Revertible, recoverable schema migrations in Vitess

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About me

Engineer at **PlanetScale**

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Founded Feb. 2018 by co-creators of Vitess

~50 employees

HQ Mountain View, remote team

Vitess

A database clustering system for horizontal scaling of MySQL

- CNCF graduated project
- Open source, Apache 2.0 licence
- Contributors from around the community

Agenda

- Recap: proxy/tablet architecture
- Recap: Online DDL in Vitess
- Introducing VReplication
- Revertible, lossless schema changes
- Recoverable, resumable migrations
- Declarative schema changes (*)

(*) Bonus, hot off the git repo

Vitess architecture brief basics

Focus on VTTablet

Vitess architecture basics

Consider a common replication cluster

Vitess architecture basics

Each MySQL server is assigned a **vttablet**

- A daemon/sidecar
- Controls the **mysqld** process
- Interacts with the **mysqld** server
- Typically on same host as **mysqld**

VTTablet

- On primary, creates **_vt** schema on backend MySQL
- Manages state of some operations on **_vt** tables
- **_vt** schema data replicated as normal

Vitess architecture basics

In production you have multiple clusters

Vitess architecture basics

User and application traffic is routed via **vtgate**

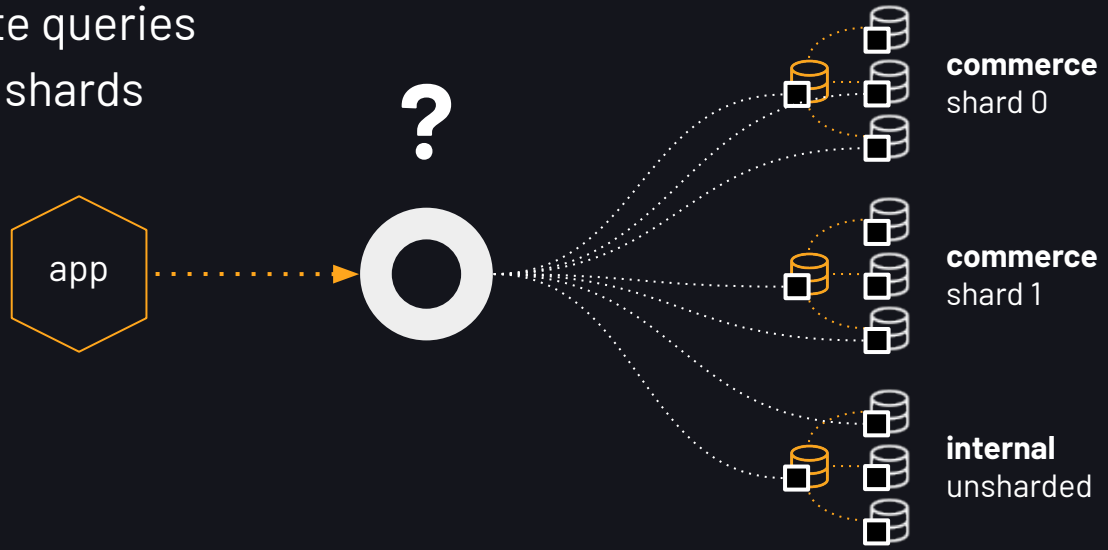
- A smart, stateless proxy
- Speaks the MySQL protocol
- Impersonates as a monolith MySQL server
- Relays queries to **vttablet**s

