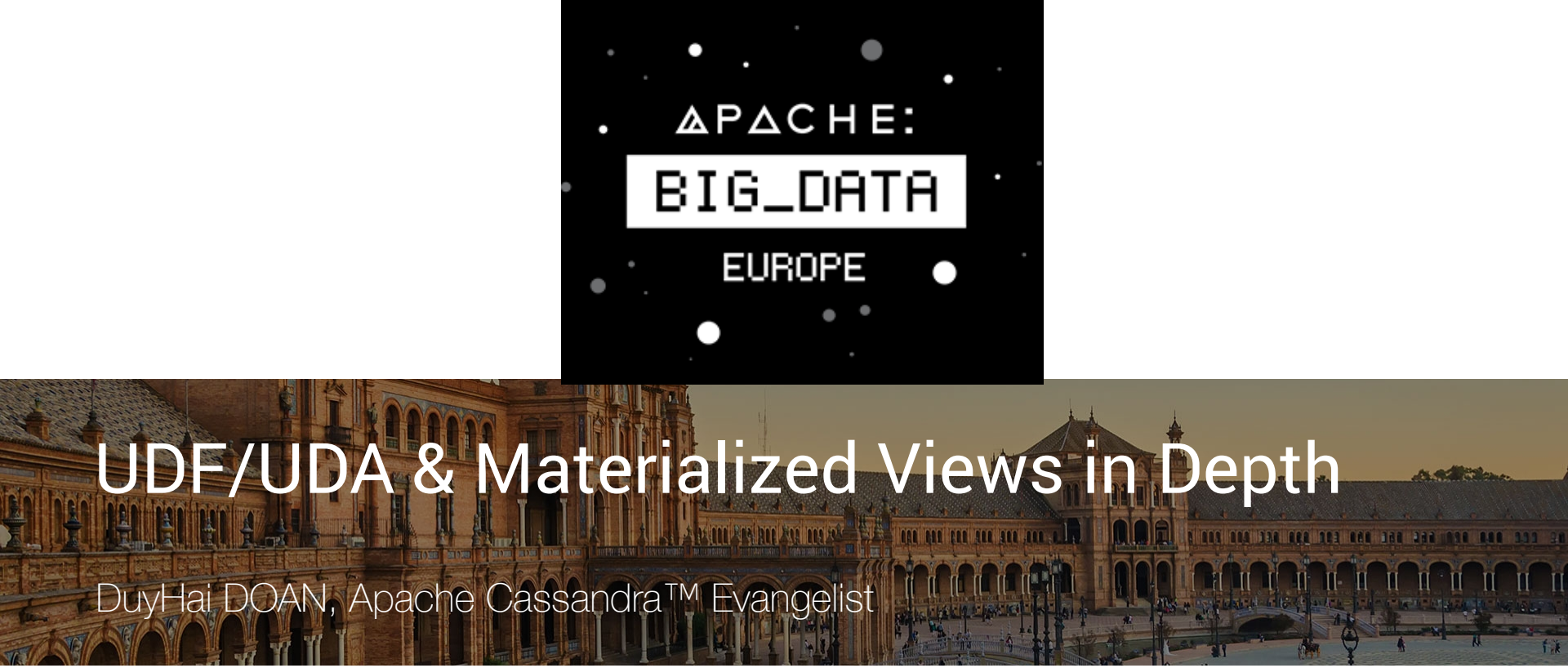


UDF/UDA & Materialized Views in Depth

DuyHai DOAN, Apache Cassandra™ Evangelist

Trademark Policy

From now on ...

Cassandra == Apache Cassandra™

Materialized Views (MV)

Why Materialized Views ?

- Relieve the pain of manual denormalization

```
CREATE TABLE user(
  id int PRIMARY KEY,
  country text,
  ...
);
CREATE TABLE user_by_country(
  country text,
  id int,
  ...,
  PRIMARY KEY(country, id)
);
```

Materialzed View In Action

```
CREATE MATERIALIZED VIEW user_by_country
AS SELECT country, id, firstname, lastname
FROM  user
WHERE country IS NOT NULL AND id IS NOT NULL
PRIMARY KEY(country, id)
```

```
CREATE TABLE user_by_country (
    country text,
    id int,
    firstname text,
    lastname text,
    PRIMARY KEY(country, id));
```

Materialzed View Syntax

CREATE MATERIALIZED VIEW [IF NOT EXISTS]

keyspace_name.view_name

AS SELECT $column_1$, $column_2$, ...

FROM keyspace_name.table_name

WHERE $column_1$ IS NOT NULL AND $column_2$ IS NOT NULL ...

PRIMARY KEY($column_1$, $column_2$, ...)

Must select all primary key columns of base table

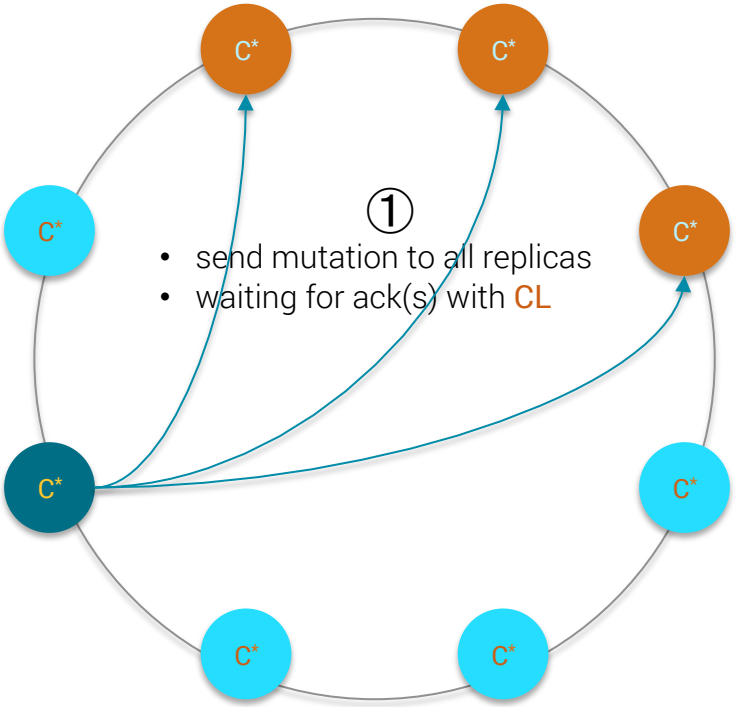
- IS NOT NULL condition for now
- more complex conditions in future

- at least all primary key columns of base table (ordering can be different)
- maximum 1 column NOT pk from base table

