Apache Phoenix: Transforming HBase into a SQL database

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http://phoenix.apache.org

About me

- Architect at Salesforce.com in Big Data group
  - Started Phoenix as internal project ~3 years ago
  - Open-source on Github ~1.5 years ago
  - Apache incubator for ~5 months
  - Graduated as Top Level Project in May 2014
- Engineer at BEA Systems
  - XQuery-based federated query engine
  - SQL-based complex event processing engine

Agenda

- What is Apache Phoenix?
- Why is it so fast?
- How does it help HBase scale?
- Roadmap
- Q&A

What is Apache Phoenix?

What is Apache Phoenix?

1. Turns HBase into a SQL database
    - Query Engine
    - MetaData Repository
    - Embedded JDBC driver
    - **Only** for HBase data

What is Apache Phoenix?

2. Fastest way to access HBase data
   - HBase-specific push down
   - Compiles queries into native HBase calls (no map-reduce)
   - Executes scans in parallel

SELECT * FROM t WHERE k IN (?,?,?)

Phoenix	Stinger (Hive 0.11)
0.04 sec	280 sec

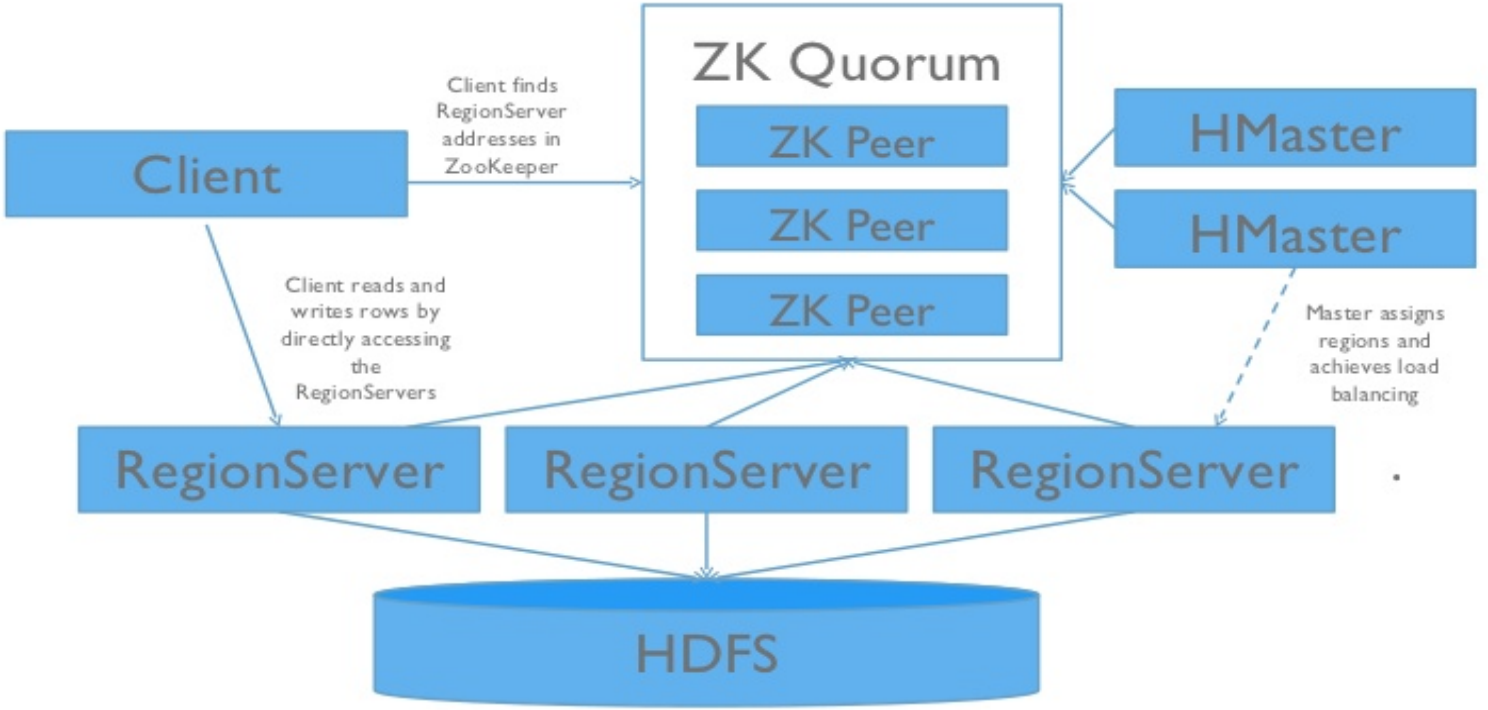
7,000x faster

* 110M row table

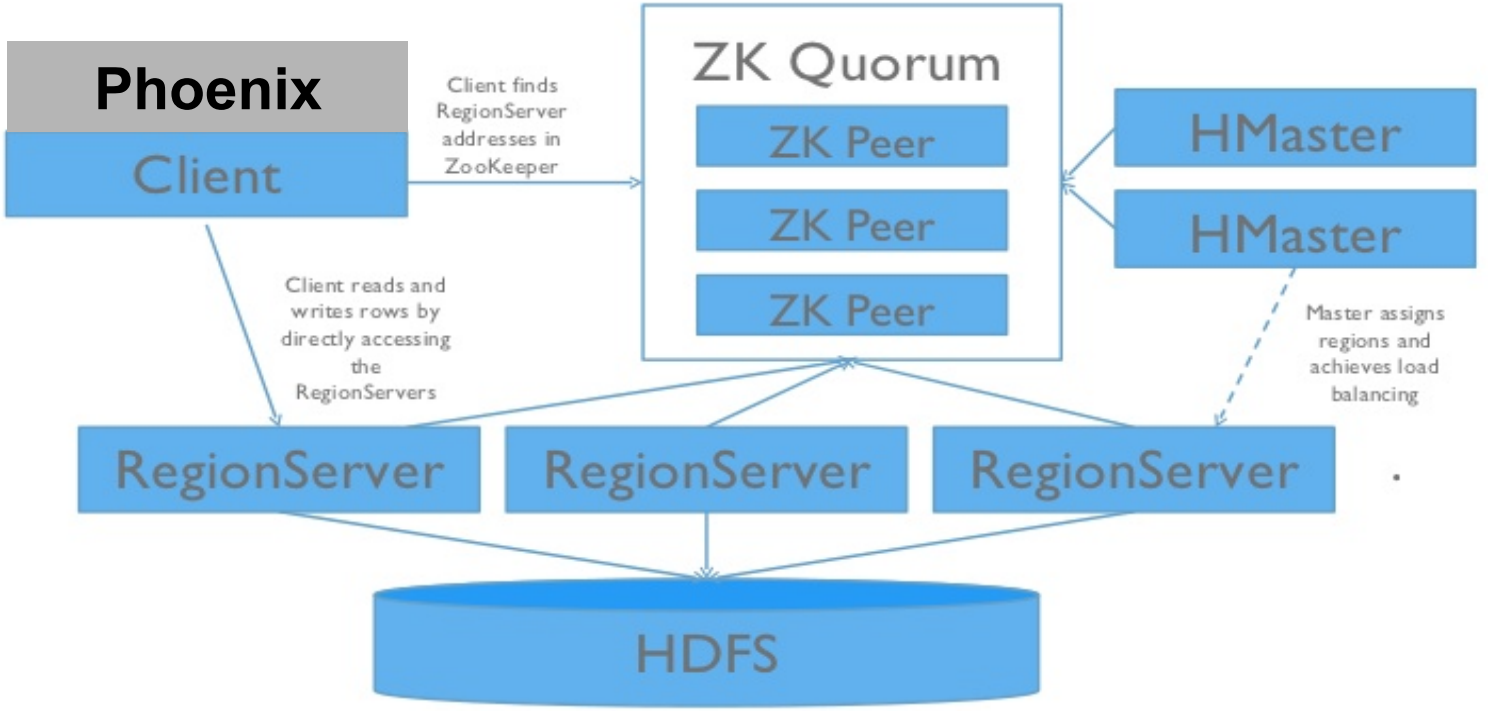
What is Apache Phoenix?

3. Lightweight
   - No additional servers required
   - 100% Java
   - Included in HDP 2.1 distribution
   - Available in Amazon EMR
   - Otherwise copy Phoenix jar into HBase lib directory on each RS

