CDC on Statement Based Replication (SBR)

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Agenda

- Introduction to CDC
- MySQL Replication Streams
- Implementing CDC on SBR
- CDC at Box

Introduction to CDC

Change Data Capture (CDC)

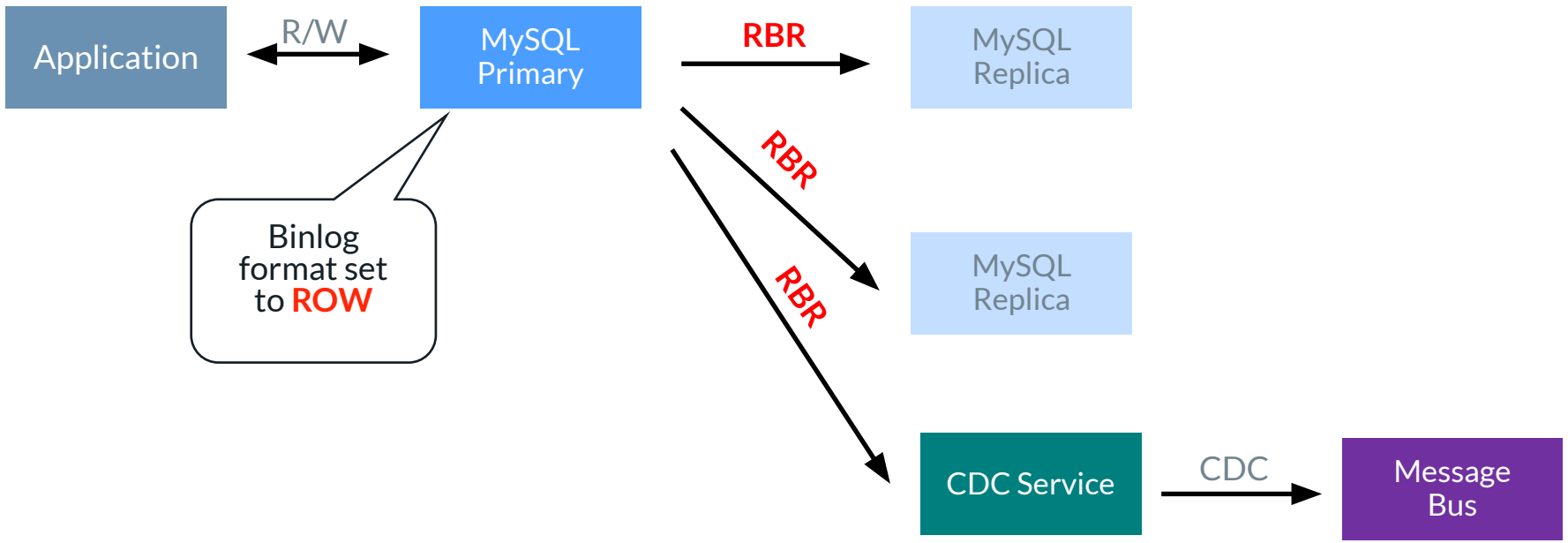
Change Data Capture is a design pattern that enables capturing changes to data and notifying actors so they can react accordingly

Anatomy of a CDC event

- CDC event is composed of
  - Pre-mutation state of the row (before)
  - Post-mutation state of the row (after)
  - Metadata
    - Table
    - Primary key
    - Mutation type


```
{
 "metadata": {
  ”primary_key": 2,
  ”table": "fruit",
  "mutation_type": ”update",
  "timestamp": 1611179777
 },
 ”before": {
  "id": 2,
  "name": ”banana",
  "quantity": 950,
  ”expiry_date": “2020-01-02”
 },
 ”after": {
  "id": 2,
  "name": ”banana",
  "quantity": 720,
  ”expiry_date": “2020-01-02”
 },
}
```

Typical CDC Pipeline Architecture for MySQL



Different Types of MySQL Replication Streams

- Row-based Replication (RBR)
- Statement-based Replication (SBR)