Materialized Views Demo

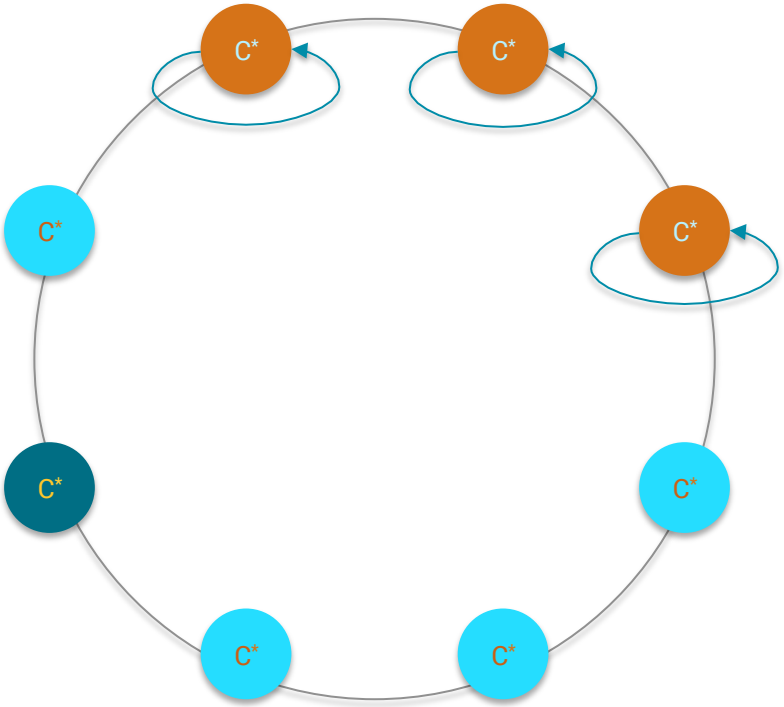
Materialized View Impl

UPDATE user
SET country='FR'
WHERE id=1



Materialized View Impl

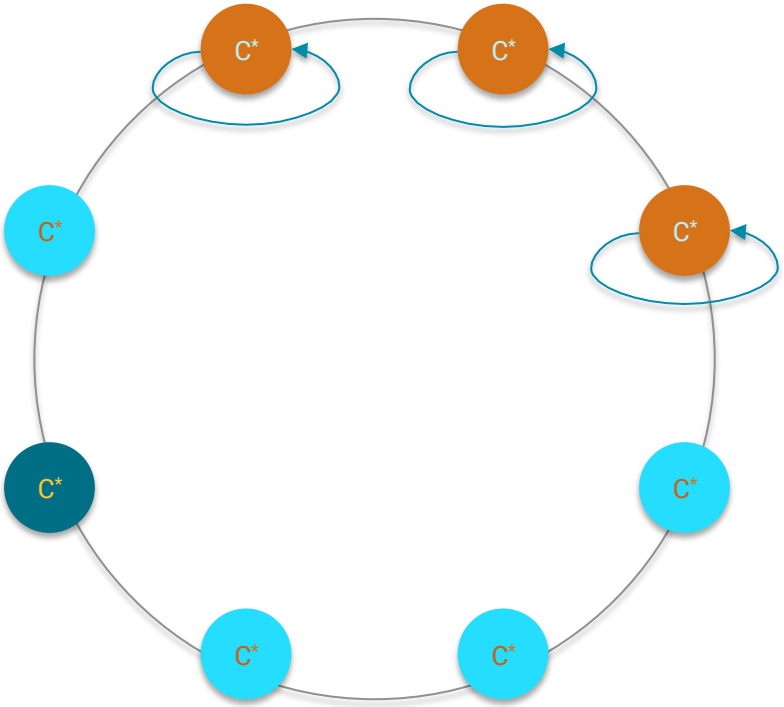
UPDATE user
SET country='FR'
WHERE id=1



② Acquire local lock on base table partition

Materialized View Impl

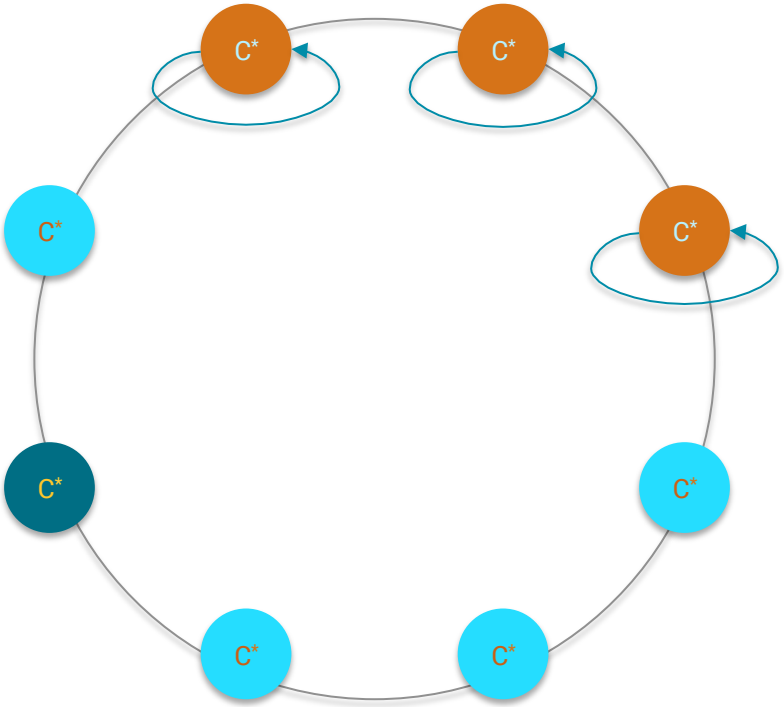
UPDATE user
SET country='FR'
WHERE id=1



③
Local read to fetch current values
SELECT * FROM user WHERE id=1

Materialized View Impl

UPDATE user
SET country='FR'
WHERE id=1

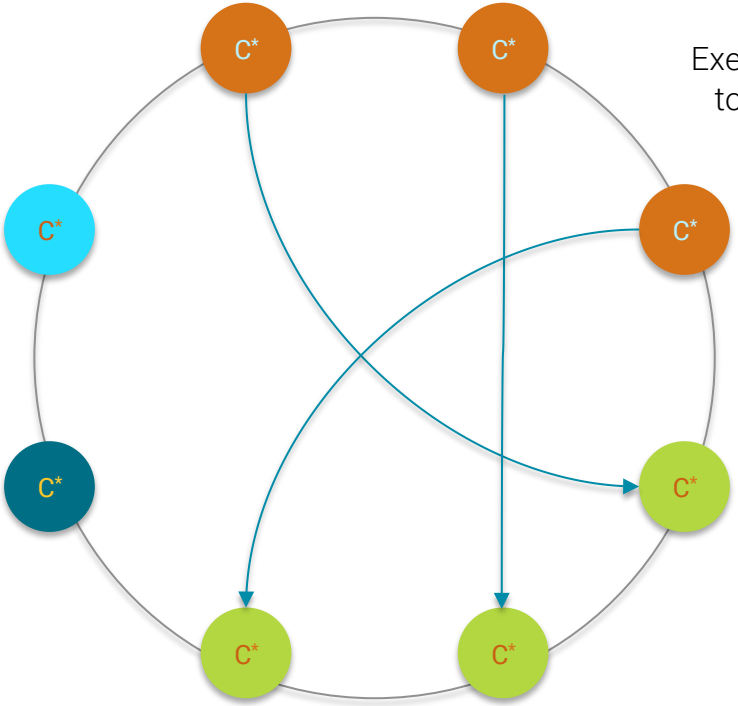


④
Create BatchLog with

- DELETE FROM user_by_country WHERE country = 'old_value'
- INSERT INTO user_by_country(country, id, …) VALUES('FR', 1, …)