Vitess architecture basics

A vitess deployment will run multiple **vtgate** servers for scale out

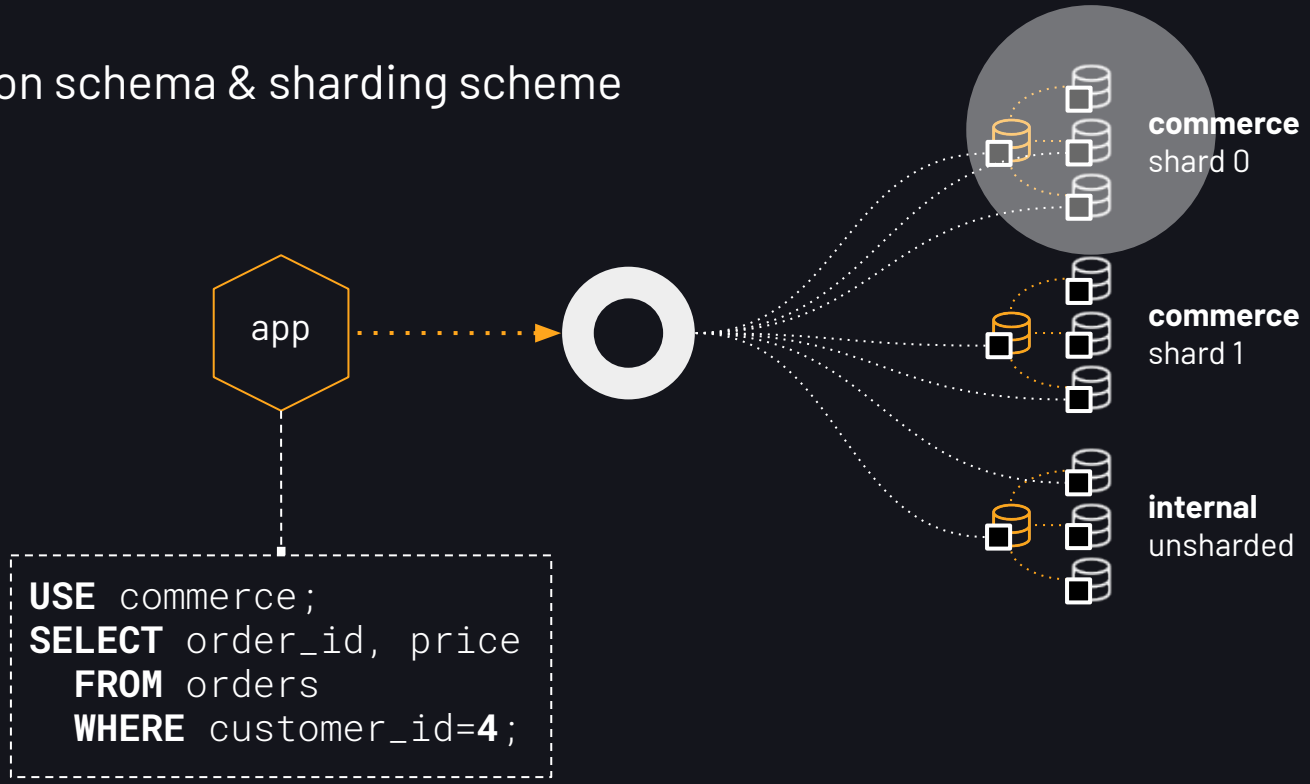
Vitess architecture basics

vtgate must transparently route queries
to correct clusters, to relevant shards



Vitess architecture basics

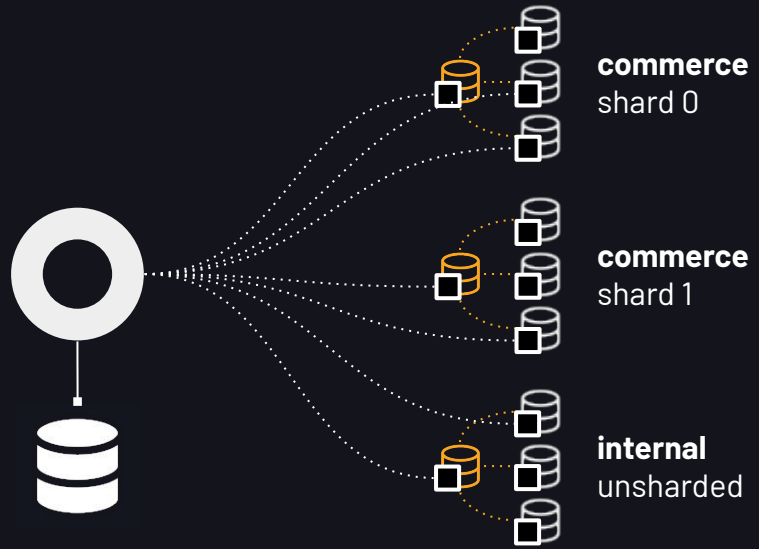
Queries route based on schema & sharding scheme