HBase Cluster Architecture



HBase Cluster Architecture



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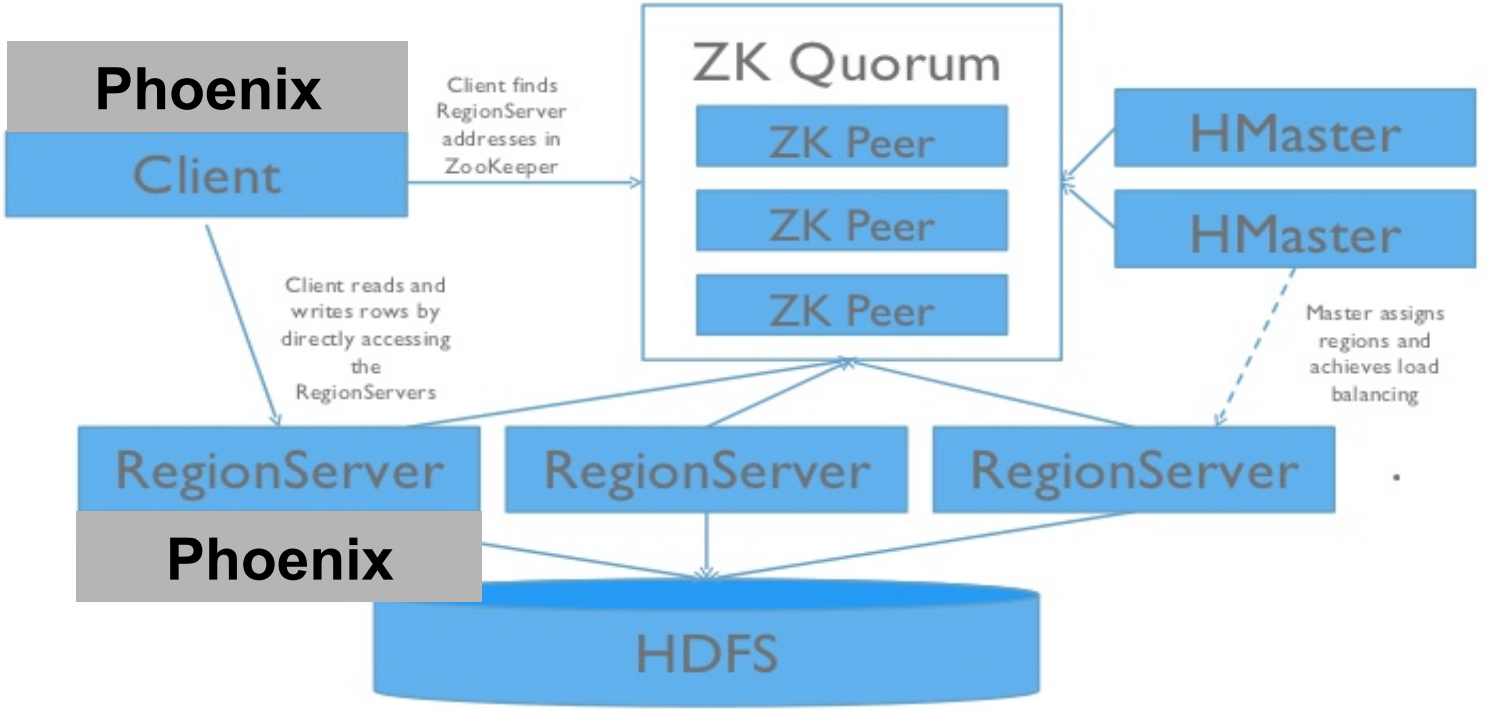


What is Apache Phoenix?

4. Integration-friendly
   - Map to existing HBase table
   - Integrate with Apache Pig
   - Integrate with Apache Flume
   - Integrate with Apache Sqoop (wip)

What is Apache Phoenix?

1. Turns HBase into a SQL database
2. Fastest way to access HBase data
3. Lightweight
4. Integration-friendly

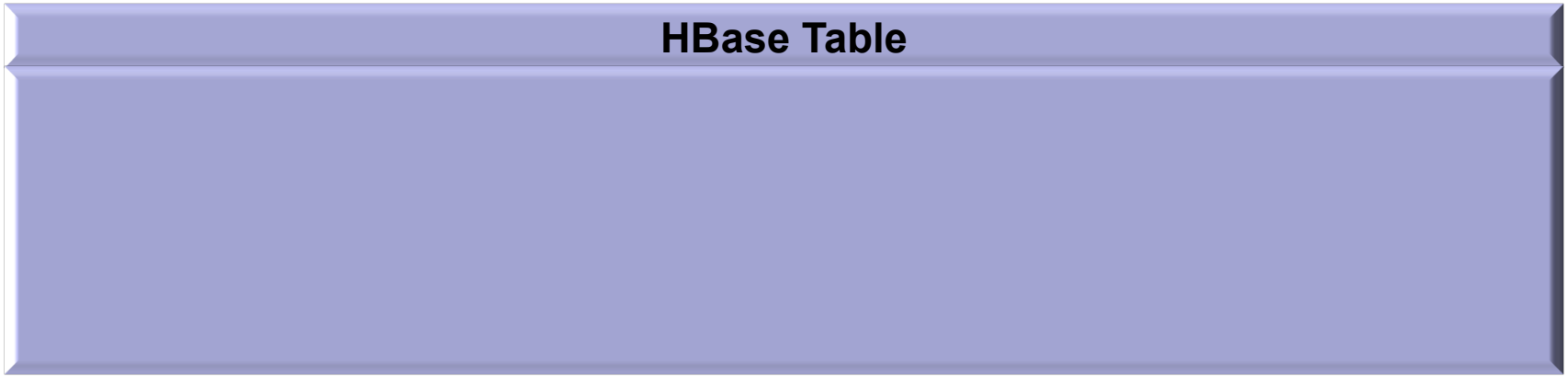
Why is Phoenix so fast?

Why is Phoenix so fast?

1. HBase
   - Fast, but “dumb” (on purpose)
2. Data model
   - Support for composite primary key
   - Binary data sorts naturally
3. Client-side parallelization
4. Push down
   - Custom filters and coprocessors

Phoenix Data Model

Phoenix maps HBase data model to the relational world



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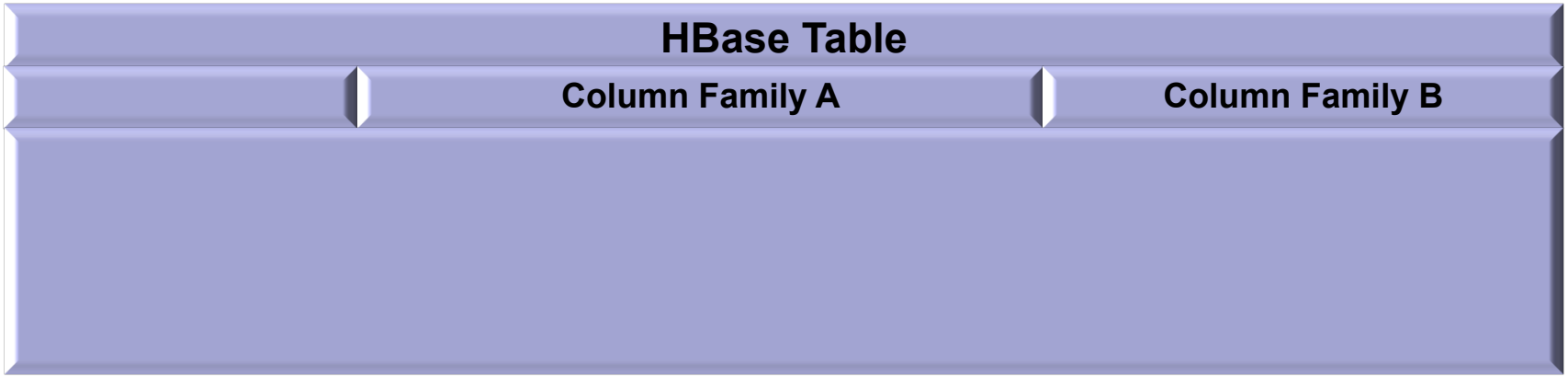

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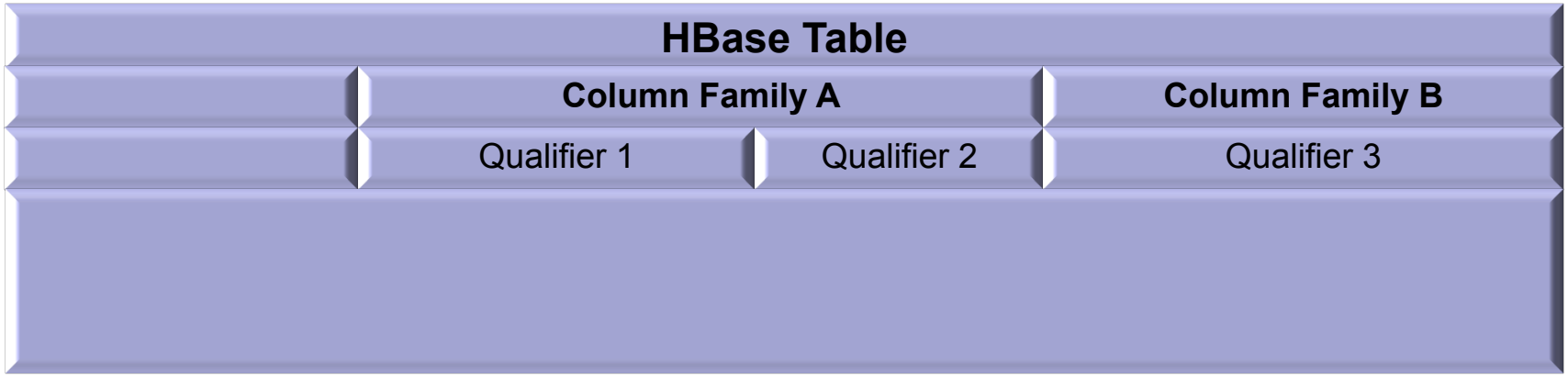

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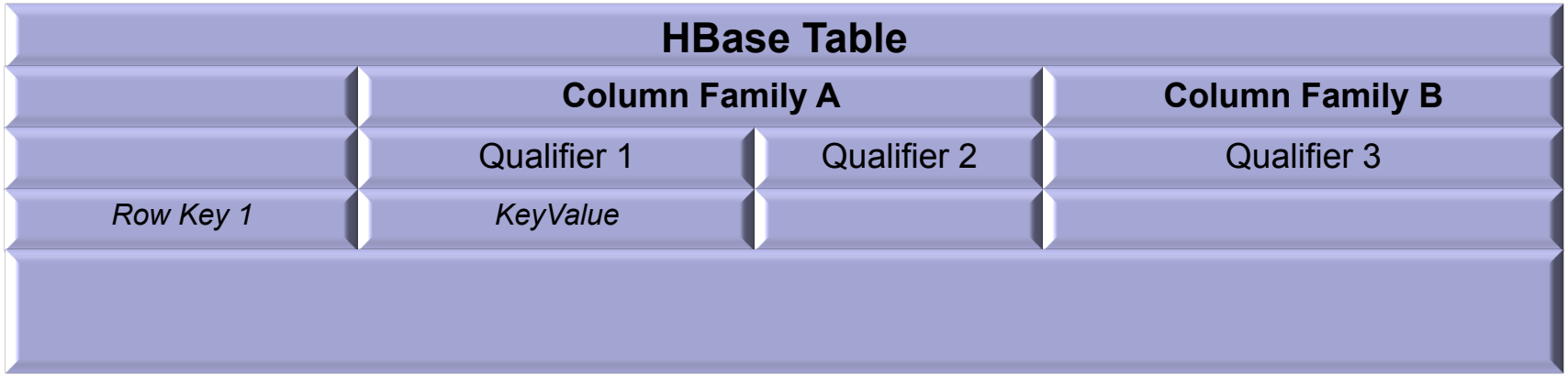