Materialized View Impl

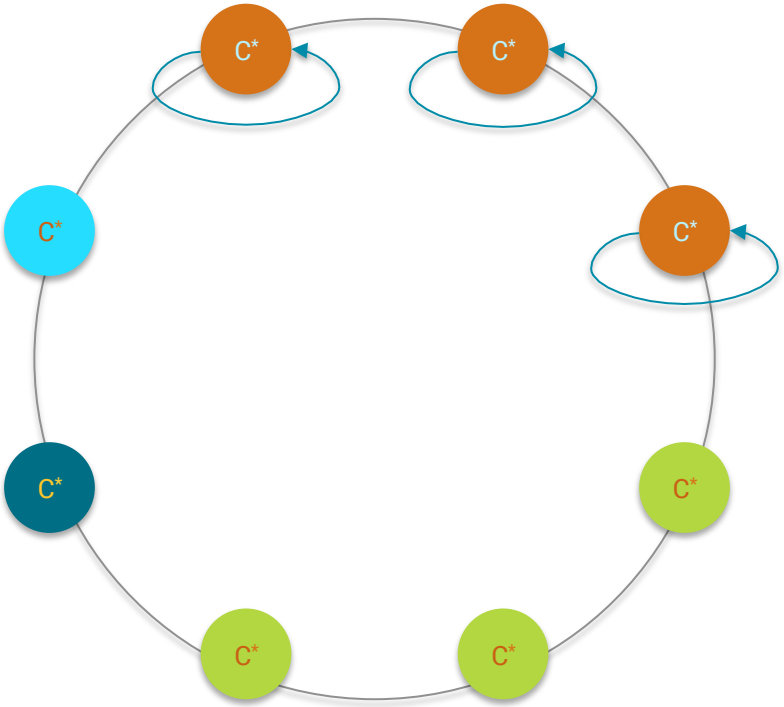
UPDATE user
SET country='FR'
WHERE id=1



⑤
Execute async BatchLog
to paired view replica
with CL = ONE

Materialized View Impl

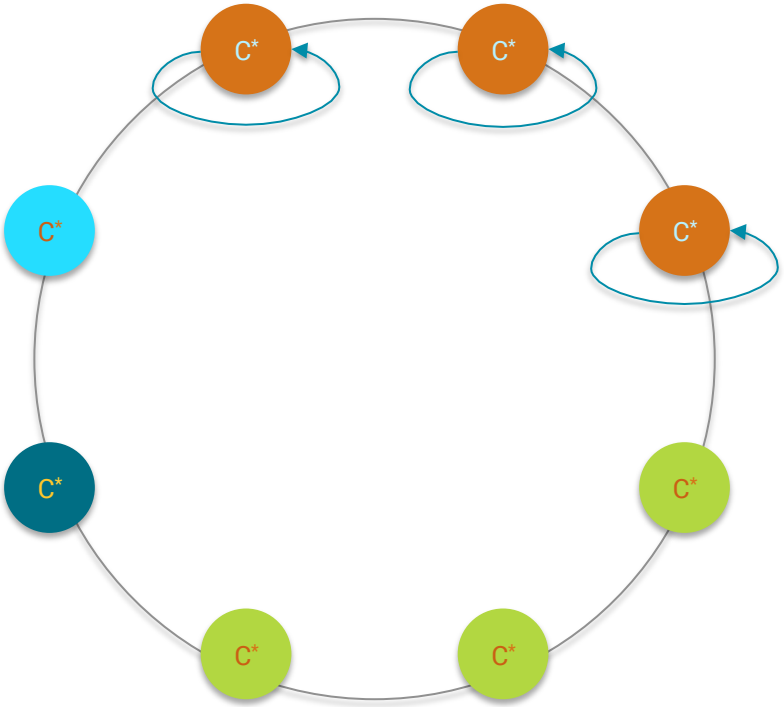
UPDATE user
SET country='FR'
WHERE id=1



⑥
Apply base table updade locally
SET COUNTRY='FR'

Materialized View Impl

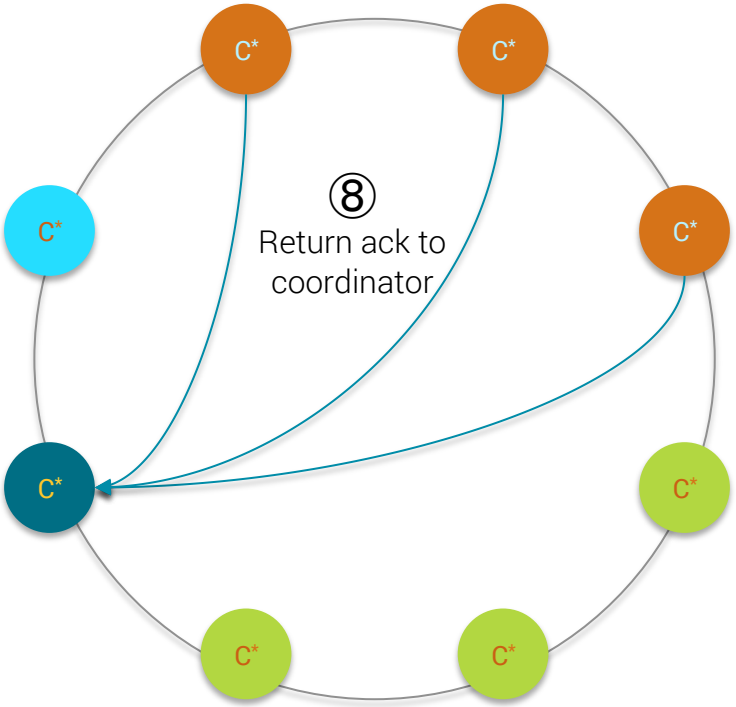
UPDATE user
SET country='FR'
WHERE id=1



⑦
Release local lock

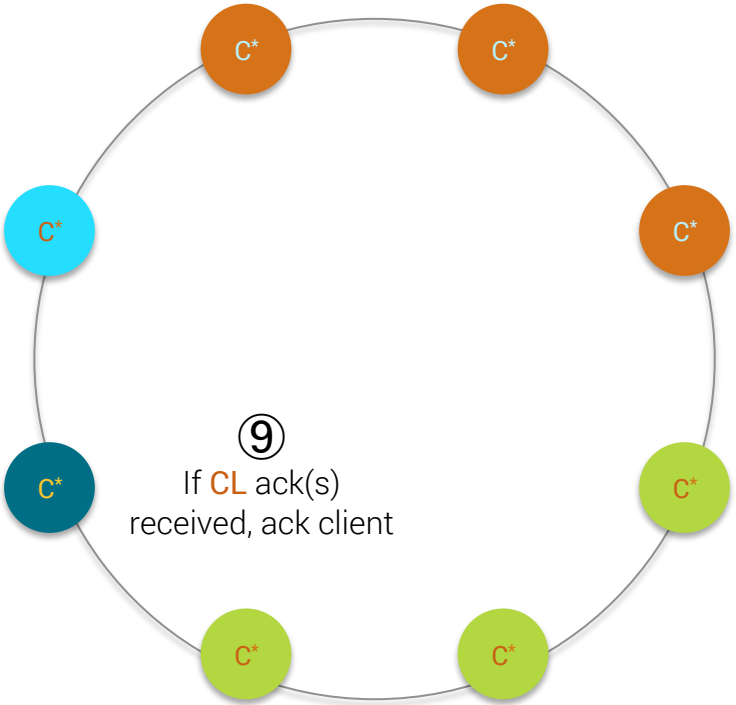
Materialized View Impl

UPDATE user
SET country='FR'
WHERE id=1



Materialized View Impl

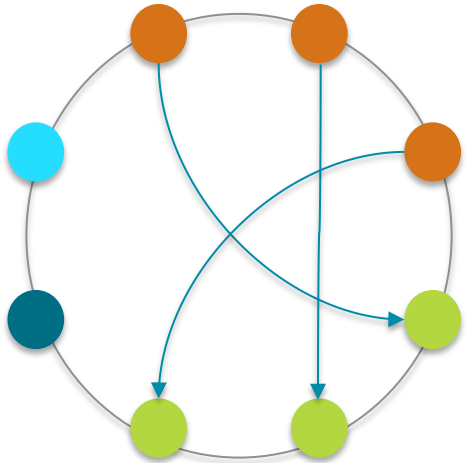
UPDATE user
SET country='FR'
WHERE id=1



Materialzed Views impl explained

What is paired replica ?

