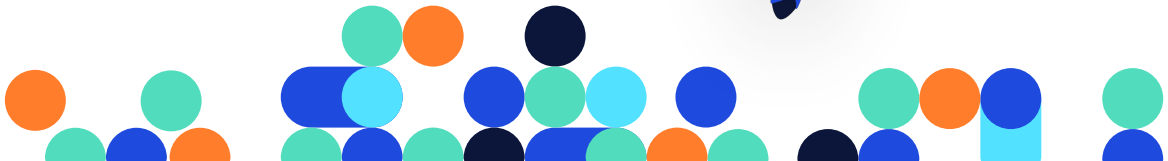
DataStax Developer Day

DATASTAX

Cassandra Data Modeling



Cassandra Data Modeling

DATASTAX

SQL (relational) vs. CQL (Cassandra)

Structuring Your Database

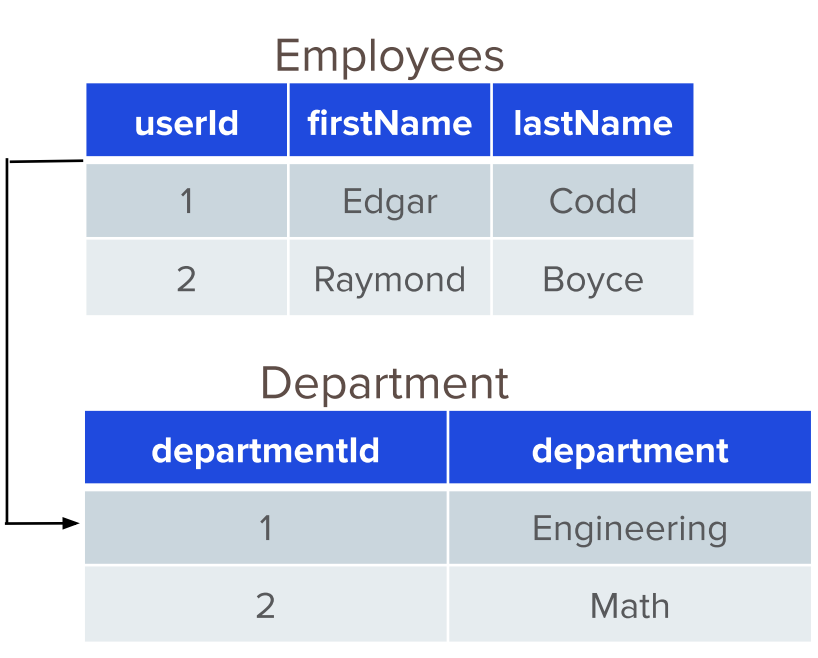
- Normalization: To reduce data redundancy and increase data integrity.
- Denormalization: Must be done in read heavy workloads to increase performance

Normalization

- Structuring a relational database
- Normal forms (3NF max)
- Why?
  - Reduce data redundancy
  - Increase data integrity.