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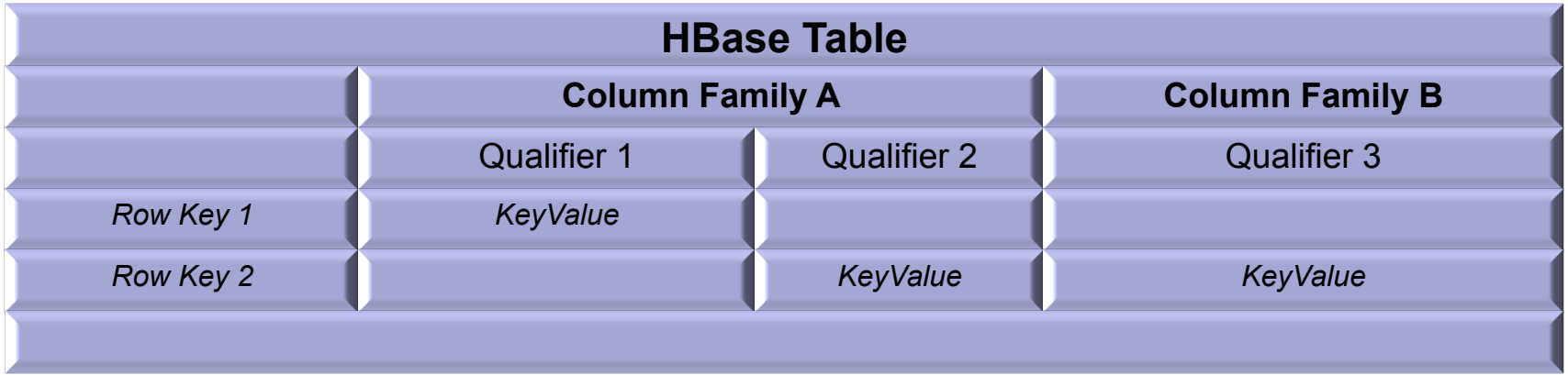

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HBase Table			
	Column Family A		**Column Family B**
	Qualifier 1	Qualifier 2	Qualifier 3
Row Key 1	*KeyValue*		
Row Key 2		*KeyValue*	*KeyValue*
Row Key 3	*KeyValue*		

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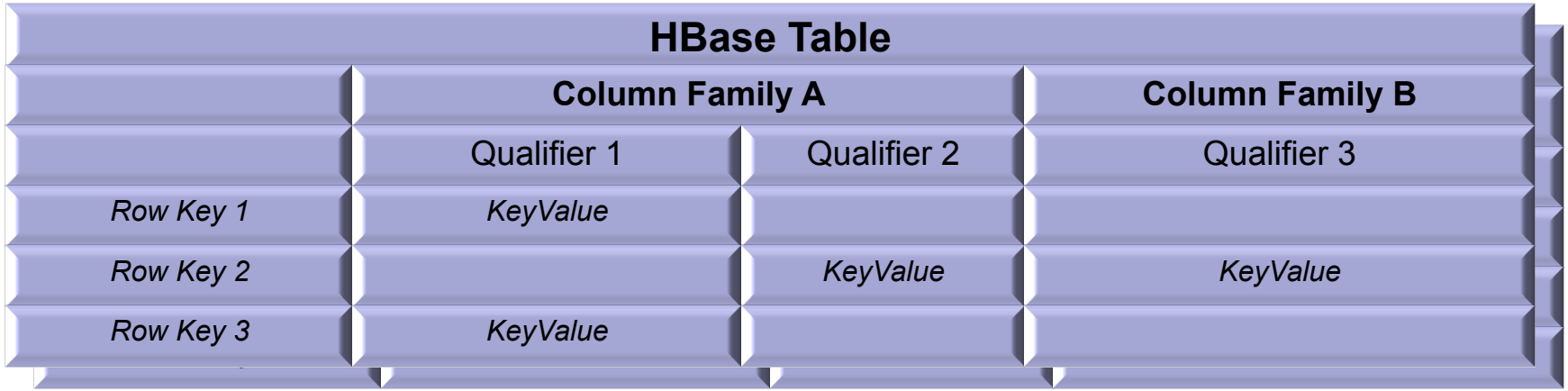

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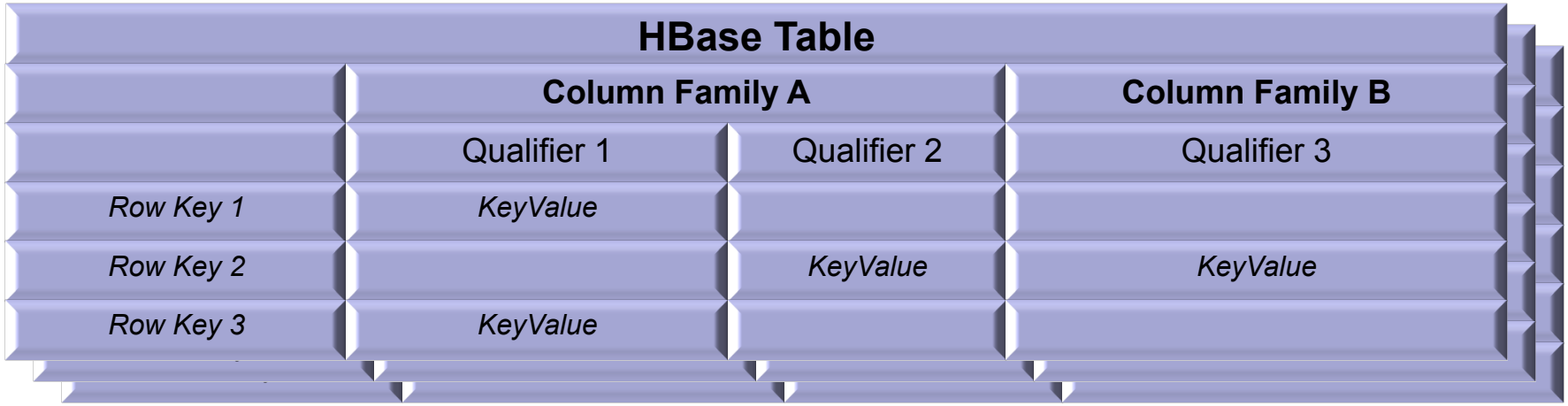

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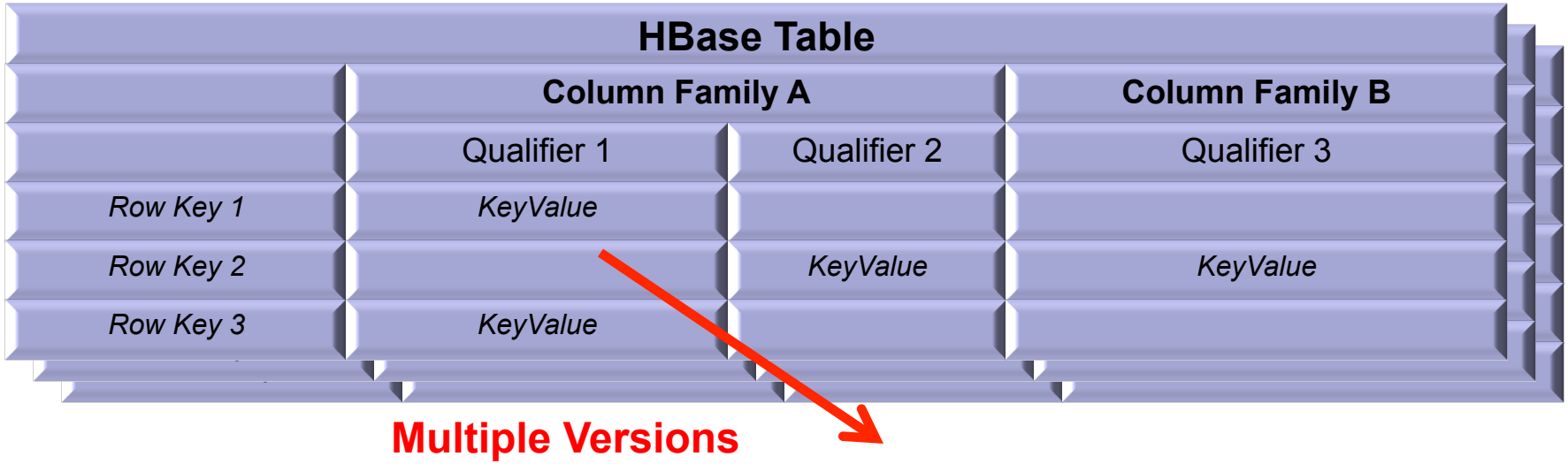

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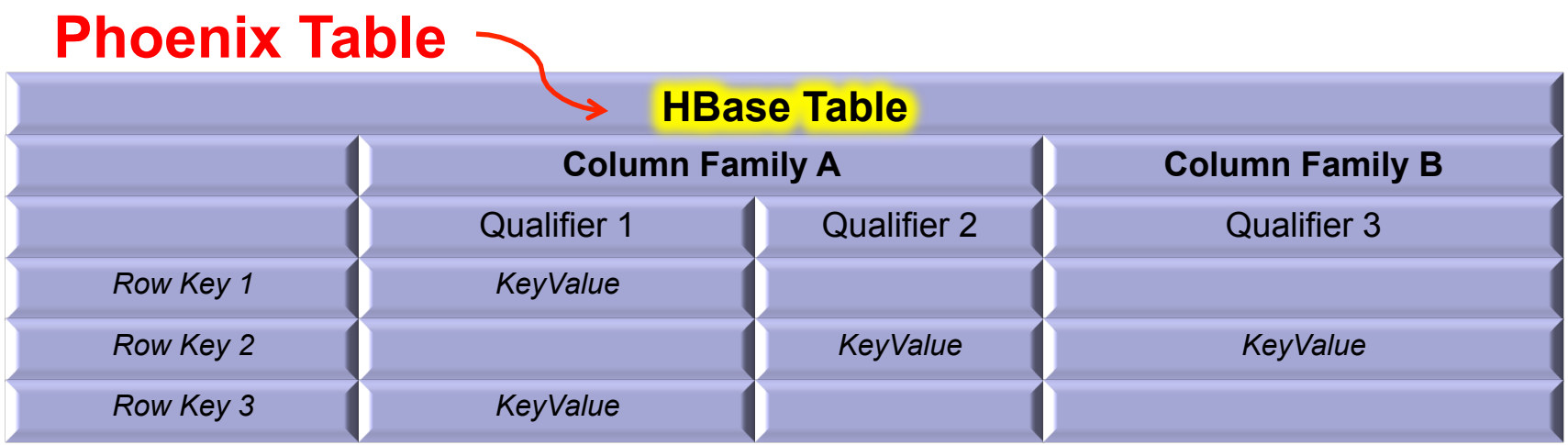