Row-based Replication (RBR)

- The binary log stores the record-level changes that occur to database tables
- State of the row before and after can be extracted from the Binlog event
- Binlog event doesn't contain the table metadata, i.e. it does not record the field names, only field number.

query

```
UPDATE `super_market`.`fruit`
SET quantity= quantity + 300
WHERE name = 'pear'
```

binlog

```
### UPDATE `super_market`.`fruit`
### WHERE
###   @1=1 /* INT meta=0 nullable=0 is_null=0 */
###   @2= 'pear' /* VARSTRING(20) meta=20 nullable=0 is_null=0 */
###   @3=273 /* INT meta=0 nullable=0 is_null=0 */
### SET
###   @1=1 /* INT meta=0 nullable=0 is_null=0 */
###   @2='pear' /* VARSTRING(20) meta=20 nullable=0 is_null=0 */
###   @3=573 /* INT meta=0 nullable=0 is_null=0 */
# at 569
```

Statement-based Replication (SBR)

- The binary log stores the SQL statements used to change databases
- Binlog event doesn’t contain pre-mutation state nor post-mutation state

```
UPDATE `super_market`.`fruit`
SET quantity= quantity + 300
WHERE name = 'pear'
```
query

```
UPDATE `super_market`.`fruit`
SET quantity= quantity + 300
WHERE name = 'pear'
```
binlog

RBR vs SBR

Summary

Requirements for CDC event	RBR	SBR
table	✓	✓
primary key	✓	✗
mutation type	✓	✓
before	✓	✗
after	✓	✗

Implementing CDC on SBR

How do we get the pre-mutation state

Our Solution

SQL Comments

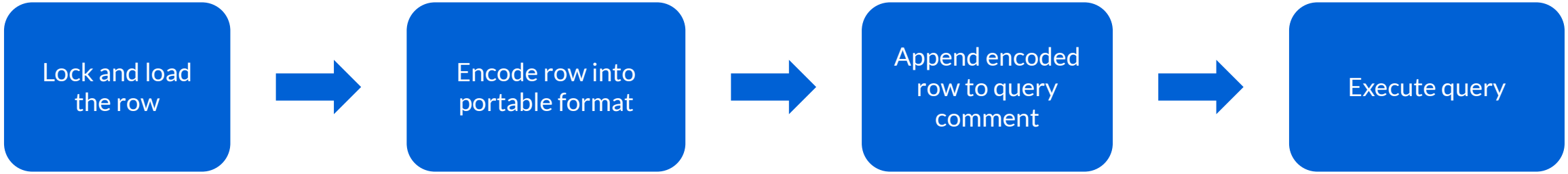
MySQL Query Comments

- MySQL supports placing comments within SQL statements
- MySQL ignores comments when parsing SQL statements
- Comments are preserved in the binlog with statement-based replication

Sample query with comments

```
select name, quantity from fruit where id in (123, 456) /*
trace_id=8826724f58f5586a.8826724f58f5586a<:8826724f58f5586a
&application=webapp
&user_id=12576
*/
```

