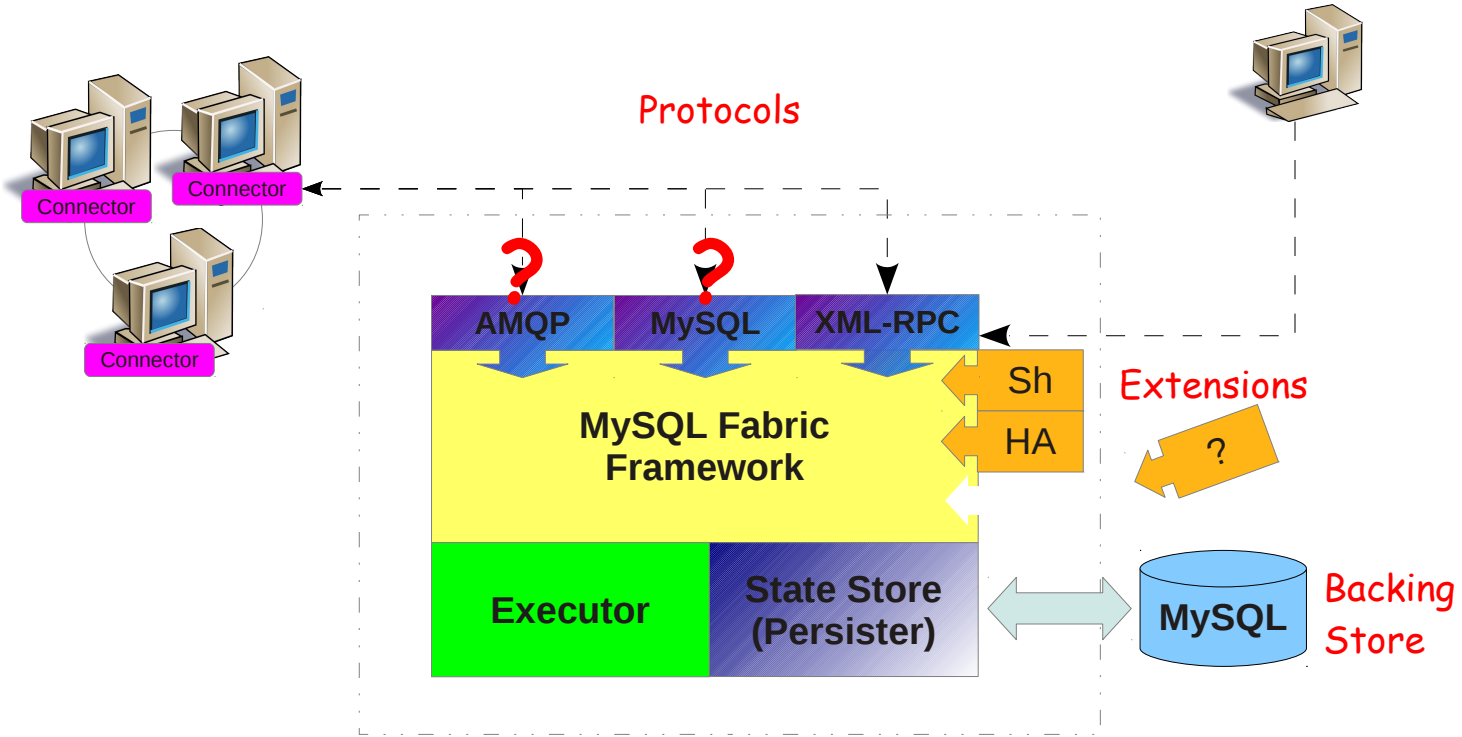
MySQL Fabric: Features

- Decision logic in connector
  - Reducing network load
- Support Transactions
  - API to provide sharding key
- Global Updates
  - Global Tables
  - Schema updates
- Procedure Executor
- Shard Multiple Tables
  - Using same key
- Sharding Functions
  - Range
  - (Consistent) Hash
- Shard Operations
  - Using built-in executor
  - Shard move
  - Shard split

Birds-eye View of a Sharded Database



MySQL Fabric Node Architecture



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MySQL Fabric: Prerequisites

- MySQL Servers (version 5.6.10 or later)
  - Server for meta-data backing store
  - Servers being managed
- Python 2.6 or 2.7
  - No support for 3.x yet
- MySQL Utilities 1.4.0
  - Available at http://labs.mysql.com/