Vitess architecture basics

topo: distributed key/value store

- Stores the state of vitess: schemas, shards, sharding scheme, tablets, roles, etc.
- etcd/consul/zookeeper
- Small dataset, mostly cached by **vtgate**



Recap: Online DDL

Vitess supports online schema migrations natively

Previously presented:

- Native support for gh-ost
- Native support for pt-online-schema-change

```
mysql> SET @@ddl_strategy='gh-ost';
mysql> ALTER TABLE my_table ADD COLUMN my_col INT NOT NULL;
```

https://www.youtube.com/watch?v=i0YZ0dRe7O8
https://fosdem.org/2021/schedule/event/vitess/

Recap: Online DDL

Automatically:

- Send DDL to appropriate shards
- Schedule migration
- Create & destroy migration account
- Run gh-ost/pt-online-schema-change
- Throttle
- Garbage-collect artifact tables

VReplication

A distributed flow in Vitess, that can:

- Move data from “here” to “there”
- Mutate the data on the fly
- Live

https://vitess.io/docs/reference/vreplication/vreplication/

VReplication use cases

VReplication runs the following core Vitess functionalities:

- Live resharding
- Materialized views
- Import from external data sources (e.g. Aurora)
- Moving tables across clusters
    - With VTGate rerouting traffic to new location

VReplication

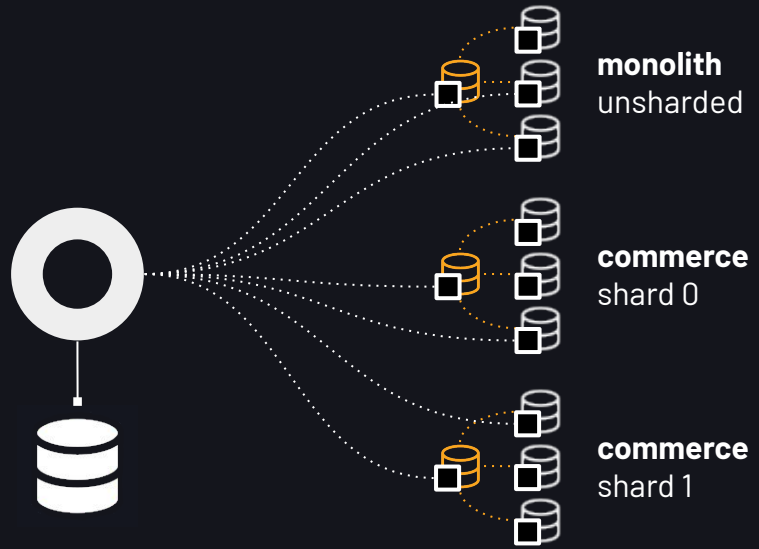
- A flow (workflow) can have 1 or more streams
- Each stream connects one source tablet (thereby a source MySQL server) with one target (a target MySQL server)
- There can be many-to-many streams, eg.. in a resharding scenario

https://vitess.io/docs/reference/vreplication/vreplication/

VReplication: MoveTables

Example: move large **messages** table out of a crowded monolith cluster into a dedicated sharded schema