Mechanics of Appending Pre-mutation State to Comments



Requirements for Serializer

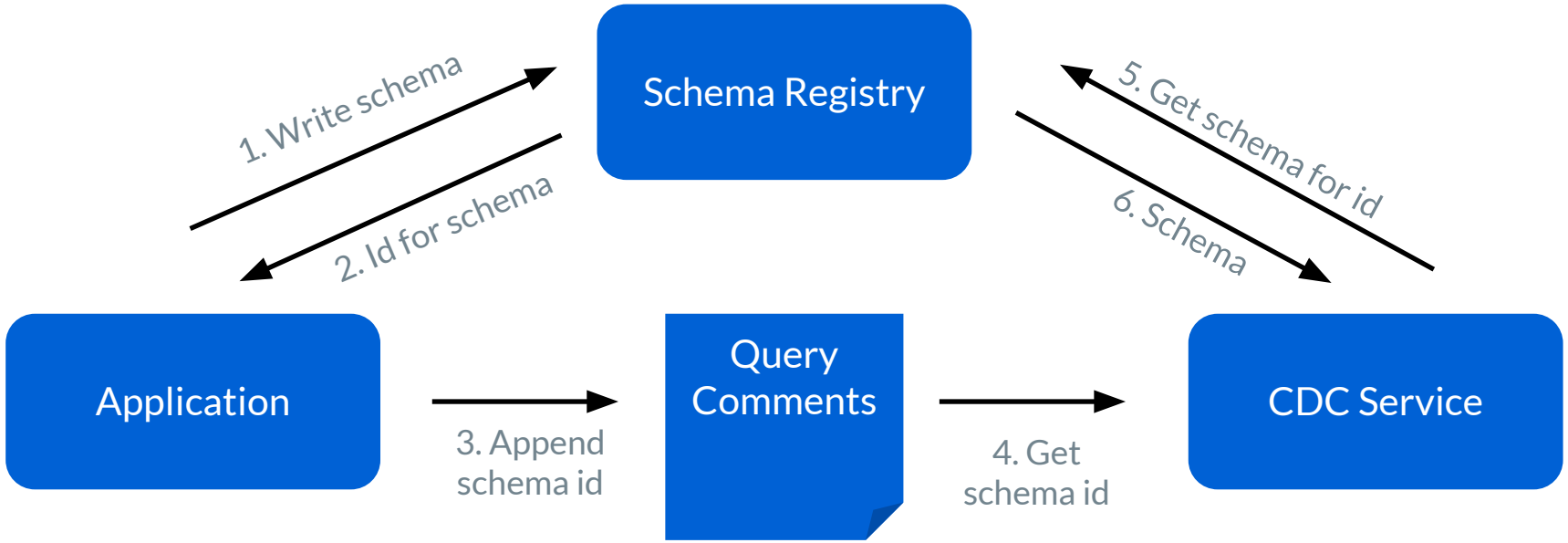
- Fully typed
  - Schema support
  - Schema evolution support
- Compact output
  - Encoded binary data should be very compact, so it takes up less storage space
  - Separate the schema from the encoded data
- Very fast

Avro for Serialization

Requirements for Serializer	
Fully Typed with Schema	✓
Schema Evolution	✓
Compact	✓
Separate Schema from Data	✓
Pretty Fast	✓

Schema Store

- Avro schema of encoded pre is stored in Confluence Schema Registry
- Every schema stored in Schema Registry has a numeric id associated with it
- Schema Id is appended to Query comments



Sample Query Comment

```
/*
trace_id=8826724f58f5586a.8826724f58f5586a<:8826724f58f5586a
&application=webapp
&pre_mutation_snapshot_schema_id=1091
&pre_mutation_snapshot_binary=FQQoYXQlZF9sxS5rXXISMTXSMQXzMDQSMDECssKQ1EoCFQESMDISMzX0MDXxX
hQmdS5QLXRlc3QCZQQoYXQlZF9sxS5rX2Zvcl9CX1ZvdmFfR2FsY2hlbmtvQ3QfZmlsZV8xMDXyMDMSMzXSMQQgc
GFzc3dvcmRfZm9yX0IgVm92YSBHYSxQxGVux28QcyBmxSxlIDESMDISMzXzMDXxXgXSc2hhcmVkX2xpbmsXXhYxMD
XyMDMSQDXSMgK0So3USgISMTXSMQXzMDQSMDICEmZ1bmMtdGVzdXQmc2hhcmVkX2xpbmtfZm9yX0QfVm92YV
9HYSxQxGVux28Qc19mxSxlXzESMDISMzXzMDXyXmBSYXQzd29yZF9mb3QfQiBSb3ZhIEdhbGQoZS5rbydzIGZpbGUg
MTXSMQXzMDMSMDICXX==
*/
```

Caveats with comments

Inclusion of pre-mutation state in comments results in query size explosion

- May need to increase max_allowed_packet
- Our existing max_allowed_packet value is big enough to support our needs
- p99 of query size increase is less than 100KB for us