MySQL Fabric: Configuration

- Backing Store
  - MySQL server
  - Persistent storage for state
  - Storage engine-agnostic
- Protocol
  - Address where node will be
  - Currently only XML-RPC
- Logging
  - Chatty: **INFO** (default)
  - Moderate: **WARNING**
  - URL for rotating log

```
[storage]
address = localhost:3306
user = fabric
password =
database = fabric
connection_timeout = 6

[protocol.xmlrpc]
address = localhost:8080
threads = 5

[logging]
level = INFO
url = file:///var/log/fabric.log
```


MySQL Fabric: Setup and Teardown

- Create the necessary tables in backing store

```
mysqlfabric manage setup
```

- Remove the tables from backing store

```
mysqlfabric manage teardown
```

- Connect to database server in “storage” section
  - Ensure that you have the necessary users and privileges

MySQL Fabric: Starting and Stopping

- Start MySQL Fabric node in foreground – print log to terminal

```
mysqlfabric manage start
```

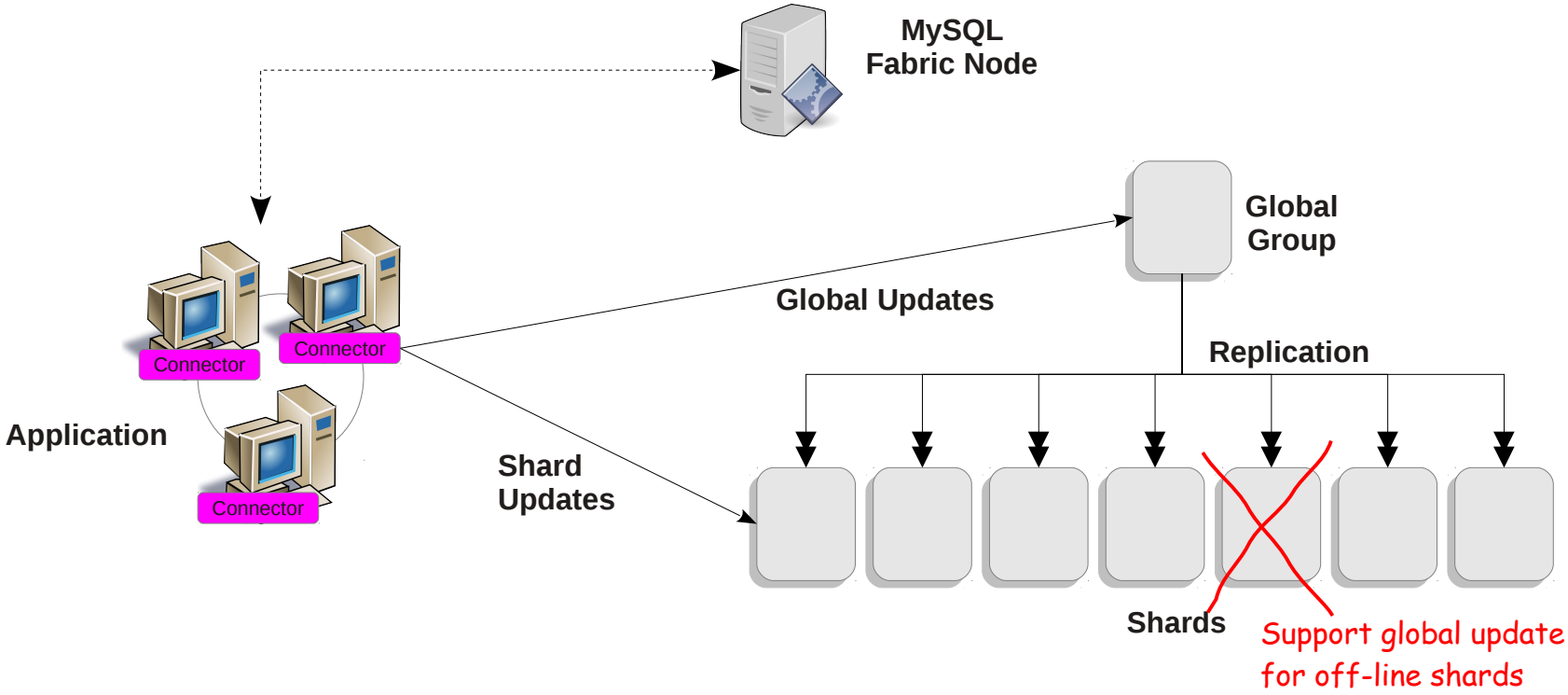
- Start MySQL Fabric node in background – print log to file

```
mysqlfabric manage start --daemonize
```

- Stop MySQL Fabric node

```
mysqlfabric manage stop
```

Sharding Architecture



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MySQL Fabric: Sharding Setup