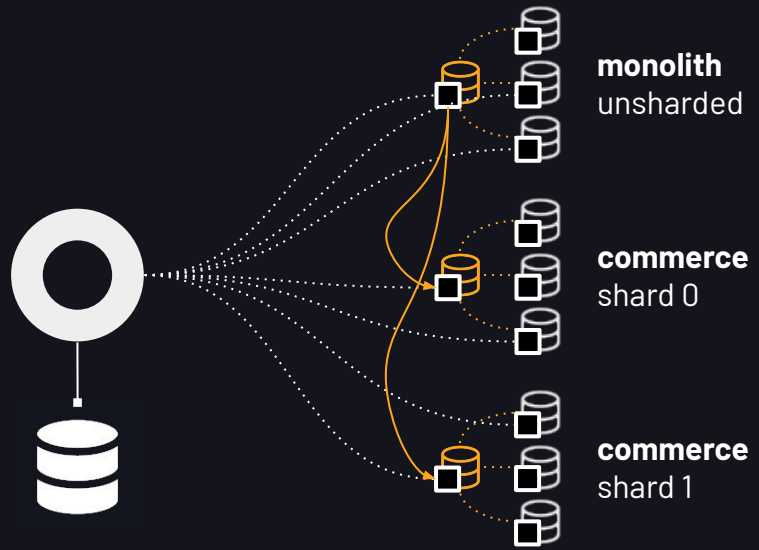
- Move data
- Move traffic



VReplication: MoveTables

Moving data:

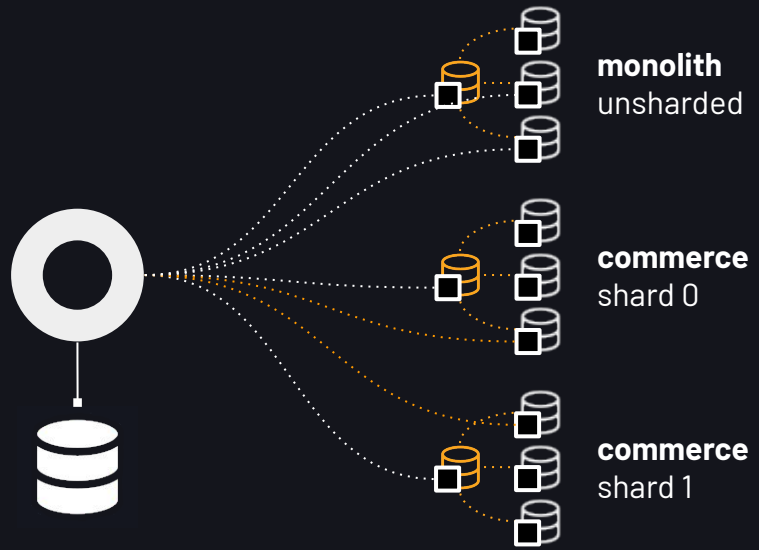
- Assume table exists on target schema/clusters
- Iterate existing table in **monolith** cluster, a bunch of rows at a time
- Insert/apply each bunch of rows onto **commerce** keyspace
- Tail **monolith** binary logs and apply ongoing changes to **messages** table



VReplication: MoveTables

Moving traffic (manual):

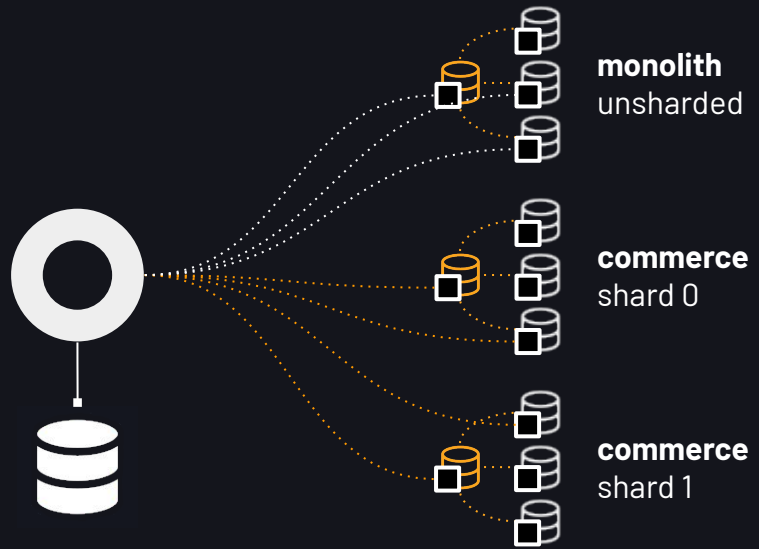
- User issues **SwitchReads**
- Vitess updates **topo** with new routing rules
- **VTGate** notified about **topo** changes
- **VTGate** routes all read traffic on **messages** to **commerce** schema/clusters