Relational Data Models

- Multiple normal forms
  - most do not go beyond 3NF
- Foreign Keys
- Joins

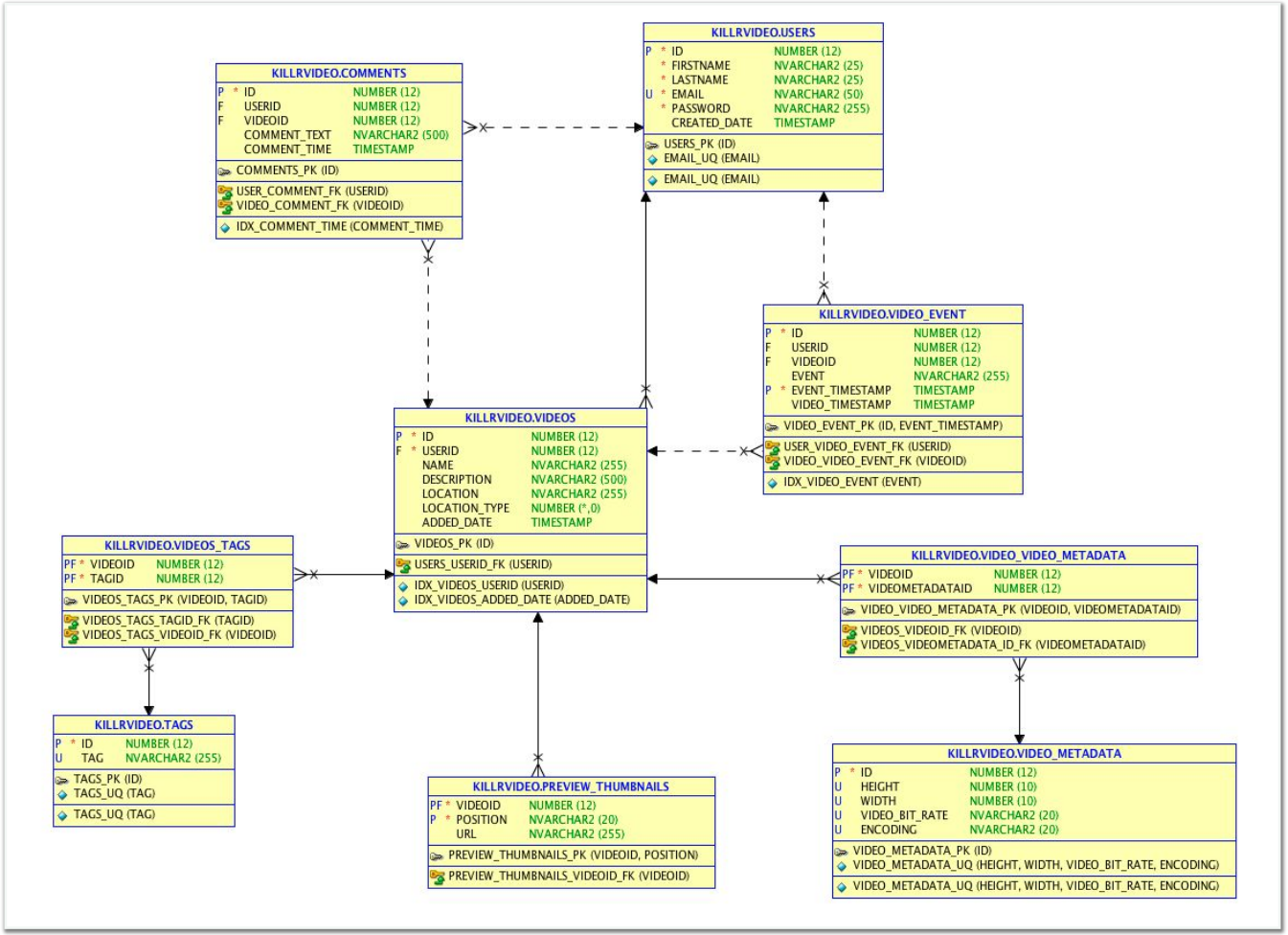


Relational Modeling

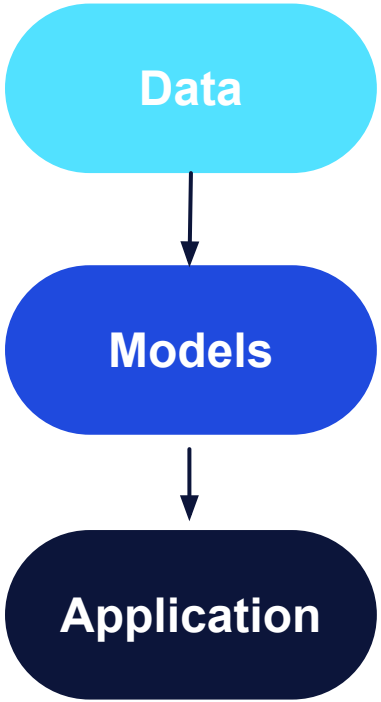
- Create entity table
- Add constraints
- Index fields
- Foreign Key relationships

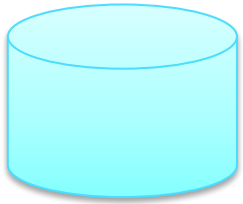
```
CREATE TABLE users (
  id          number(12) NOT NULL ,
  firstname    nvarchar2(25) NOT NULL ,
  lastname     nvarchar2(25) NOT NULL,
  email       nvarchar2(50) NOT NULL,
  password     nvarchar2(255) NOT NULL,
  created_date timestamp(6),
  PRIMARY KEY (id),
  CONSTRAINT email_uq UNIQUE (email)
);

-- Users by email address index
CREATE INDEX idx_users_email ON users (email);
```

```
CREATE TABLE videos (
  id number(12),
  userid number(12) NOT NULL,
  name nvarchar2(255),
  description nvarchar2(500),
  location nvarchar2(255),
  location_type int,
  added_date timestamp,
  CONSTRAINT users_userid_fk
    FOREIGN KEY (userid)
    REFERENCES users (Id) ON DELETE CASCADE,
  PRIMARY KEY (id)
);
```