- Base primary replica for **id=1** is paired with MV primary replica for **country='FR'**
- Base secondary replica for **id=1** is paired with MV secondary replica for **country='FR'**
- etc …



Materialzed Views impl explained

Why **local lock** on base replica ?

- to provide **serializability** on concurrent updates

Why **BatchLog** on base replica ?

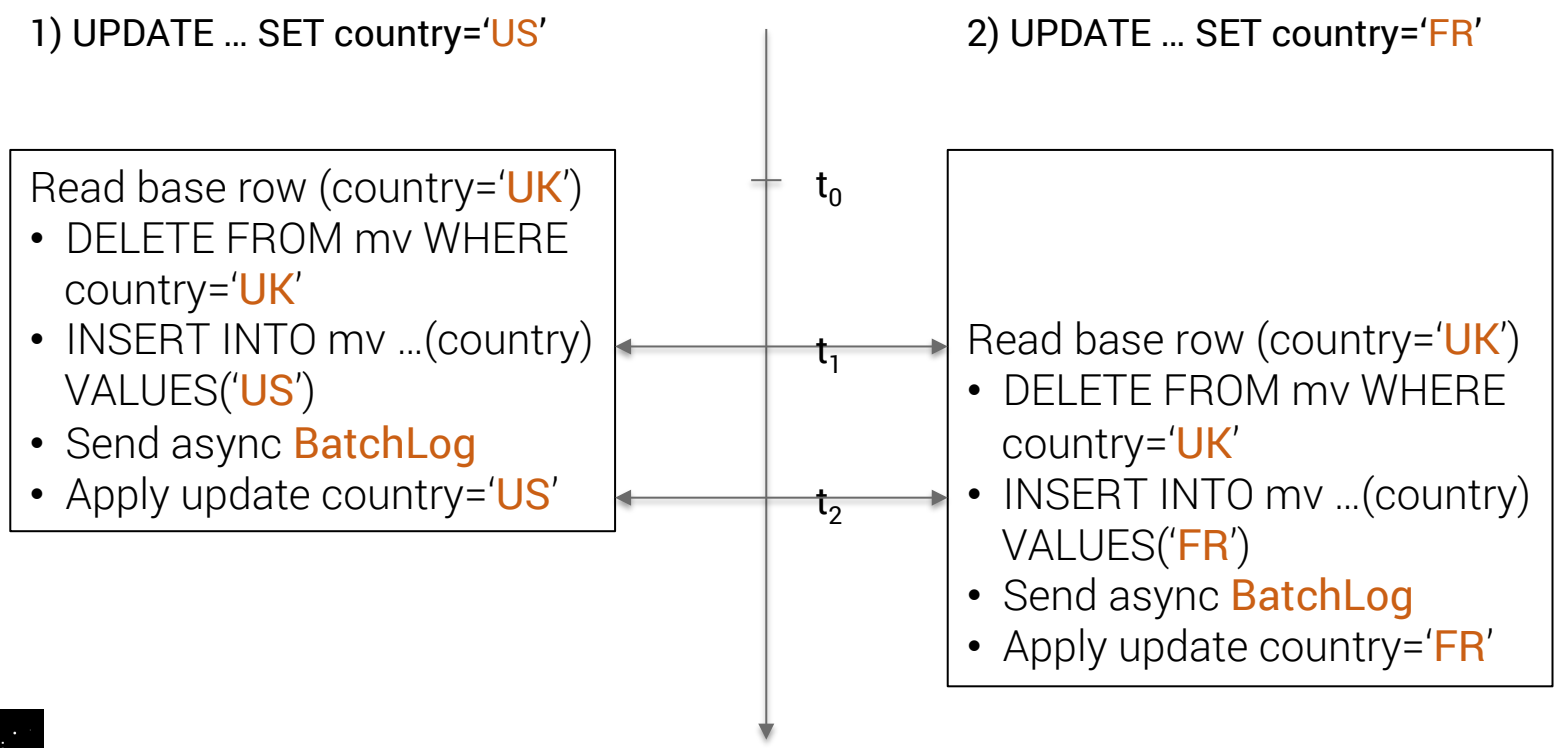
- necessary for **eventual durability**
- replay the MV delete + insert until successful

Why **BatchLog** on base replica uses **CL = ONE** ?

- each base replica is responsible for update of its **paired** MV replica
- CL > ONE will create un-necessary **duplicated mutations**

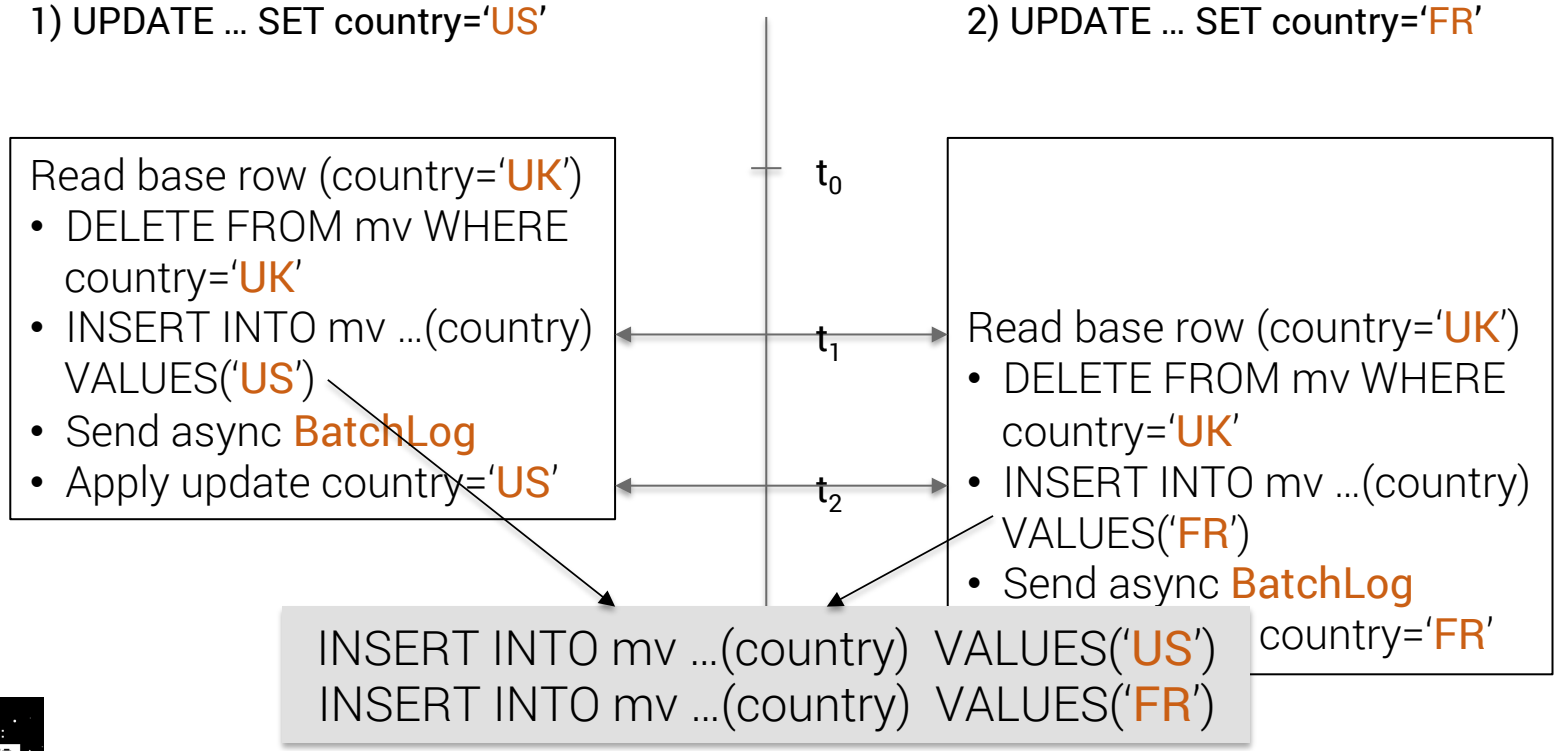
MV Failure Cases: concurrent updates

Without Local Lock



MV Failure Cases: concurrent updates

Without Local Lock



MV Failure Cases: concurrent updates

With Local Lock

1) UPDATE … SET country='US'