VReplication: MoveTables

Moving traffic (manual):

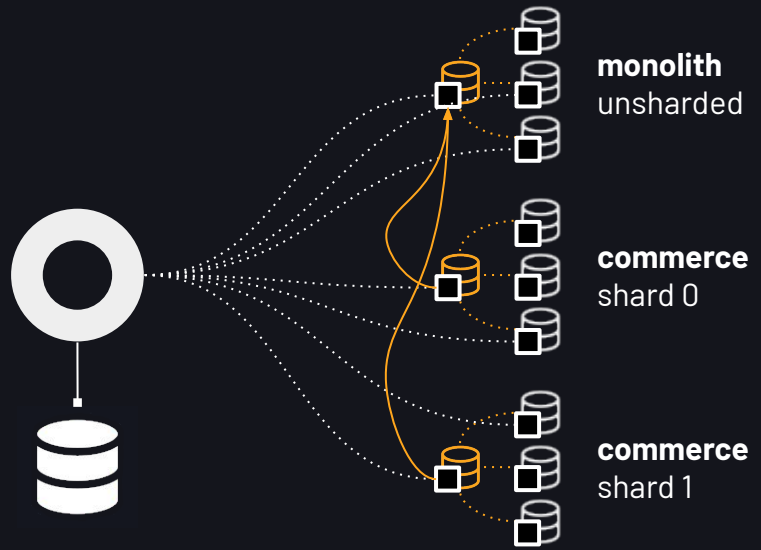
- User issues **SwitchWrites**
- Vitess updates **topo** with new routing rules
- **VTGate** notified about **topo** changes
- **VTGate** routes all write traffic on **messages** to **commerce** keyspace
- Client can later explicitly query **messages** on **commerce** schema rather than **monolith** schema



VReplication: MoveTables

Reverse replication:

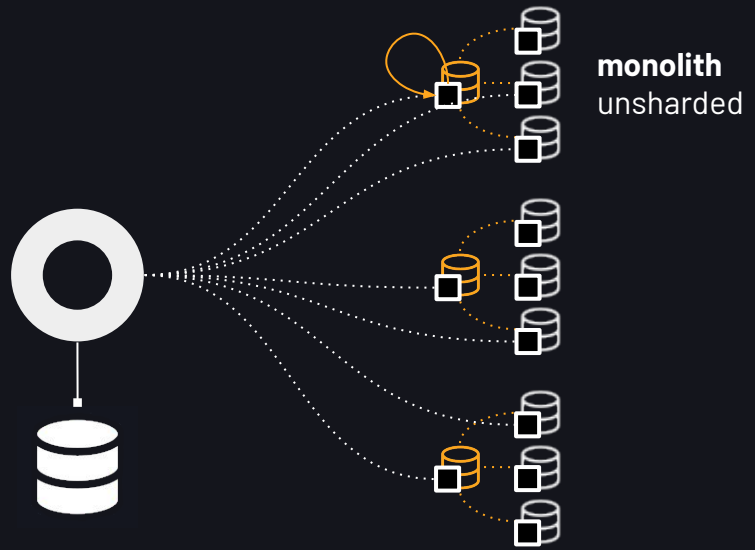
- It is possible to stream **messages** changes back from **commerce** to **monolith**
- Gives the app a path for failback