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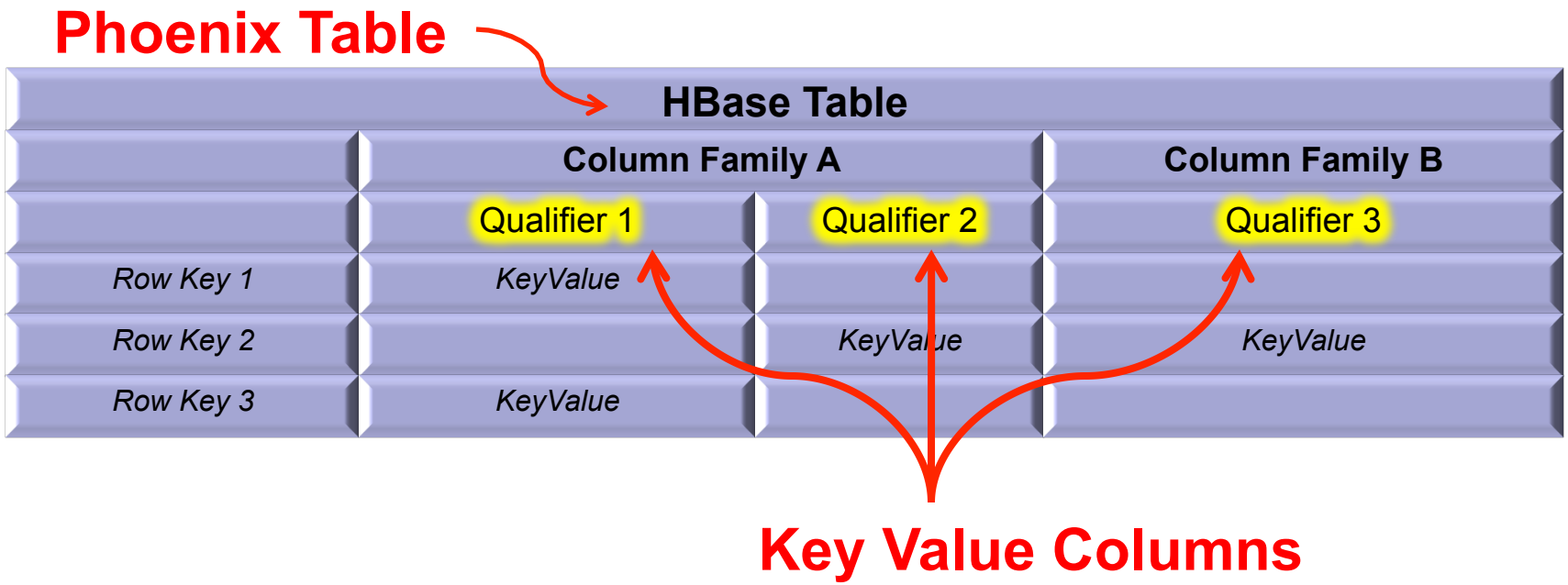

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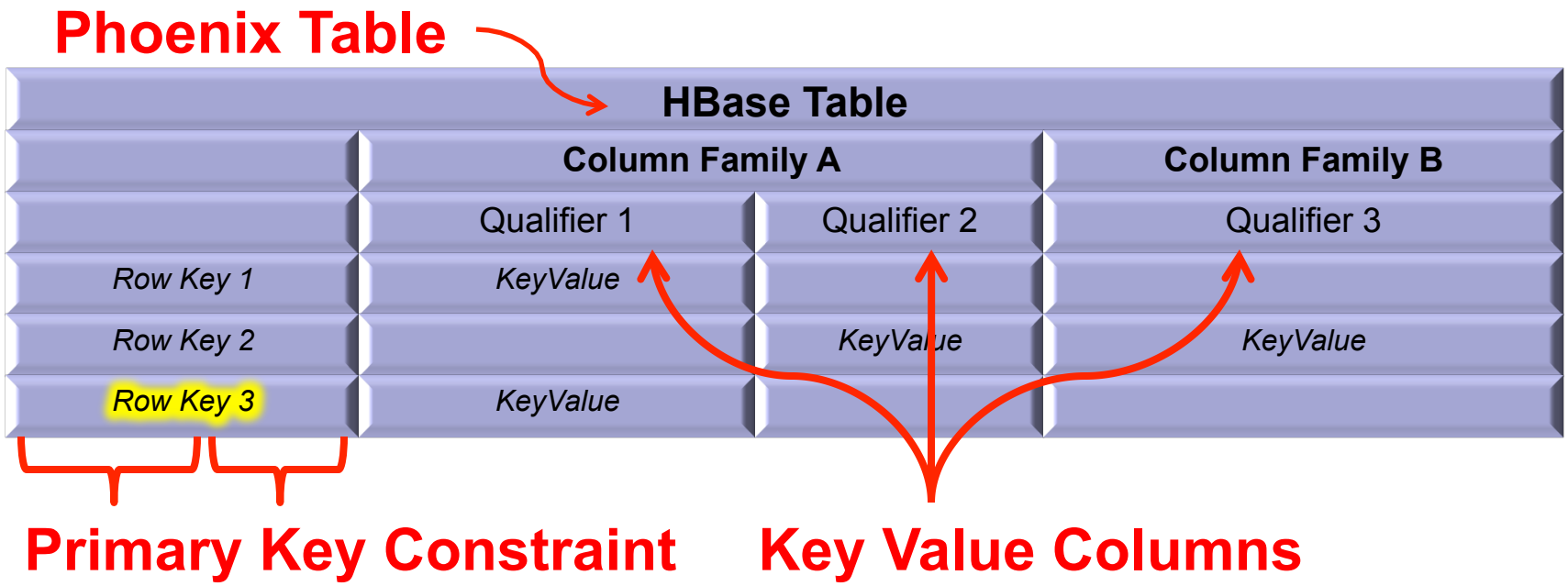

Example

Over metrics data for servers with a schema like this:

SERVER METRICS	
HOST	VARCHAR
DATE	DATE
RESPONSE_TIME	INTEGER
GC_TIME	INTEGER
CPU_TIME	INTEGER
IO_TIME	INTEGER

Row Key

Example

Over metrics data for servers with a schema like this:

SERVER METRICS	
HOST	VARCHAR
DATE	DATE
RESPONSE_TIME	INTEGER
GC_TIME	INTEGER
CPU_TIME	INTEGER
IO_TIME	INTEGER

Key Values

Example

DDL command looks like this:

```
CREATE TABLE SERVER_METRICS (
        HOST                VARCHAR,
        DATE                DATE,
        RESPONSE_TIME       INTEGER,
        GC_TIME             INTEGER,
        CPU_TIME            INTEGER,
        IO_TIME             INTEGER,
        CONSTRAINT pk PRIMARY KEY (HOST, DATE))
```

Example

With data that looks like this:

SERVER METRICS			
HOST + DATE		RESPONSE_TIME	GC_TIME
SF1	1396743589	1234	
SF1	1396743589		8012
…			
SF3	1396002345	2345	
SF3	1396002345		2340
SF7	1396552341	5002	1234
…			

Row Key

Example

With data that looks like this:

SERVER METRICS			
HOST + DATE		RESPONSE_TIME	GC_TIME
SF1	1396743589	1234	
SF1	1396743589		8012
…			
SF3	1396002345	2345	
SF3	1396002345		2340
SF7	1396552341	5002	1234
…			

Key Values

Phoenix Push Down: Example

```
SELECT host, avg(response_time)
FROM server_metrics
WHERE date > CURRENT_DATE() – 7
AND host LIKE ‘SF%’
GROUP BY host
```