Read base row (country='UK')
- DELETE FROM mv WHERE country='UK'
- INSERT INTO mv …(country) VALUES('US')
- Send async BatchLog
- Apply update country='US'

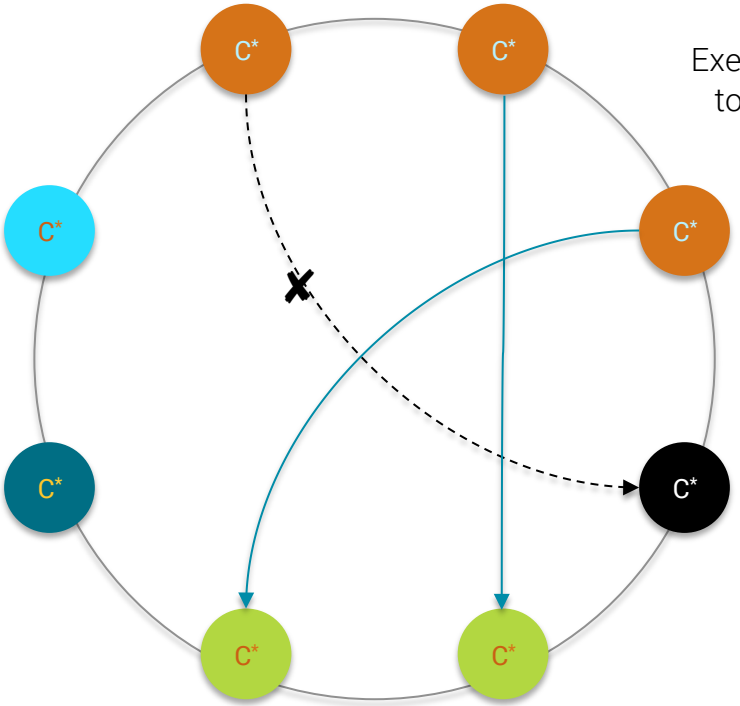
2) UPDATE … SET country='FR'

Read base row (country='US')
- DELETE FROM mv WHERE country='US'
- INSERT INTO mv …(country) VALUES('FR')
- Send async BatchLog
- Apply update country='FR'

21

MV Failure Cases: failed updates to MV

UPDATE user
SET country='FR'
WHERE id=1

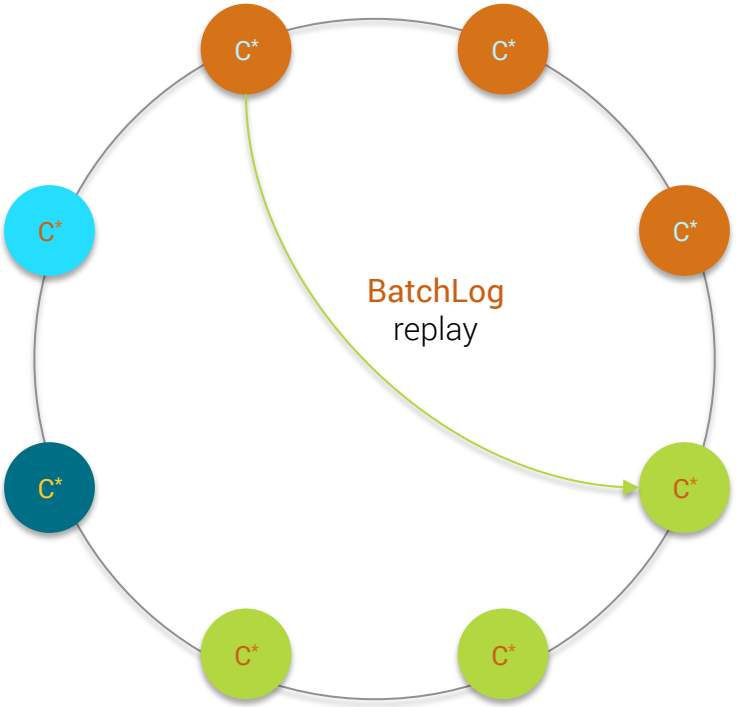


⑤
Execute async BatchLog
to paired view replica
with CL = ONE

MV replica down

MV Failure Cases: failed updates to MV

UPDATE user
SET country='FR'
WHERE id=1



MV replica up

Materialized View Performance

- Write performance
  - local lock
  - local read-before-write for MV → update contention on partition (*most of perf hits*)
  - local batchlog for MV
  - ☞ you only pay this price **once** whatever number of MV
  - for each base table update: **mv_count x 2** *(DELETE + INSERT)* extra mutations

Materialized View Performance

- Write performance vs **manual denormalization**
  - MV better because *no client-server network traffic for read-before-write*
  - MV better because *less network traffic* for multiple views (*client-side BATCH*)

- Makes developer life easier → **priceless**

Materialized View Performance

- Read performance vs **secondary index**
  - MV better because **single node read** (secondary index can hit many nodes)
  - MV better because **single read path** (secondary index = *read index + read data*)

Materialized Views Consistency

- Consistency level
  - CL honoured for base table, ONE for MV + local batchlog
- **Weaker consistency guarantees** for MV than for base table.
- Exemple, write at QUORUM
  - guarantee that QUORUM replicas of base tables have received write
  - guarantee that QUORUM of MV replicas will **eventually** receive *DELETE + INSERT*

Materialized Views Gotchas

- Beware of hot spots !!! MV **user_by_gender** 
- Only 1 non-pk column for MV
- No **static column** for MV view
  - *1:1 relationship* between static column & partition key
  - if MV supports static column → MV has same partition key as base table → uselesss …

Materialized Views Operations

- Repair, read-repair, index rebuild, decomission …
  - repair on base replica (*mutation-based* repair) → update on MV paired replica
  - possible to repair a MV *independently from base table*
  - read-repair on MV behaves as normal read-repair
  - read-repair on base table updates MV
  - hints replay on base table updates MV

Materialized Views Operations

- MV build status ?
  - system.views_builds_in_progress
  - system.built_views
  - data are node-local !!!

```
cqlsh:system> select * from system.views_builds_in_progress;

 keyspace_name | view_name | generation_number | last_token
---------------+-----------+-------------------+------------

(0 rows)
cqlsh:system> select * from system.built_views ;

 keyspace_name | view_name
---------------+-------------------
         music |     albums_by_year
         music | artists_by_country
```

Materialized Views Schema Ops

- Schema
  - MV can be tuned as normal table (ALTER MATERIALIZED VIEW …)
  - cannot drop column from base table used by MV
  - can add column to base table, initial value = null from MV
  - cannot drop base table, drop all MVs first

Single non-pk column limitation

- Because of Cassandra consistency model
- Because null value forbidden for primary key column

```
CREATE MATERIALIZED VIEW user_by_gender_and_age
AS SELECT country, id, firstname, lastname
FROM  user
WHERE gender IS NOT NULL AND age IS NOT NULL AND id IS NOT NULL
PRIMARY KEY((gender, age) id)
```