- Set up some groups
  - `my_global` – for global updates
  - `my_group.*` – for the shards
  - Add servers to the groups
- Create a shard mapping
  - A “distributed database”
  - Mapping keys to shards
  - Give information on what tables are sharded
- Add shards

MySQL Fabric: Create Groups and add Servers

- Define a group

```
mysqlfabric group create my_global
```

- Add servers to group

```
mysqlfabric group add my_global global.example.com \
  mats xyzzy
mysqlfabric group add my_global …
```

User + Password
(Likely to go away)

MySQL Fabric: Create Groups and add Servers

- Promote one server to be primary

```
mysqlfabric group promote my_global
```

- Tell failure detector to monitor group

```
mysqlfabric group activate my_global
```

MySQL Fabric: Set up Shard Mapping

- Define shard mapping

```
mysqlfabric sharding define hash my_global
```

Will show the shard map identifier (a number)

- Add tables that should be sharded

```
mysqlfabric sharding add_mapping 1 \
  employees.employees emp_no
mysqlfabric sharding add_mapping 1 \
  employees.salaries emp_no
```

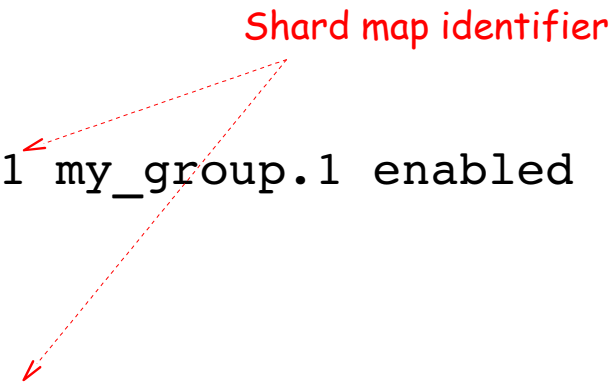
Shard map identifier

- Tables not added are global

MySQL Fabric: Add Shards

- Add shards to shard mapping

```
mysqlfabric sharding add_shard 1 my_group.1 enabled
    .
    .
    .
mysqlfabric sharding add_shard 1 my_group.N enabled
```



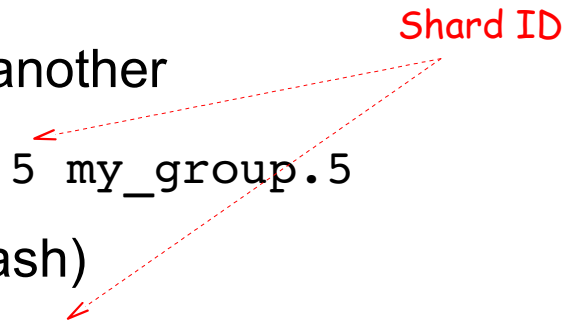
MySQL Fabric: Moving and Splitting Shards

- Moving a shard from one group to another

```
mysqlfabric sharding move 5 my_group.5
```

- Splitting a shard into two pieces (hash)

```
mysqlfabric sharding split 5 my_group.6
```



Working with a Sharded Database

Fabric-aware Connector API

- Support Transactions
  - Sharding key out of band

- Fabric-aware Connectors
  - Connector/J
  - Connector/Python
  - Connector/PHP
- Fabric-aware Frameworks
  - Doctrine
  - Hibernate
- Focus on Connector/Python

Fabric-aware Connector API

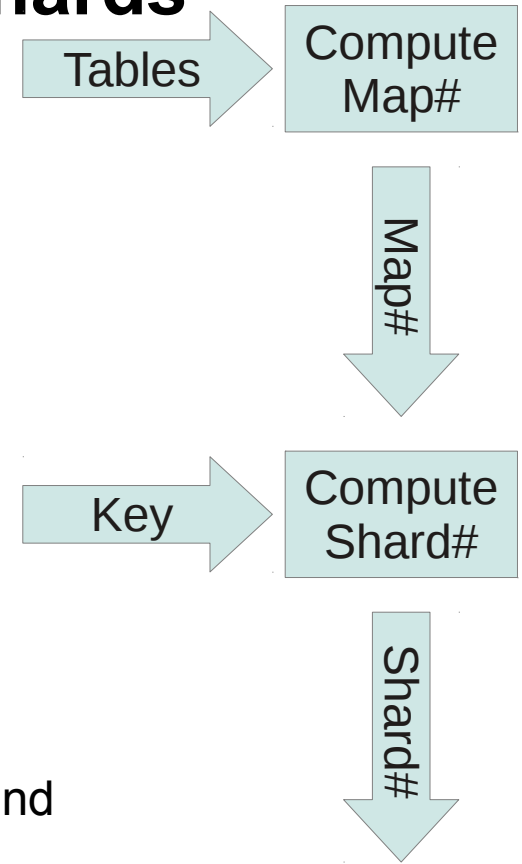
- Establish a “virtual” connection
  - Real server connection established lazily
- Provide connection information for the *Fabric node*
  - Fabric node will provide information about real servers

```
import mysql.connector.fabric as connector

conn = connector.MySQLFabricConnection(
    fabric={"host": "fabric.example.com", "port" : 8080},
    user='mats', database="employees")
```