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Phoenix Push Down

1. Skip scan filter
2. Aggregation
3. TopN
4. Hash Join

Phoenix Push Down: Skip scan

```
SELECT host, avg(response_time)
FROM server_metrics
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```
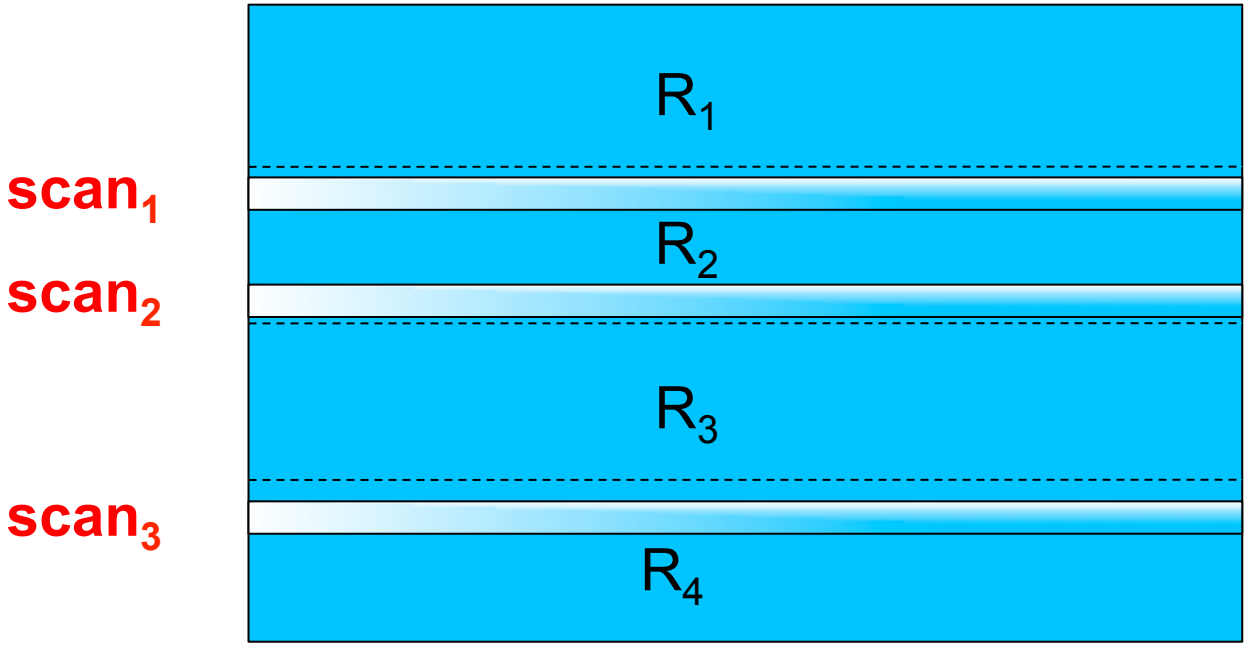

Phoenix Push Down: Skip scan

Phoenix Push Down: Skip scan
Client-side parallel scans



Phoenix Push Down: Skip scan Server-side filter

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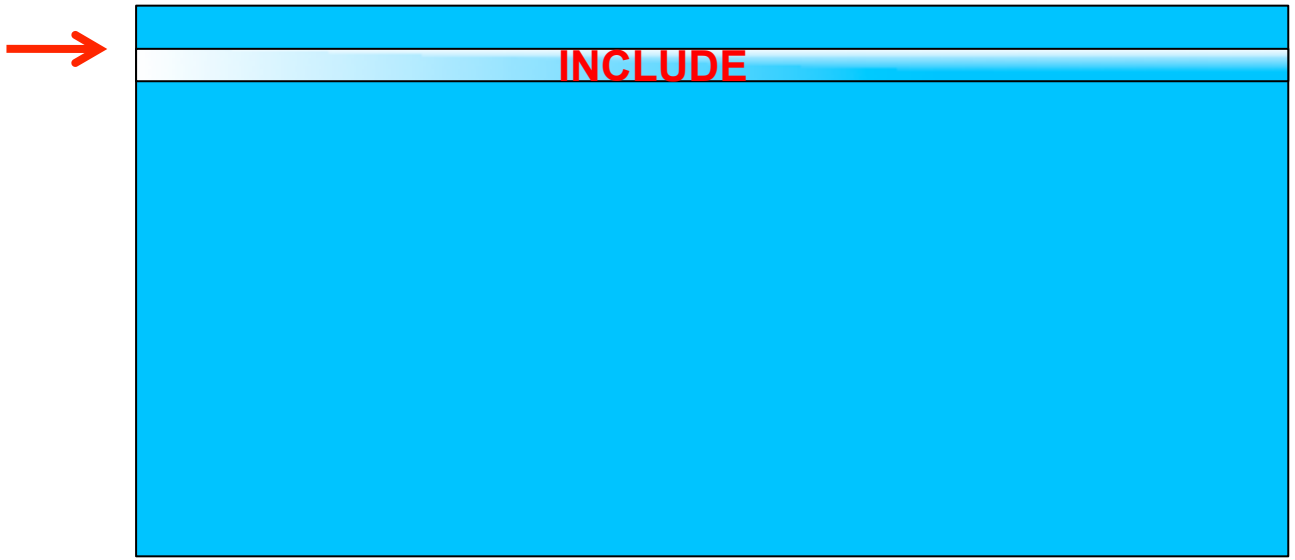

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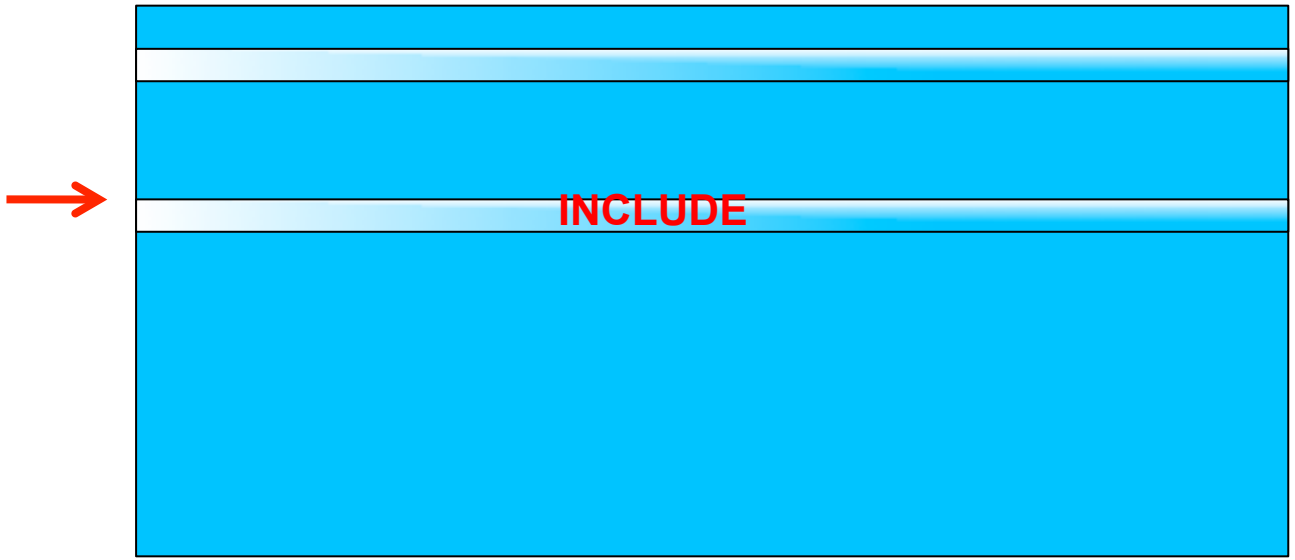

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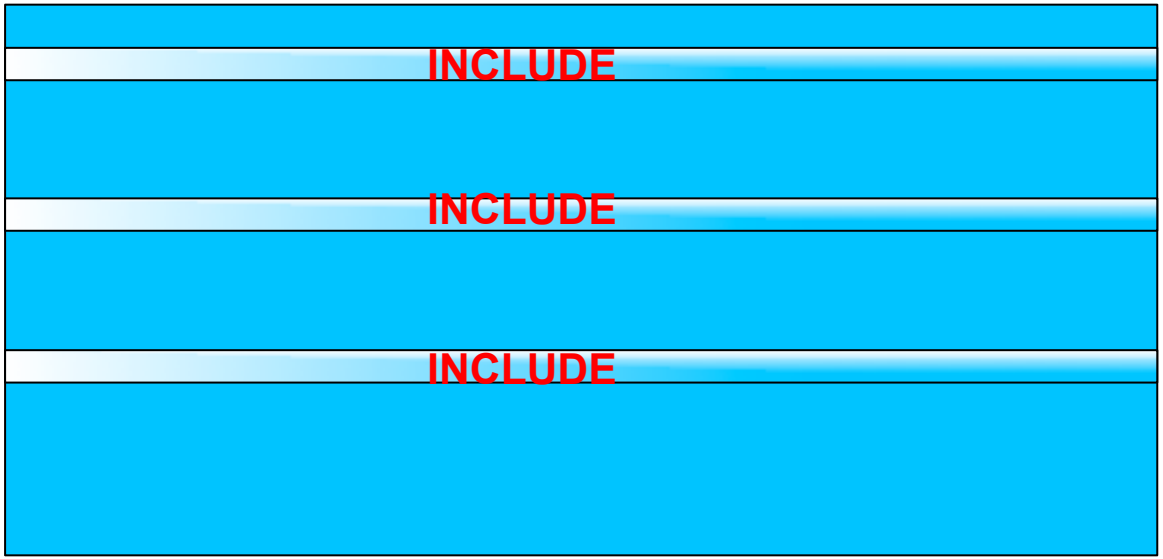


Phoenix Push Down: Aggregation