KILLRVIDEO.USERS
P * ID NUMBER (12)
* FIRSTNAME NVARCHAR2 (25)
* LASTNAME NVARCHAR2 (25)
U * EMAIL NVARCHAR2 (50)
* PASSWORD NVARCHAR2 (255)
CREATED_DATE TIMESTAMP
USERS_PK (ID)
EMAIL_UQ (EMAIL)
EMAIL_UQ (EMAIL)
KILLRVIDEO.COMMENTS
P * ID NUMBER (12)
F USERID NUMBER (12)
F VIDEOID NUMBER (12)
COMMENT_TEXT NVARCHAR2 (500)
COMMENT_TIME TIMESTAMP
COMMENTS_PK (ID)
USER_COMMENT_FK (USERID)
VIDEO_COMMENT_FK (VIDEOID)
IDX_COMMENT_TIME (COMMENT_TIME)
KILLRVIDEO.VIDEO_EVENT
P * ID NUMBER (12)
F USERID NUMBER (12)
F VIDEOID NUMBER (12)
EVENT NVARCHAR2 (255)
P * EVENT_TIMESTAMP TIMESTAMP
VIDEO_TIMESTAMP TIMESTAMP
VIDEO_EVENT_PK (ID, EVENT_TIMESTAMP)
USER_VIDEO_EVENT_FK (USERID)
VIDEO_VIDEO_EVENT_FK (VIDEOID)
IDX_VIDEO_EVENT (EVENT)
KILLRVIDEO.VIDEOS
P * ID NUMBER (12)
F * USERID NUMBER (12)
NAME NVARCHAR2 (255)
DESCRIPTION NVARCHAR2 (500)
LOCATION NVARCHAR2 (255)
LOCATION_TYPE NUMBER (*,0)
ADDED_DATE TIMESTAMP
VIDEOS_PK (ID)
USERS_USERID_FK (USERID)
IDX_VIDEOS_USERID (USERID)
IDX_VIDEOS_ADDED_DATE (ADDED_DATE)
KILLRVIDEO.VIDEOS_TAGS
PF * VIDEOID NUMBER (12)
PF * TAGID NUMBER (12)
VIDEOS_TAGS_PK (VIDEOID, TAGID)
VIDEOS_TAGS_TAGID_FK (TAGID)
VIDEOS_TAGS_VIDEOID_FK (VIDEOID)
KILLRVIDEO.VIDEO_VIDEO_METADATA
PF * VIDEOID NUMBER (12)
PF * VIDEOMETADATAID NUMBER (12)
VIDEO_VIDEO_METADATA_PK (VIDEOID, VIDEOMETADATAID)
VIDEOS_VIDEOID_FK (VIDEOID)
VIDEOS_VIDEOMETADATA_ID_FK (VIDEOMETADATAID)
KILLRVIDEO.TAGS
P * ID NUMBER (12)
U TAG NVARCHAR2 (255)
TAGS_PK (ID)
TAGS_UQ (TAG)
TAGS_UQ (TAG)
KILLRVIDEO.PREVIEW_THUMBNAILS
PF * VIDEOID NUMBER (12)
P * POSITION NVARCHAR2 (20)
URL NVARCHAR2 (255)
PREVIEW_THUMBNAILS_PK (VIDEOID, POSITION)
PREVIEW_THUMBNAILS_VIDEOID_FK (VIDEOID)
KILLRVIDEO.VIDEO_METADATA
P * ID NUMBER (12)
U HEIGHT NUMBER (10)
U WIDTH NUMBER (10)
U VIDEO_BIT_RATE NVARCHAR2 (20)
U ENCODING NVARCHAR2 (20)
VIDEO_METADATA_PK (ID)
VIDEO_METADATA_UQ (HEIGHT, WIDTH, VIDEO_BIT_RATE, ENCODING)
VIDEO_METADATA_UQ (HEIGHT, WIDTH, VIDEO_BIT_RATE, ENCODING)