Digression: Computing Shards

- Multiple Mappings
  - Which mapping to use?
  - Application don't care
    … but know tables in transaction
  - Currently only one mapping
- Computing shard requires
  - Tables + sharding key
- Extended Connector API
  - Extra properties passed out-of-band



Connector API: Shard Specific Query

- Provide tables in query
  - **Property:** `tables`
  - Fabric will compute map
- Provide sharding key
  - **Property:** `key`
  - Fabric will compute shard

```
conn.set_property(tables=['employees.employees', 'employees.titles'],
                  key=emp_no)
cur = conn.cursor()
cur.execute("INSERT INTO employees VALUES (%s,%s,%s)",
            (emp_no, first_name, last_name))
cur.execute("INSERT INTO titles(emp_no,title,from_date)"
            " VALUES (%s,%s,CURDATE())",
            (emp_no, 'Intern'));
conn.commit()
```

Transactions work fine!

Connector API: Shard Specific Query

- Provide tables in query
  - **Property:** `tables`
  - Fabric will compute map
- Provide sharding key
  - **Property:** `key`
  - Fabric will compute shard

```
conn.set_property(tables=['employees.employees', 'employees.titles'],
                  key=emp_no)
cur = conn.cursor()
cur.execute(
    "SELECT first_name, last_name, title"
    "  FROM employees JOIN titles USING (emp_no)"
    " WHERE emp_no = %d", (emp_no,))
for row in cur:
    print row[0], row[1], ",", row[2]
```

Join queries are sent to correct shard and executed there

Connector API: Global Update

- Provide tables in query
  - **Property:** `tables`
  - Fabric will compute map
- Set global scope
  - **Property:** `scope`
  - Query goes to global group

```
conn.set_property(tables=['employees.titles'], scope='GLOBAL')
cur = conn.cursor()
cur.execute("ALTER TABLE employees.titles ADD nickname VARCHAR(64)")
```


Closing Remarks

Thoughts for the Future

- Connector multi-cast
  - Scatter-gather
- Internal interfaces
  - Improve extension support
  - Improve procedures support
- Command-line interface
  - Improving usability
  - Focus on ease-of-use
- More protocols
  - MySQL-RPC Protocol?
  - AMQP?
- More frameworks?
- More HA group types
  - DRBD
  - MySQL Cluster
- Fabric-unaware connectors?

Thoughts for the Future

- "More transparent" sharding
  - Single-query transactions
  - Cross-shard joins is a problem
- Multiple shard mappings
  - Independent tables
- Multi-way shard split
  - Efficient initial sharding
  - Better use of resources
- High-availability executor
  - Node failure stop execution
  - Replicated State Machine
  - Fail over to other Fabric node
- Distributed failure detector
  - Connectors report failures
  - Custom failure detectors

MySQL Connect Sessions

- MySQL High Availability: Managing Farms of Distributed Servers
  - September 22, 5:30pm-6:30pm in Imperial Ballroom B
- Scaling PHP Applications
  - September 22, 10:00am-11:00am in Union Square Room ¾
- MySQL Sharding, Replication, and HA
  - September 21, 5:30-6:30pm in Imperial Ballroom B

References

- MySQL Forum: *Fabric, Sharding, HA, Utilities*
  - http://forums.mysql.com/list.php?144
- A Brief Introduction to MySQL Fabric
  - http://mysqlmusings.blogspot.com/2013/09/brief-introduction-to-mysql-fabric.html
- MySQL Fabric – Sharding – Introduction
  - http://vnwrites.blogspot.com/2013/09/mysqlfabric-sharding-introduction.html
- Migrating From an Unsharded to a Sharded Setup
  - http://vnwrites.blogspot.com/2013/09/mysqlfabric-sharding-migration.html

Keeping in Touch

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- **Blog:** http://vnwrites.blogspot.com

Thank you!