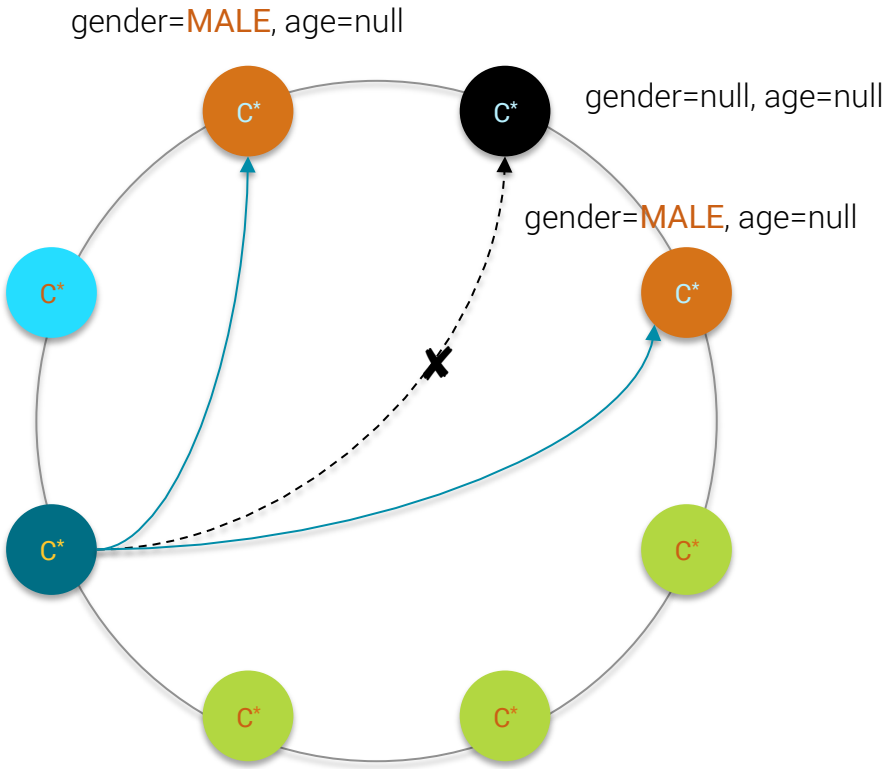
Single non-pk column limitation

- Possible RULE : UPDATE MV ONLY IF ALL COLUMNS IN PK NOT NULL

Multiple non-PK columns in MV PK

CL = QUORUM

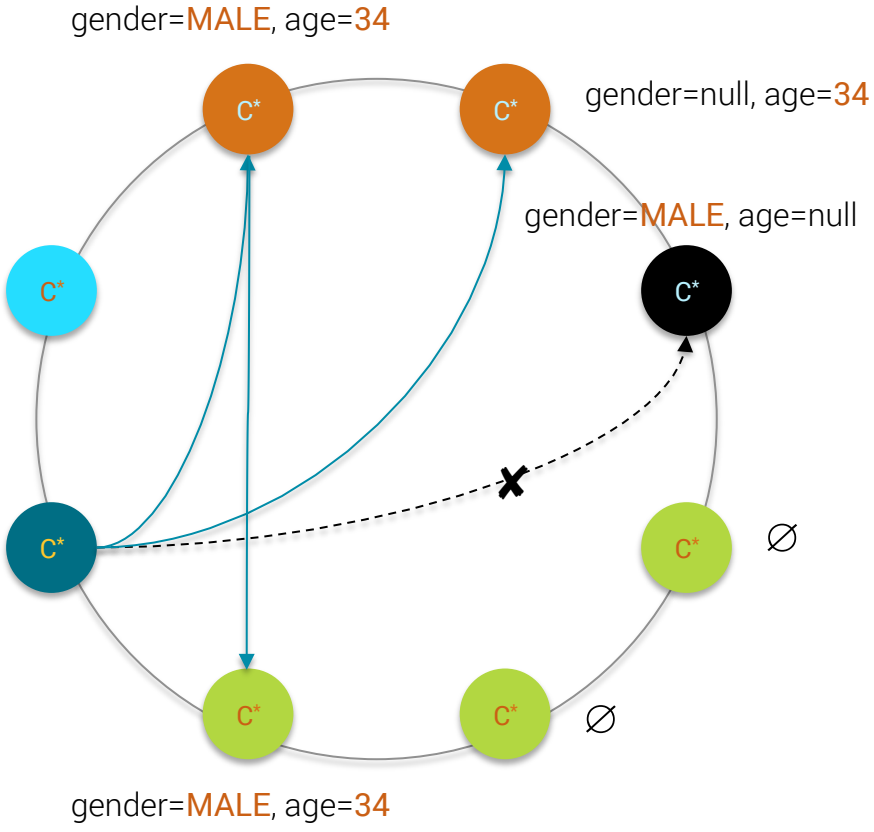
UPDATE user
SET gender='MALE'
WHERE id=1