```
SELECT host, avg(response_time)
FROM server_metrics
WHERE date > CURRENT_DATE() – 7
AND host LIKE ‘SF%’
GROUP BY host
```

Phoenix Push Down: Aggregation
Aggregate on server-side

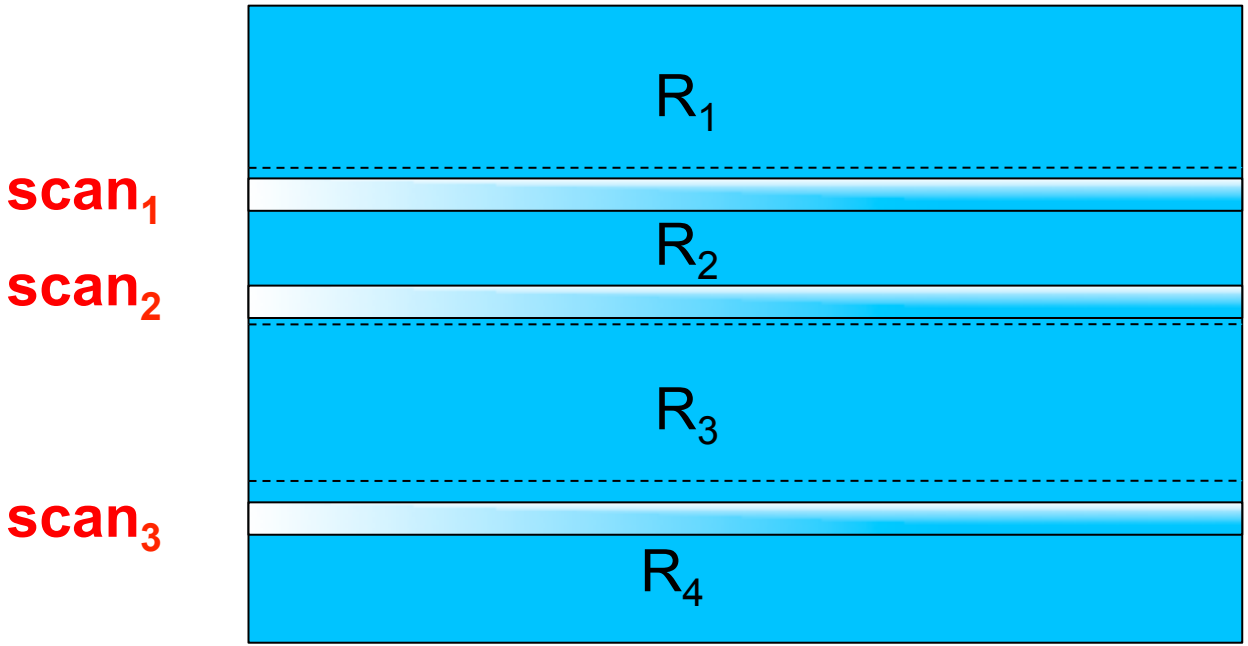
SERVER METRICS				
HOST	DATE	KV_1	KV_2	KV_3
SF1	Jun 2 10:10:10.234	239	234	674
SF1	Jun 3 23:05:44.975		23	234
SF1	Jun 9 08:10:32.147	256	314	341
SF1	Jun 9 08:10:32.147	235	256	
SF1	Jun 1 11:18:28.456		235	23
SF1	Jun 3 22:03:22.142	234		314
SF1	Jun 3 22:03:22.142	432	234	256
SF2	Jun 1 10:29:58.950	23	432	
SF2	Jun 2 14:55:34.104	314	876	23
SF2	Jun 3 12:46:19.123	256	234	314
SF2	Jun 3 12:46:19.123		432	
SF2	Jun 8 08:23:23.456	876	876	235
SF2	Jun 1 10:31:10.234	234	234	876
SF3	Jun 1 10:31:10.234	432	432	234
SF3	Jun 3 10:31:10.234		890	
SF3	Jun 8 10:31:10.234	314	314	235
SF3	Jun 1 10:31:10.234	256	256	876
SF3	Jun 1 10:31:10.234	235		234
SF3	Jun 8 10:31:10.234	876	876	432
SF3	Jun 9 10:31:10.234	234	234	
SF3	Jun 3 10:31:10.234		432	276
…	…	…	…	…

SERVER METRICS	
HOST	AGGREGATE VALUES
SF1	3421
SF2	2145
SF3	9823

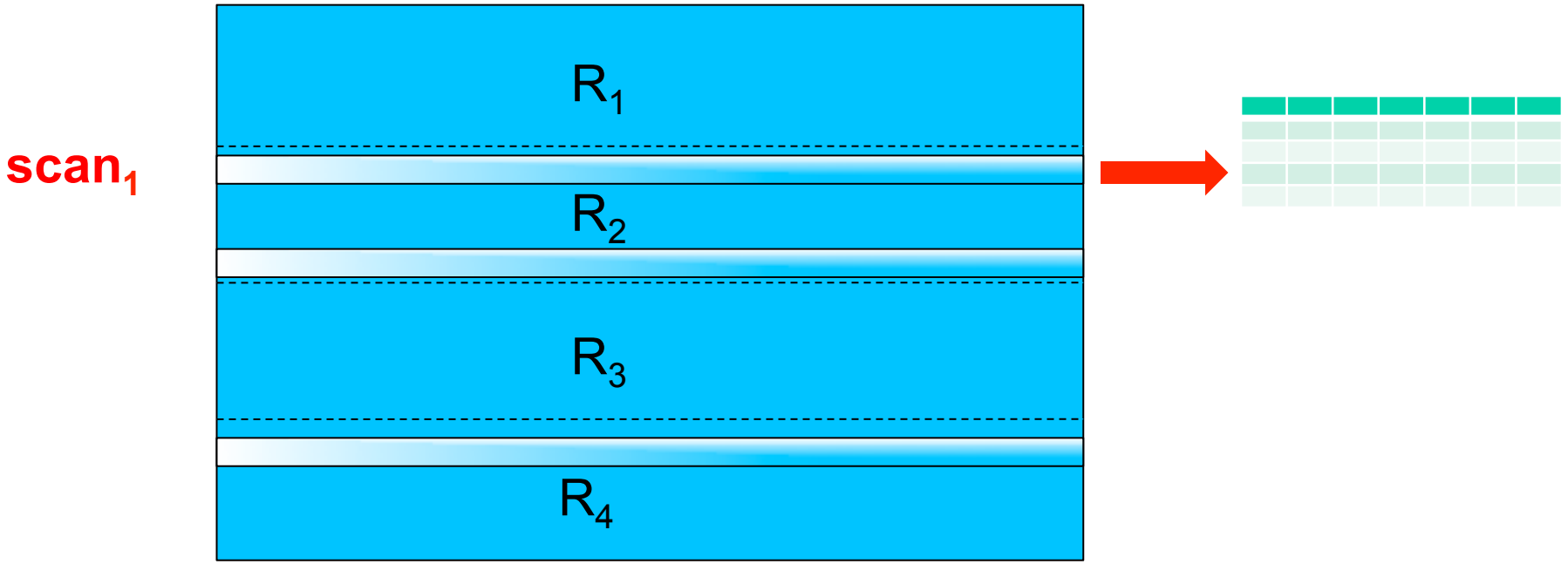
Phoenix Push Down: TopN

```
SELECT host, date, gc_time
FROM server_metrics
WHERE date > CURRENT_DATE() – 7
AND host LIKE ‘SF%’
ORDER BY gc_time DESC
LIMIT 5
```

Phoenix Push Down: TopN
Client-side parallel scans



Phoenix Push Down: TopN
Each region holds N rows



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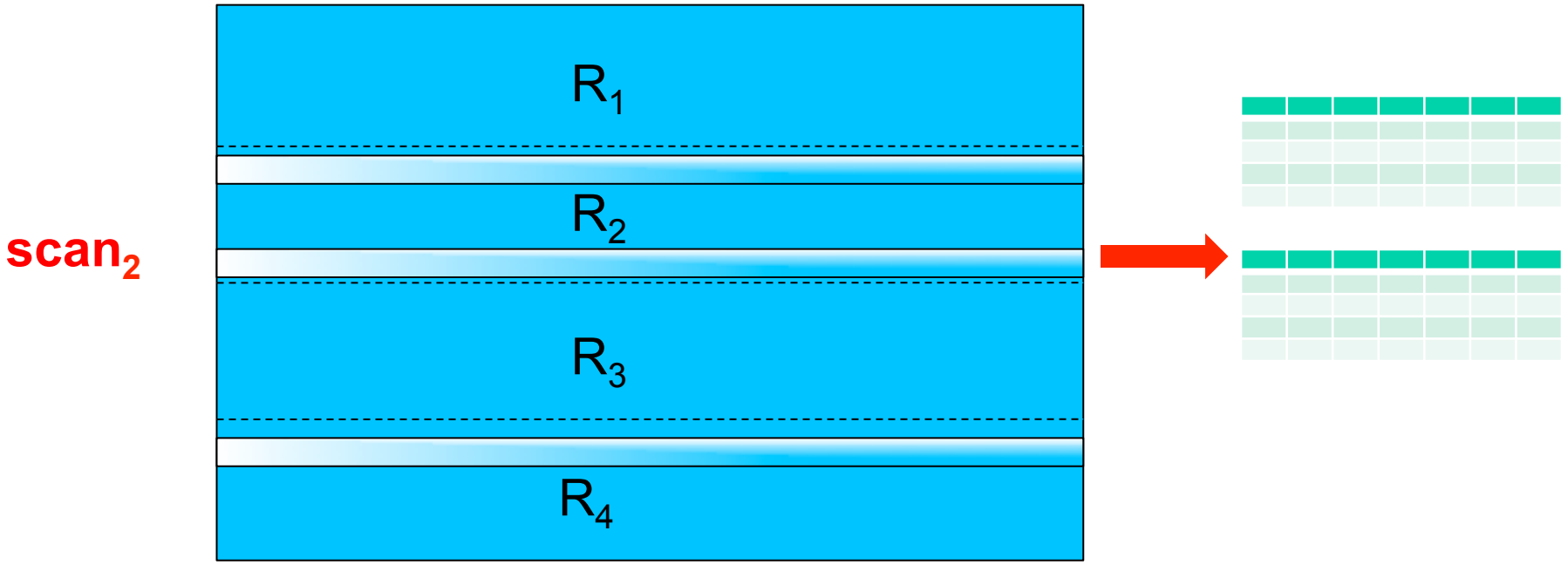

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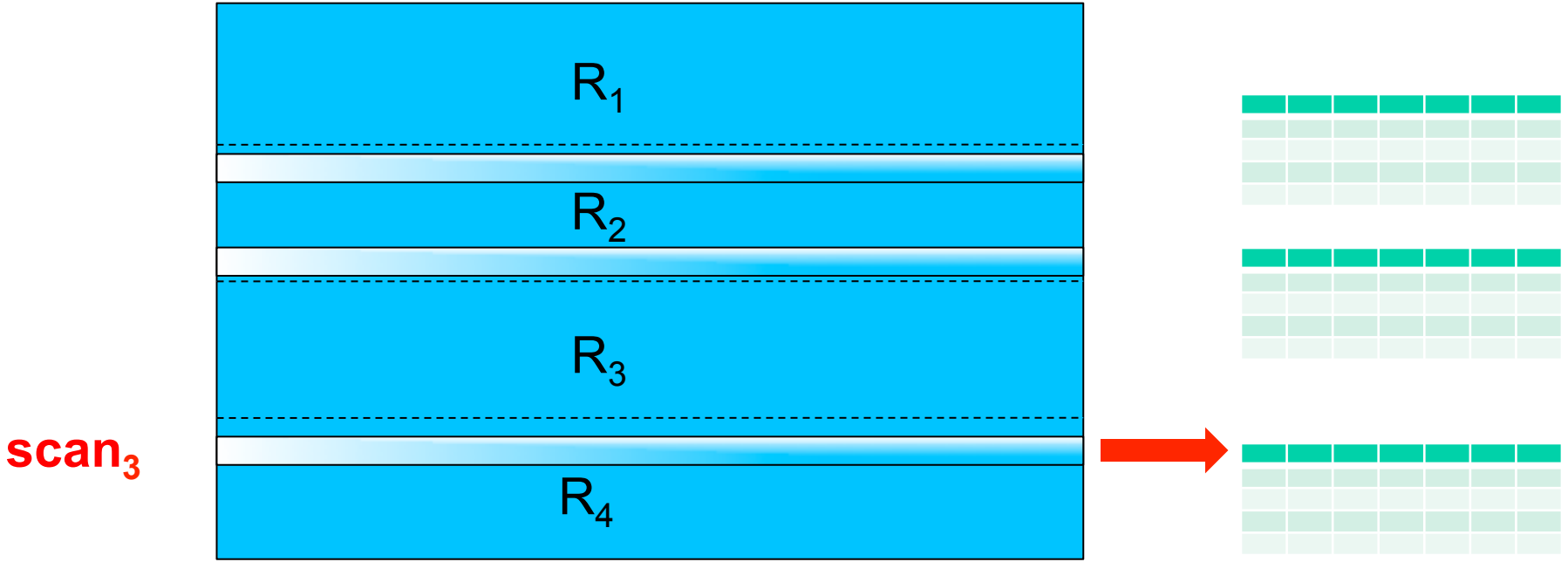
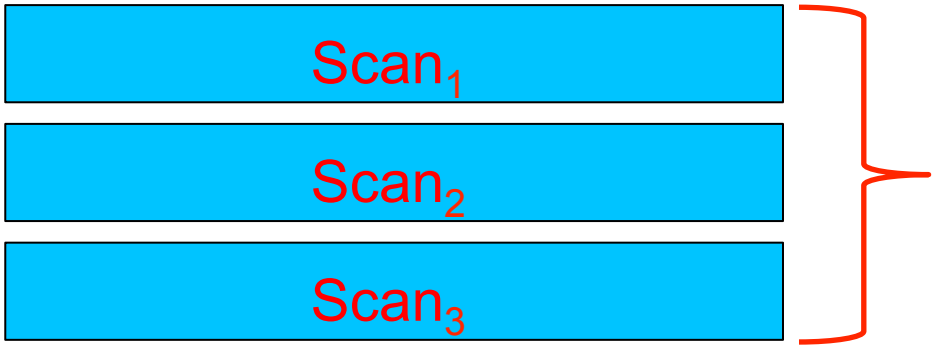


Phoenix Push Down: TopN
Client-side final merge sort



SERVER METRICS		
HOST	DATE	GC_TIME
SF3	Jun 2 10:10:10.234	22123
SF5	Jun 3 23:05:44.975	19876
SF2	Jun 9 08:10:32.147	11345
SF2	Jun 1 11:18:28.456	10234
SF1	Jun 3 22:03:22.142	10111

Phoenix Push Down: TopN Secondary Index