VReplication for Online DDL

Same essentials as MoveTables, but:

- Source and target schemas are the same.
- Automatic creation of target table in new schema
- Automatic analysis of schema and filter query
- Automatic cut-over
- Instead of **SwitchWrites** we switch tables



VReplication Online DDL

Looks just like a **gh-ost** or **pt-osc** online DDL:

```
mysql> SET @@ddl_strategy='online';
mysql> ALTER TABLE my_table ADD COLUMN my_col INT NOT NULL;
```

Added value:

- Internal to vitess, unified logic for moving data around
- Super powers, courtesy VReplication's logic

Revertible Online DDL

- Run a schema migration.
- Cut-over. Wait. What. This. Is. Wrong.
- Revert the migration. Lossless.

Revertible Online DDL

DEMO

Revertible Online DDL: how?

- **VReplication** uses two underlying tables:
  - **_vt.vreplication**
    - General purpose information
    - Filter/rule query
    - GTID pos
    - Updates in same commit with binlog event changes
  - **_vt.copy_state**
    - Row-copy information
    - Last known row copy range
    - Empty on startup, empty on completion
    - Updates in same commit with row copy
- These two tables formulate the *state* of a **VReplication** stream

Revertible Online DDL: how?

During “normal” **ALTER TABLE**:

- On cut-over, disable writes on original table
- Consume remaining binlog events
- Mark GTID pos
- Rename tables

Revertible Online DDL: how?

During **REVERT VITESS_MIGRATION**:

- Create a new **_vt.vreplication** stream entry, a single stream workflow
- Populate with GTID pos from completed migration
- Formulate new filter/rule query to point back to *OLD* table
- Keep **_vt.copy_state** empty for the new workflow
- Tell **VReplication** to *go on*
- To **VReplication** the new setup looks to be an unfinished workflow, where row copy is complete, and with binlog events still in queue

Revertible Online DDL: CREATE & DROP

- **CREATE TABLE** and **DROP TABLE** statements are revertible
- **REVERT** for a **DROP TABLE** reinstates the table populated with data at time of **DROP**
- **REVERT** for **CREATE TABLE** vanishes the table
- As with **ALTER TABLE**, these **REVERT**s are *revertible*.

Recoverable Online DDL

- You run a schema migration
- It takes days and days
- Please. Don’t. Let. There. Be. A. Failover.
- Sorry. This. Maintenance. Work. Will. Have. To. Wait.

Recoverable Online DDL: how?

- **_vt.vreplication** and **_vt.copy_state** committed together with data changes.
- Both tables are replicated as normal.
- However lagging a replica may be, **_vt.vreplication** and **_vt.copy_state** on that replica are *always consistent* with the data on that replica.
- In case of failover the replica becomes a **primary**.
- **VReplication** on the primary notices **_vt.vreplication** and **_vt.copy_state** and *proceeds from that point on.*

Recoverable Online DDL: how?

- Objective: “don’t care” approach. Do your normal work and forget about whether a migration is running.
- Status: “works on my machine”
- More formal validation/testing required

Declarative Online DDL

Say where you want to go, not how to get there.

Declarative Online DDL

DEMO

Declarative Online DDL: how?

- In a full declarative approach you present your entire schema
- This may not play well for known Vitess use case.
- Compromise: a hybrid approach. Per table, either:
  - **CREATE TABLE**, or
  - **DROP TABLE**
  - But never **ALTER TABLE**

Declarative Online DDL: how?

Per table, Vitess compares existing schema with desired schema.

- Creates a table if needed
- Drops a table if needed
- Evaluates a *diff* if needed
  - Either diff is empty, or
  - Diff is a **ALTER TABLE** statement, passed on to **VReplication**/**gh-ost**/**pt-osc** as Online DDL.

Resources

Docs: vitess.io/docs/

Code: github.com/vitessio/vitess

Slack: vitess.slack.com

Thank you!

Questions?

github.com/shlomi-noach
@ShlomiNoach