Multiple non-PK columns in MV PK

CL = QUORUM

```
UPDATE user
SET age=34
WHERE id=1
```

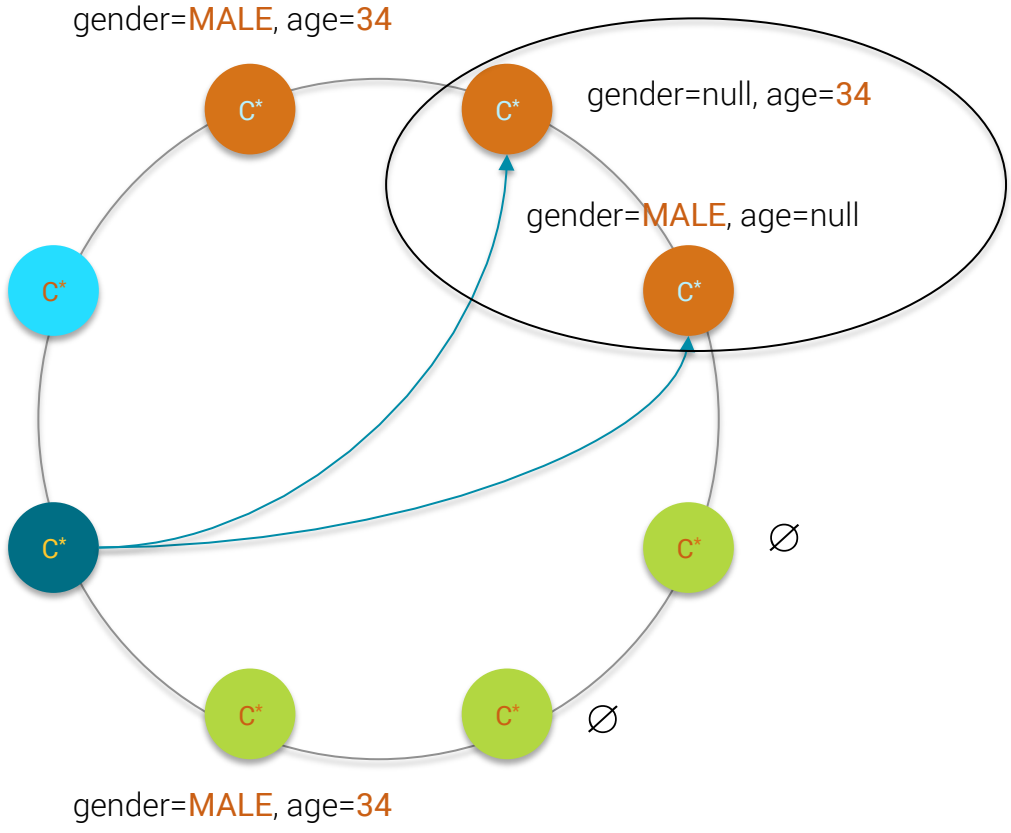


Multiple non-PK columns in MV PK

CL = QUORUM

```
SELECT age,gender
FROM user
WHERE id=1
```

1	34	MALE



Multiple non-PK columns in MV PK

gender=MALE, age=34

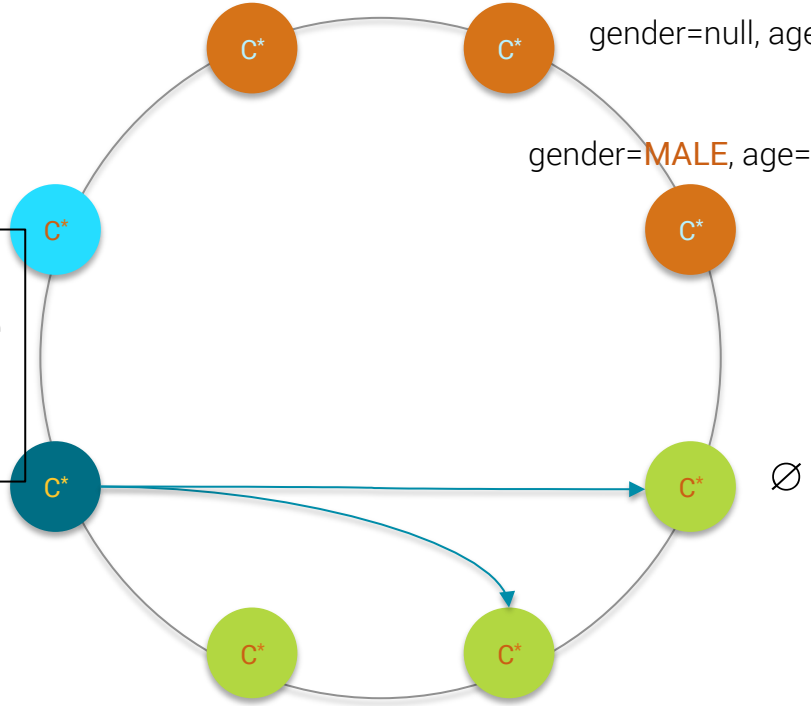
gender=null, age=34

gender=MALE, age=null

CL = QUORUM

```
SELECT * FROM
user_by_gender_and_age
WHERE gender='MALE'
AND age=34
```

∅



∅

gender=MALE, age=34

Single non-pk column limitation

- Possible RULE 2: **ALLOW NULL VALUE FOR COLUMN IN PK**

```
INSERT INTO user(id, name) VALUES(1, 'John DOE');
...
...
...
INSERT INTO user(id, name) VALUES(1000_000, 'Helen SUE');
```

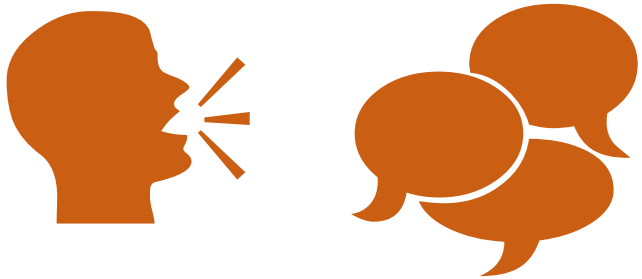
No age, No gender

Single non-pk column limitation

- Possible RULE 2: ALLOW NULL VALUE FOR COLUMN IN PK

(null, null) single partition with 10^6 users

Living in Danger



Q & A

User Define Functions (UDF)

Rationale

- Push computation server-side
  - save network bandwidth (1000 nodes!)
  - simplify client-side code
  - provide standard & useful function (sum, avg …)
  - accelerate analytics use-case (pre-aggregation for Spark)

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALL ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE language
AS $$
      // source code here
$$;
```

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE
AS $$
    // source code here
$$;
```

An UDF is keyspace-wide

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE language
AS $$
    // source code here
$$;
```

Param name to refer to in the code
Type = CQL3 type

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE la
AS $$
    // source
$$;
```

Always called
Null-check mandatory in code

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE la
AS $$
     // source
$$;
```

If any input is null, code block is skipped and return null

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE language
AS $$
    // source code
$$;
```

CQL types

- primitives (boolean, int, ...)
- collections (list, set, map)
- tuples
- UDT

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE language
AS $$
    // source code here
$$;
```

JVM supported languages

- Java, Scala
- Javascript (slow)
- Groovy, Jython, JRuby
- ~~Clojure~~ (JSR 223 impl issue)

How to create an UDF ?

```
CREATE [OR REPLACE] FUNCTION [IF NOT EXISTS]
[keyspace.]functionName (param1 type1, param2 type2, ...)
CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT
RETURN returnType
LANGUAGE language
AS $$
    // source code here
$$;
```

UDF Demo

UDA

- Real use-case for UDF
- Aggregation server-side → huge network bandwidth saving
- Provide similar behavior for Group By, Sum, Avg etc …

How to create an UDA ?

```
CREATE [OR REPLACE] AGGREGATE [IF NOT EXISTS]
[keyspace.]aggregateName(type1, type2, ...)
SFUNC accumulatorFunction
STYPE stateType
[FINALFUNC finalFunction]
INITCOND initCond;
```

Only type, no param name

State type

Initial state type

How to create an UDA ?

```
CREATE [OR REPLACE] AGGREGATE [IF NOT EXISTS]
[keyspace.]aggregateName(type1, type2, ...)
SFUNC accumulatorFunction
STYPE stateType
[FINALFUNC finalFunction]
INITCOND initCond;
```

Accumulator function. Signature:
accumulatorFunction(stateType, $type_1$, $type_2$, ...)
RETURNS stateType

How to create an UDA ?

```
CREATE [OR REPLACE] AGGREGATE [IF NOT EXISTS]
[keyspace.]aggregateName(type1, type2, ...)
SFUNC accumulatorFunction
STYPE stateType
[FINALFUNC finalFunction]
INITCOND initCond;
```

Optional final function. Signature: finalFunction(stateType)

How to create an UDA ?