```
CREATE INDEX gc_time_index
ON server_metrics (gc_time DESC, date DESC)
INCLUDE (response_time)
```

GC_TIME_INDEX	
GC_TIME	INTEGER
DATE	DATE
HOST	VARCHAR
RESPONSE_TIME	INTEGER

Row Key

Phoenix Push Down: TopN Secondary Index

```
CREATE INDEX gc_time_index
ON server_metrics (gc_time DESC, date DESC)
INCLUDE (response_time)
```

GC_TIME_INDEX	
GC_TIME	INTEGER
DATE	DATE
HOST	VARCHAR
RESPONSE_TIME	INTEGER

Key Value

Phoenix Push Down: TopN
Secondary Index

- Original query doesn’t change
- Phoenix rewrites query to use index table
- All referenced columns must exist in index table for it to be considered
- Stats coming soon!

Phoenix Push Down: Hash Join

```
SELECT m.*, i.location
FROM server_metrics m
JOIN host_info i ON m.host = i.host
WHERE m.date > CURRENT_DATE() – 7
AND i.location = ‘SF’
ORDER BY m.gc_time DESC
LIMIT 5
```

Phoenix Push Down: Hash Join Separate LHS and RHS

```
SELECT m.*, i.location
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```

Phoenix Push Down: Hash Join Separate LHS and RHS

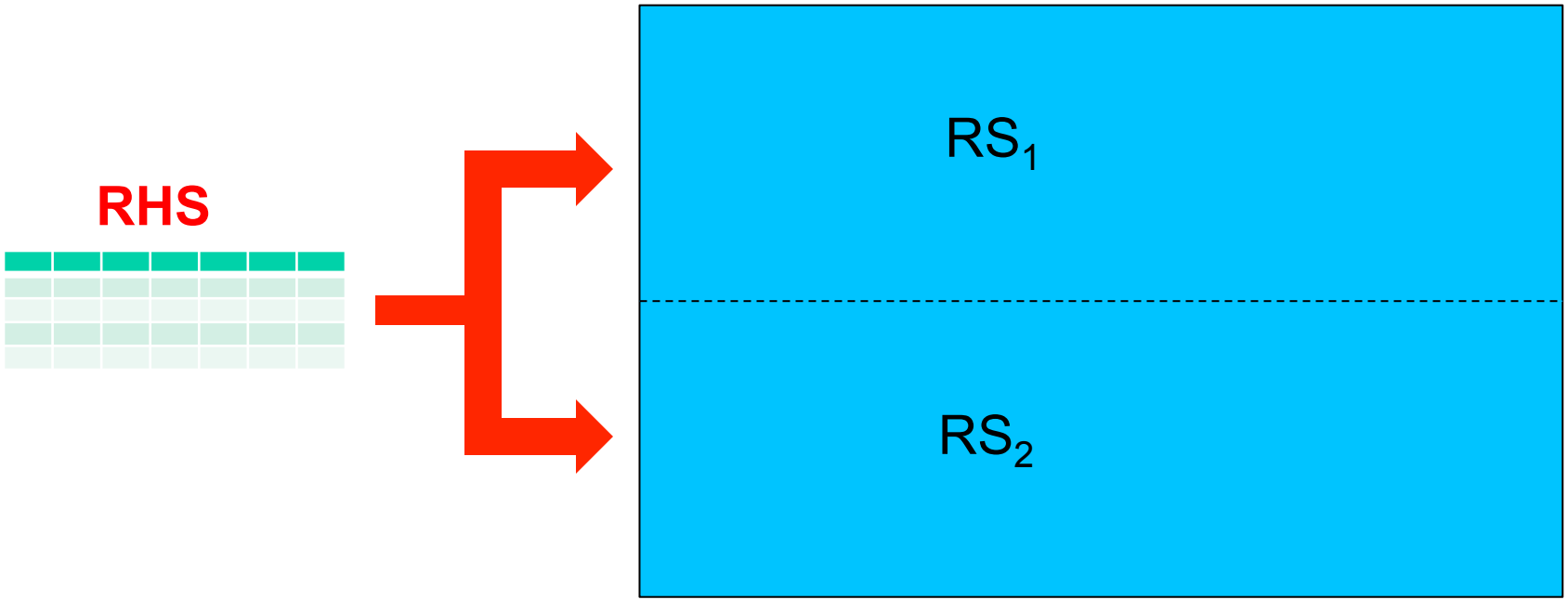
LHS

```
SELECT *
FROM server_metrics
WHERE date >
CURRENT_DATE() – 7
ORDER BY gc_time DESC
LIMIT 5
```

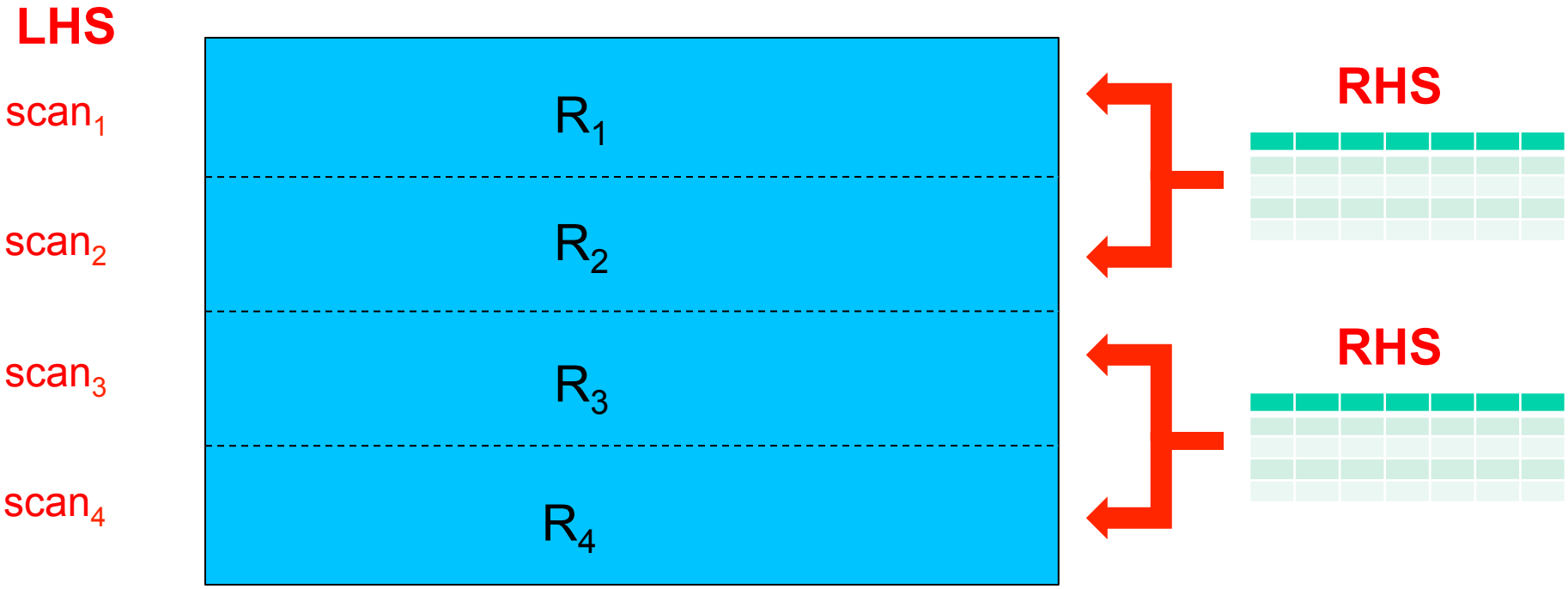
RHS

```
SELECT location
FROM host_info
WHERE location = ‘SF’
```

Phoenix Push Down: Hash Join
Execute & broadcast RHS to each RS



Phoenix Push Down: TopN
Server-side map lookup during scan



How does Phoenix help HBase scale?