Relational Modeling





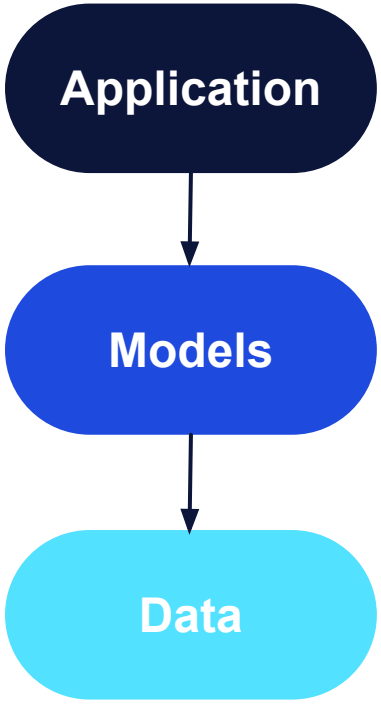
Employees

userId	firstName	lastName
1	Edgar	Codd
2	Raymond	Boyce

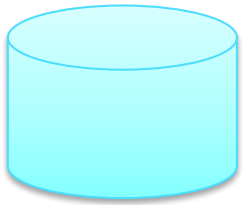
Department

departmentId	department
1	Engineering
2	Math

Cassandra Modeling



id	firstName	lastName	department
1	Edgar	Codd	Engineering
2	Raymond	Boyce	Math



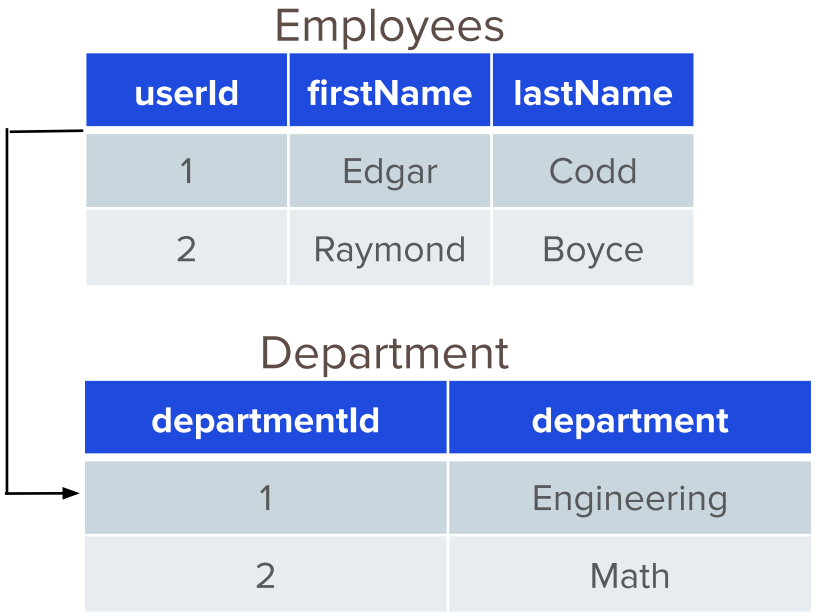
Denormalization - Why?

- Improve read performance of a database
- Reduce write performance
  - Adding redundant copies of data

CQL vs SQL

- No joins
- Limited aggregations

```
SELECT e.First, e.Last, d.Dept
FROM Department d, Employees e
WHERE ‘Codd’ = e.Last
AND e.deptId = d.id
```



Applying Denormalization

- Combine table columns into a single view
- Eliminate the need for joins
- Queries are concise and easy to understand

Employees

id	firstName	lastName	department
1	Edgar	Codd	Engineering
2	Raymond	Boyce	Math

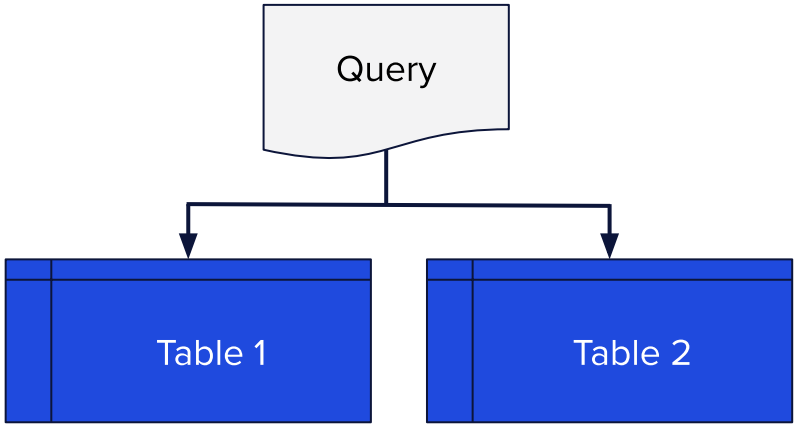
```
SELECT First, Last, Dept
FROM employees
WHERE id = ‘1’
```