Binlog files may get too big

- Might affect binlog file retention period on disk
- Not any worse than Row-Based Binlogs
- Additional 6-8MB/sec data added to our binlogs across all the shards

May need to impose restrictions on the mutation cardinality

- Protects from appending very large pre-mutation binaries to comments

Recap

Requirements for CDC event	SBR
table	✓
primary key	✗
mutation type	✓
before	✓✗
after	✗

SQL Comments

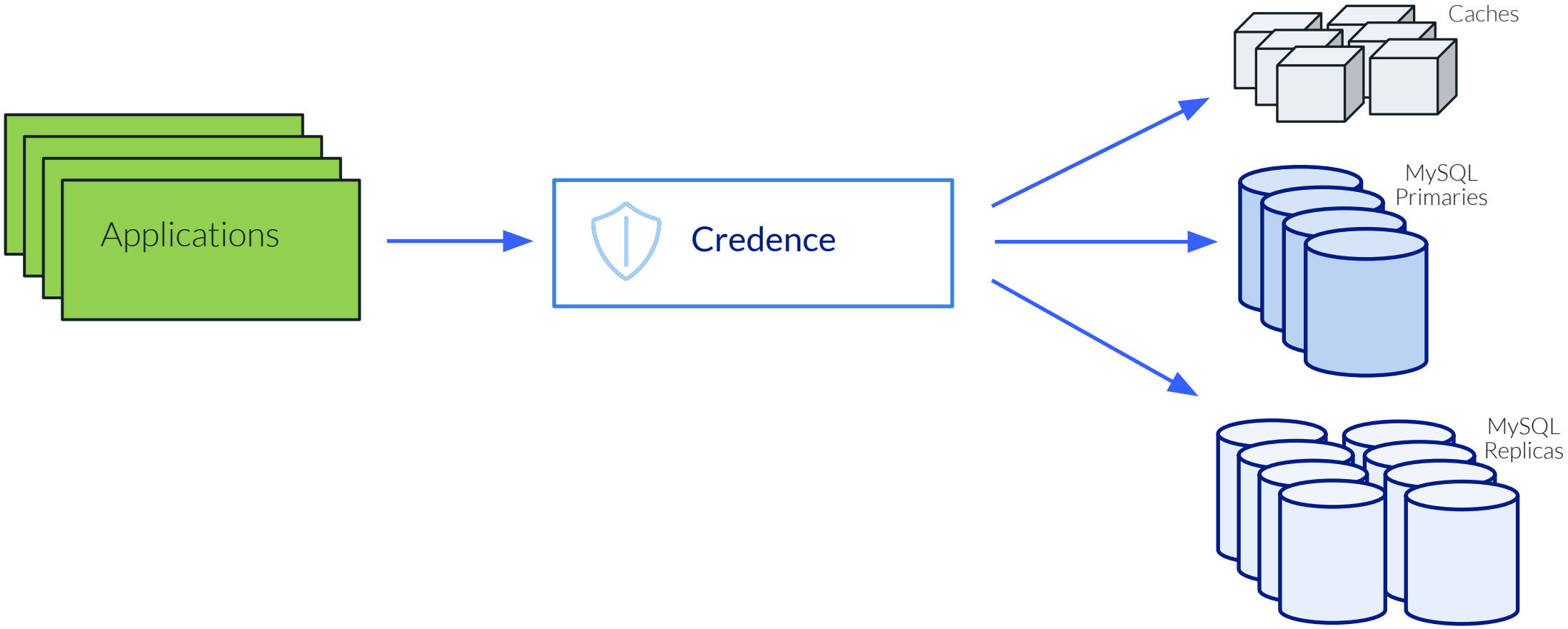
Computing post-mutation state & primary key

Credence

Distributed Data Access Service at Box

- Provides a uniform way to interact with relational data at Box
- Primarily responsible for protecting MySQL
- Provides strongly **opinionated** APIs supporting **limited** set of data access patterns