```
CREATE [OR REPLACE] AGGREGATE [IF NOT EXISTS]
[keyspace.]aggregateName(type1, type2, ...)
SFUNC accumulatorFunction
STYPE stateType
[FINALFUNC finalFunction]
INITCOND initCond;
```

UDA return type ?

If finalFunction

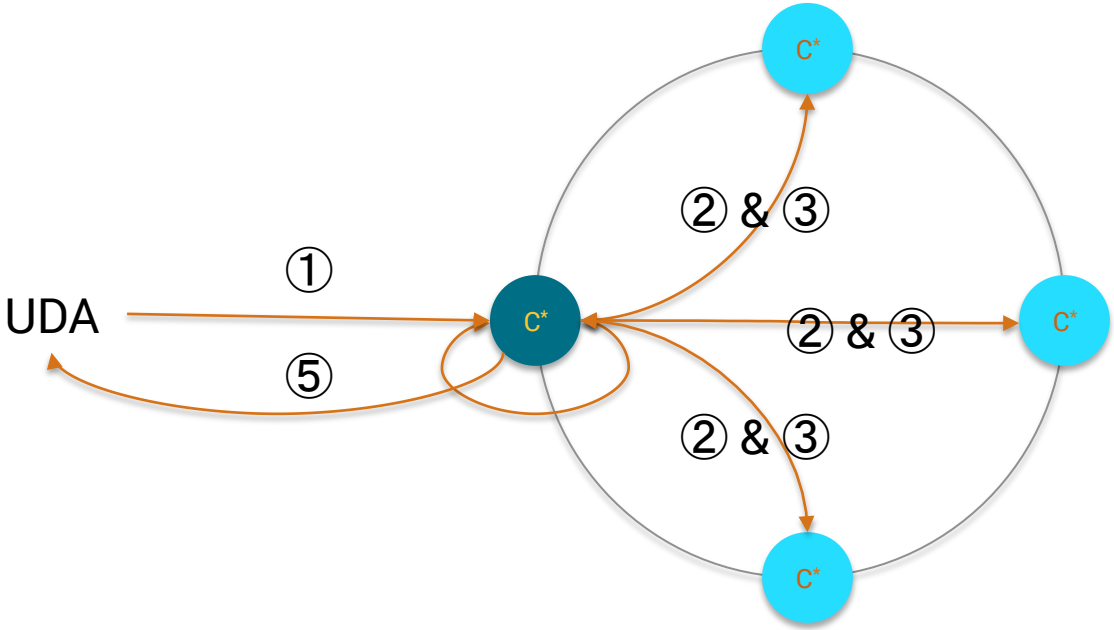
- return type of finalFunction

Else

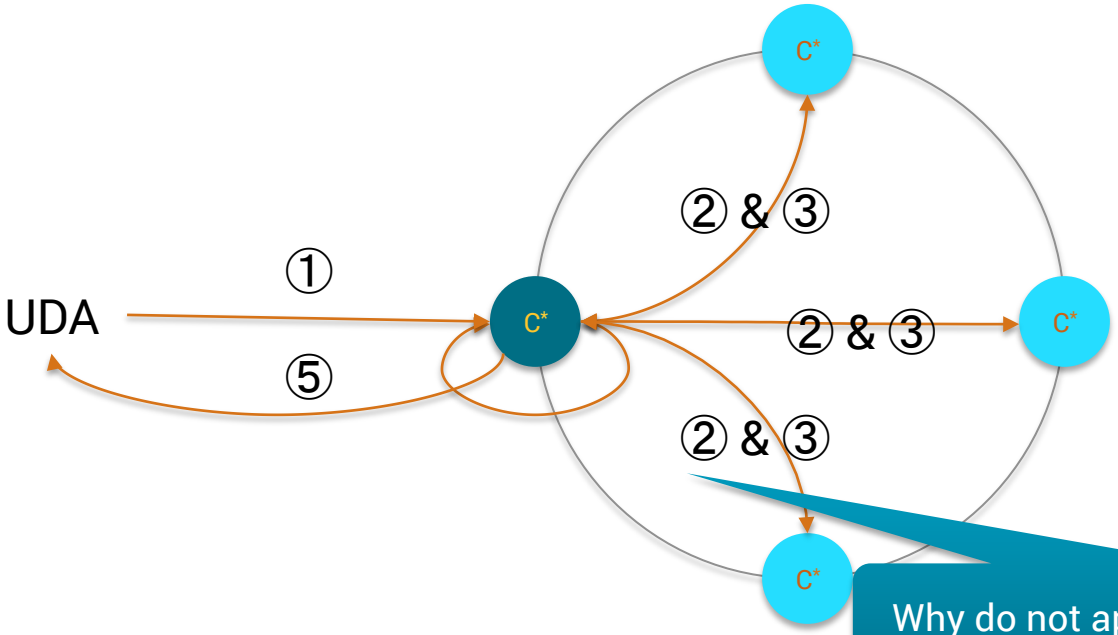
- return stateType

UDA Demo

Gotchas

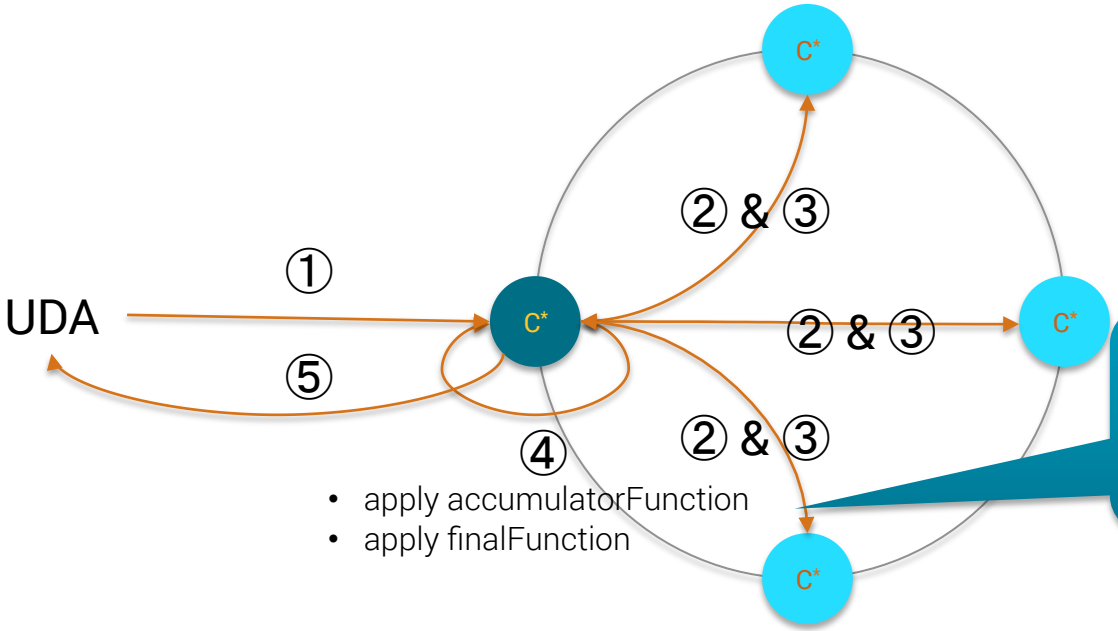


Gotchas



Why do not apply UDF/UDA on replica node ?

Gotchas



1. Because of eventual consistency
2. UDF/UDA applied AFTER last-write-win logic

Gotchas

- UDA in Cassandra is **not distributed !**
- Execute UDA on a large number of rows (10^6 for ex.)
  - single fat partition
  - multiple partitions
  - full table scan
- → Increase client-side timeout
  - default Java driver timeout = 12 secs
  - **JAVA-1033** JIRA for *per-request timeout setting*

Cassandra UDA or Apache Spark ?

Consistency Level	Single/Multiple Partition(s)	Recommended Approach
ONE	Single partition	UDA with token-aware driver because node local
ONE	Multiple partitions	Apache Spark because distributed reads
> ONE	Single partition	UDA because data-locality lost with Spark
> ONE	Multiple partitions	Apache Spark definitely

Cassandra UDA or Apache Spark ?

Consistency Level	Single/Multiple Partition(s)	Recommended Approach
ONE	Single partition	UDA with token-aware driver because node local
ONE	Multiple partitions	Apache Spark because distributed reads
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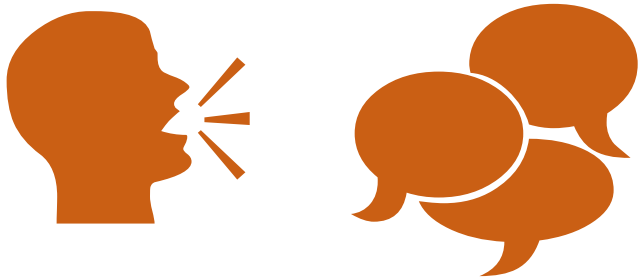

Q & A

Thank You

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