Denormalization in Apache Cassandra

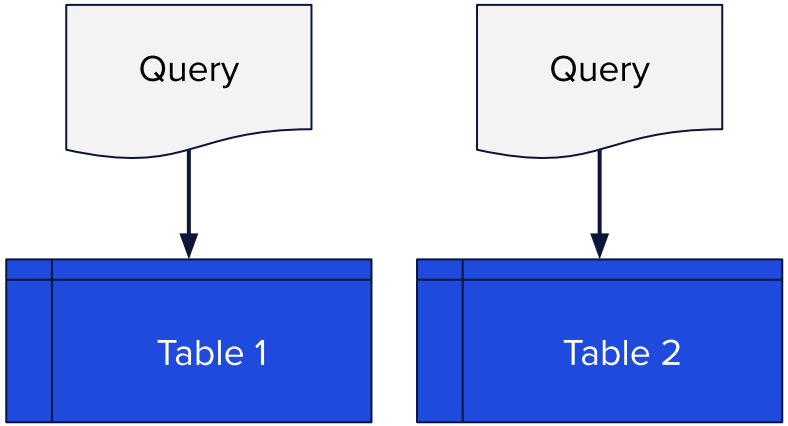
- Denormalization of tables in Apache Cassandra is absolutely critical.
- The biggest take away is to think about your queries first.
- There are no JOINS in Apache Cassandra.

Queries in Relational vs NoSQL Databases

- In a relational database, one query can access and join data from multiple tables



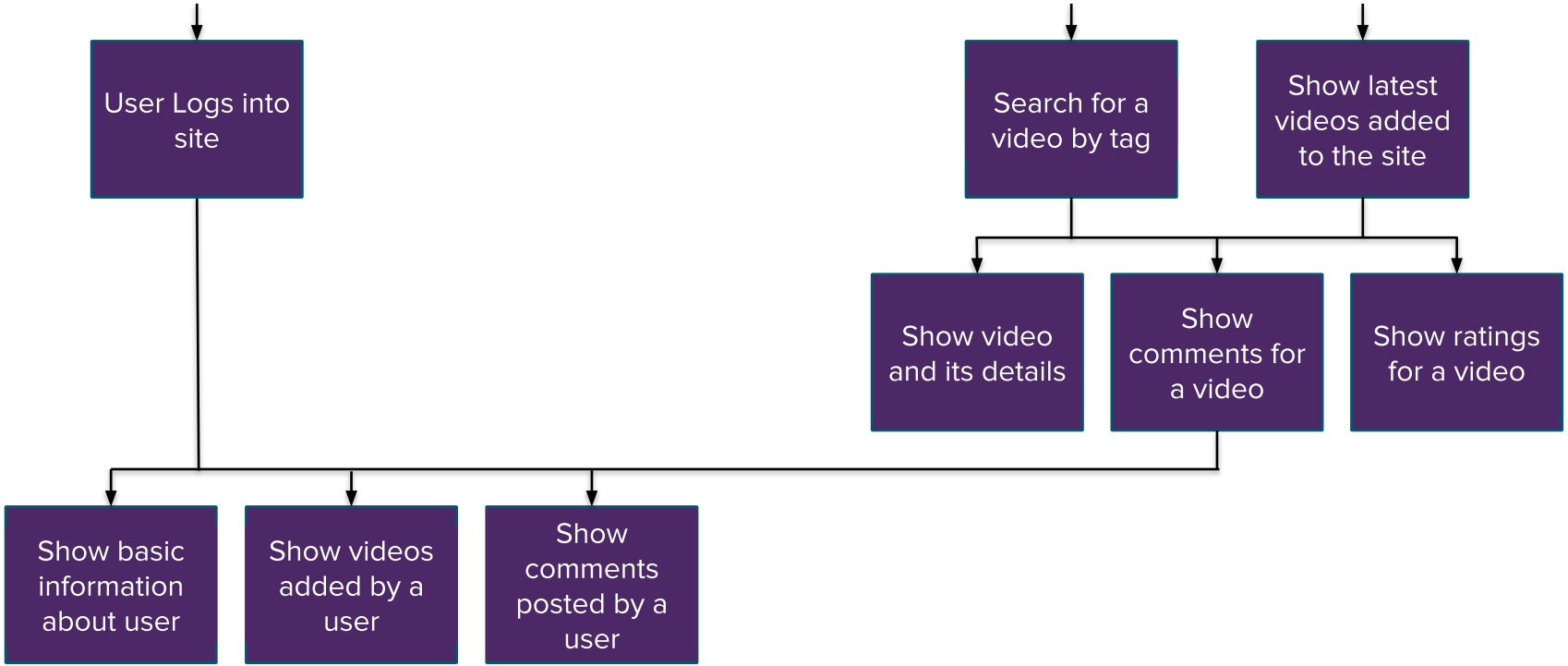
- In Apache Cassandra, you cannot join data, queries can only access data from one table