How does Phoenix help HBase scale?

1. Phoenix allows multiple tables to share same physical HBase table
    - Updateable VIEW
    - Multi-tenant TABLE + tenant-specific VIEW
    - Support for secondary indexes on VIEWs

How does Phoenix help HBase scale?

2. HBase wants small # of big tables instead of large # of small tables
   - Each region for each column family of each table consumes resources

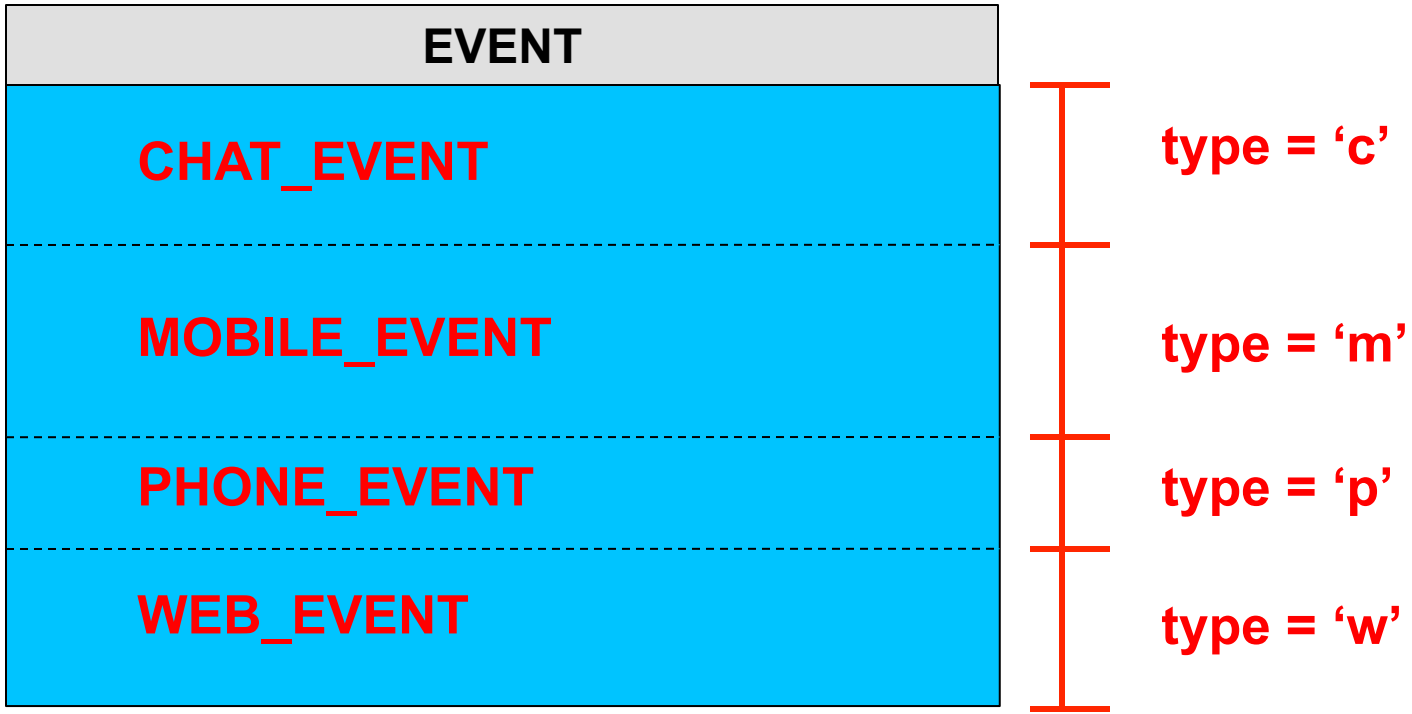
Phoenix Shared Tables: VIEW

```
CREATE TABLE event (
    type CHAR(1),
    event_id BIGINT,
    created_date DATE,
    created_by VARCHAR,
    CONSTRAINT pk PRIMARY KEY (type, event_id));
```

```
CREATE VIEW web_event (
    referrer VARCHAR) AS
SELECT * FROM event
WHERE type='w';
```

- Includes columns from TABLE
- Cannot define PK
- Updateable if only equality expressions separated by AND

Phoenix Shared Tables: VIEW
Same physical HBase table



Phoenix Shared Table: MULTI_TENANT

```
CREATE TABLE event (
    tenant_id VARCHAR,
    type CHAR(1),
    event_id BIGINT,
    created_date DATE,
    created_by VARCHAR,
    CONSTRAINT pk PRIMARY KEY (tenant_id, type, event_id))
   MULTI_TENANT=true;
```

First PK column identifies tenant ID

Phoenix Shared Table: MULTI_TENANT

```
CREATE VIEW web_event (
      referrer VARCHAR) AS
SELECT * FROM event
WHERE type='w';
```

Tenant-specific connection

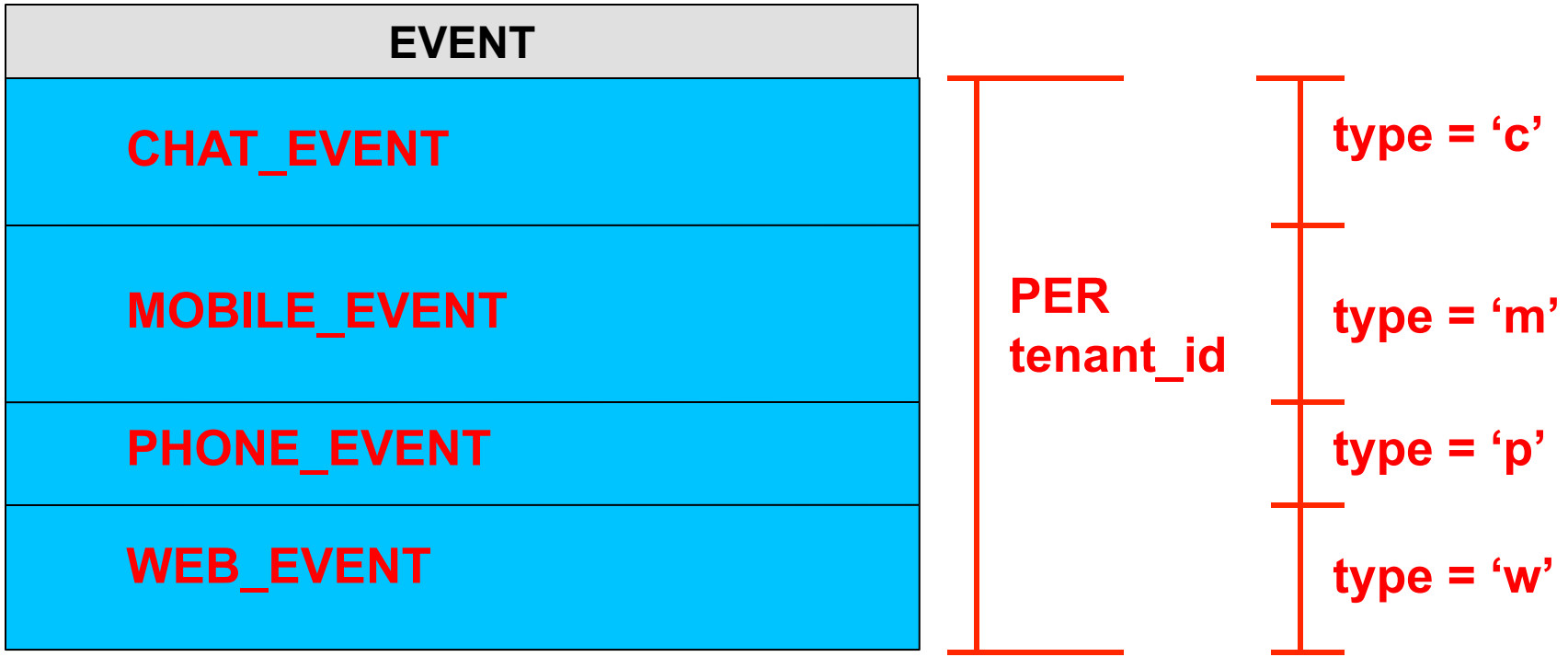
```
DriverManager.connect("jdbc:phoenix:localhost;tenantId=me");
```

```
CREATE VIEW my_web_event AS
SELECT * FROM web_event;
```

Tenant-specific view

Phoenix Shared Tables: MULTI_TENANT
Same physical HBase table

Phoenix Shared Tables: MULTI_TENANT Same physical HBase table



Phoenix Shared Tables: MULTI_TENANT

- Tenant-specific connection may only see and operate on *their* data
  - MetaData APIs honor this
  - Phoenix automatically manages scan ranges
- Primary key constraint of base table may not be changed
  - Indexes in separate shared table may be added to a VIEW
- DDL operations restricted
  - No ALTER of base table
  - No DROP of columns referenced in WHERE clause

Phoenix Roadmap

- ~~Derived/nested tables~~ (in 3.1/4.1)
- ~~Local Indexes~~ (in 4.1)
- Transactions
- More Join strategies
- Correlated sub-queries
- Cost-based query optimizer
- OLAP extensions

Thank you!
Questions/comments?