Credence Architecture



Mutation Queries Supported By Credence

- Multi-row inserts with explicit column values
- Conditional updates only by primary key
  - New column values are explicit
- Delete only by primary key

Insert	INSERT INTO `super_market`.`fruit` (id ,name ,quantity ,expiry_date) VALUES (1 ,'apple' ,100 ,'2021 - 01 - 01 ') , (2 ,'banana' ,950 ,'2021 - 01 - 02 ')
Update	UPDATE `super_market`.`fruit` SET quantity = CASE WHEN id = 1 THEN 88 WHEN id = 2 THEN 950 ELSE quantity END WHERE id IN (1 ,2)
Delete	DELETE FROM `super_market`.`fruit` WHERE id IN (1 ,2)

Queries Not Supported by Credence

Mutation queries with MySQL computed column values

- ex: update fruit set quantity = quantity + 100 where id = 2
- Clients who need to execute this kind of query would read the locked row to compute final values before executing mutation queries in a transaction

Delete/Update queries with unbounded where clause

- ex: delete fruit where expiry_date <1609509729
- Clients who need to execute this kind of query would load the primary keys first using the read apis and issue delete queries using primary keys in a transaction

How to Compute Post-mutation State & PK

- Parse mutation queries to extract columns modified and their new values (diff) as well primary keys
- Post can be computed by merging pre-mutation state with diff within CDC pipeline
  - post = pre + diff
- No additional changes to query size

Compute Post-mutation State & PK for Insert

```
INSERT INTO `super_market`.`fruit` ( id, name , quantity, expiry_date )
VALUES
        ( 1 ,'apple' ,100 ,'2021 - 01 - 01 ' )
/*
trace_id=8826724f58f5586a.8826724f58f5586a<:8826724f58f55
86a
&application=webapp
*/
```

Compute Post-mutation State & PK for Insert

Raw diff

```
( id, name , quantity, expiry_date )
( 1 ,'apple' ,100 ,'2021 - 01 - 01 ' )
```

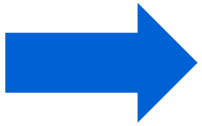
diff

Columns changed	New values
id	1
name	apple
quantity	100
expiry_date	2021-01-01

Compute Post-mutation State & PK For Insert

diff

Columns changed	New values
id	1
name	apple
quantity	100
expiry_date	2021-01-01



post

Columns changed	New values
id	1
name	apple
quantity	100
expiry_date	2021-01-01

Compute Post-mutation State & PK for Update

```
UPDATE `super_market`.`fruit`
SET quantity = CASE WHEN id = 1 THEN 88 ELSE quantity END
WHERE id IN ( 1 )
/*
trace_id=8826724f58f5586a.8826724f58f5586a<:8826724f58f558
6a
&application=webapp
&pre_mutation_snapshot_schema_id=1091
&pre_mutation_snapshot_binary=FQQoYXQlZF9sxS5rXXISMTXSM
QXzMDQSMDECssKQ1EoCFQESMDISMz==
*/
```

Compute Post-mutation State & PK For Update

Raw diff

```
quantity = CASE WHEN id = 1 THEN 88
ELSE quantity END
```

diff

Columns changed	New values
quantity	88

Raw pre

```
pre_mutation_snapshot_schema_id=1091&
pre_mutation_snapshot_binary=FQQoYXQl
ZF9sxS5rXXISMTXSMQXzMDQSMDECss
KQ1EoCFQESMDISMzX0MDXxXhQmdS5
QLXRlc3QCZQQoYXQlZF9sxS5rX2Zvcl9
CX1ZvdmF==
```

pre

Columns changed	New values
id	1
name	apple
quantity	100
expiry_date	2021-01-01

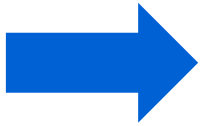
Compute Post-mutation State & PK for Update

pre

Columns changed	New values
id	1
name	apple
quantity	100
expiry_date	2021-01-01

diff

Columns changed	New values
quantity	88



post

Columns changed	New values
id	1
name	apple
quantity	88
expiry_date	2021-01-01

Downside of Parsing Queries

- Query parsing can get complicated and often error prone
- Binlog tailer implementation is tightly coupled with data access service that creates and executes queries

Techniques to Avoid Query Parsing

/ Append diff to query comments

/ Append post-mutation state to query comments

Both options results in further explosion of query and binlog file size

Implementing CDC on SBR - Recap

Requirements for CDC event	SBR
table	✓
primary key	✗
mutation type	✓
before	✗
after	✗

Query Parsing

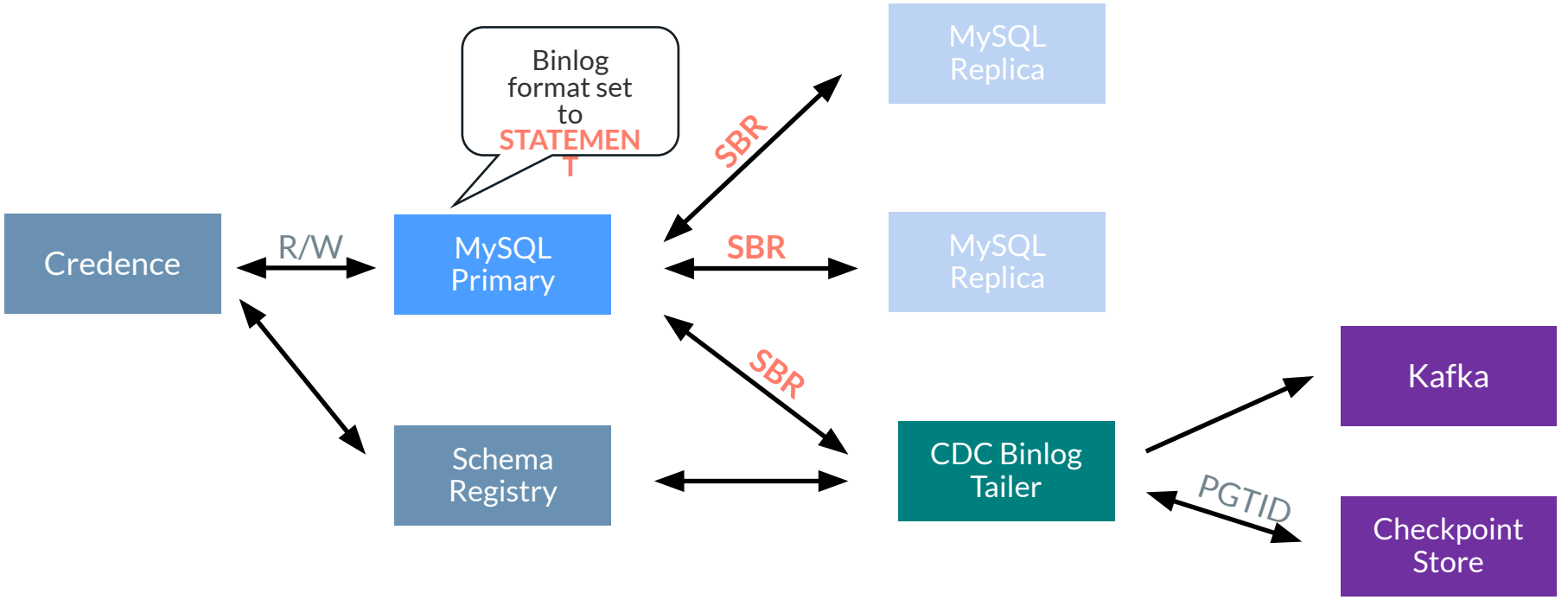
SQL Comments

Query Parsing

CDC at Box

CDC at Box

Architecture



Scale of CDC at Box

100s	10,000s	10s
MySQL Shards	CDC events per sec	CDC Consumers

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