Modeling Queries

- What are your application's workflows?
- Knowing your queries in advance is CRITICAL
- Different from RDBMS because I can't just JOIN or create a new indexes to support new queries
- One table per one query

Some Application Workflows in KillrVideo



Some Queries in KillrVideo to Support Workflows

Users

User Logs into site

Find user by email address

Show basic information about user

Find user by id

Comments

Show comments for a video

Find comments by video (latest first)

Show comments posted by a user

Find comments by user (latest first)

Ratings

Show ratings for a video

Find ratings by video

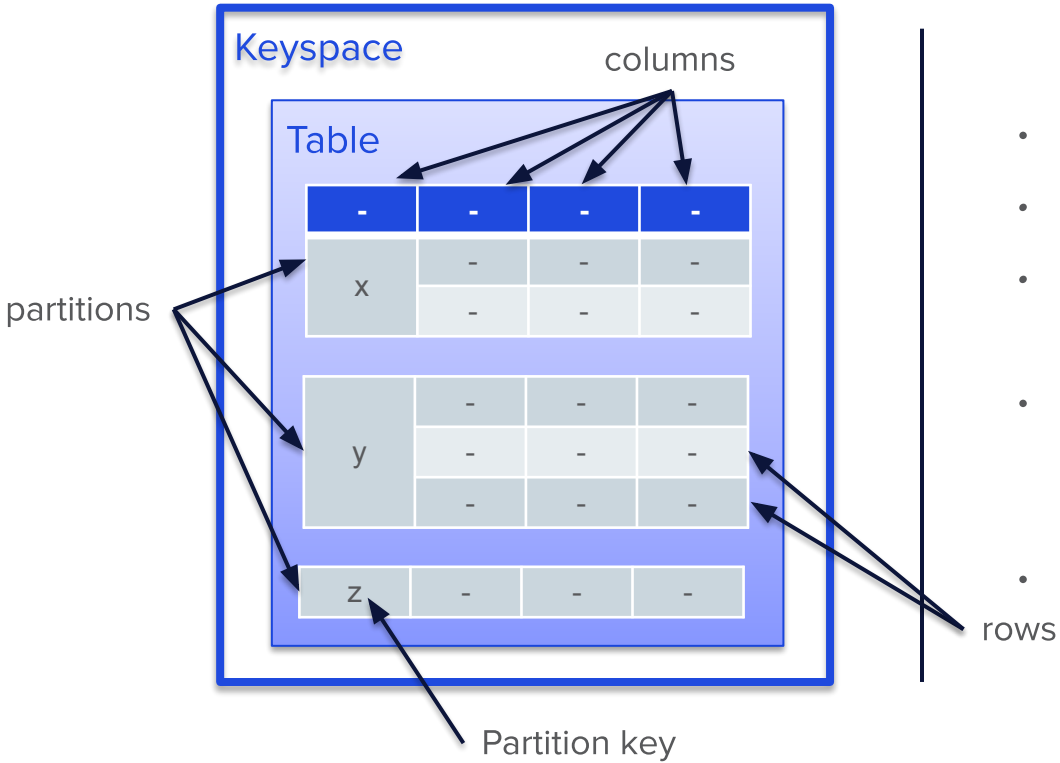
Cassandra Data Modeling

Denormalization Mind Shift

Cassandra Data Modeling Principles

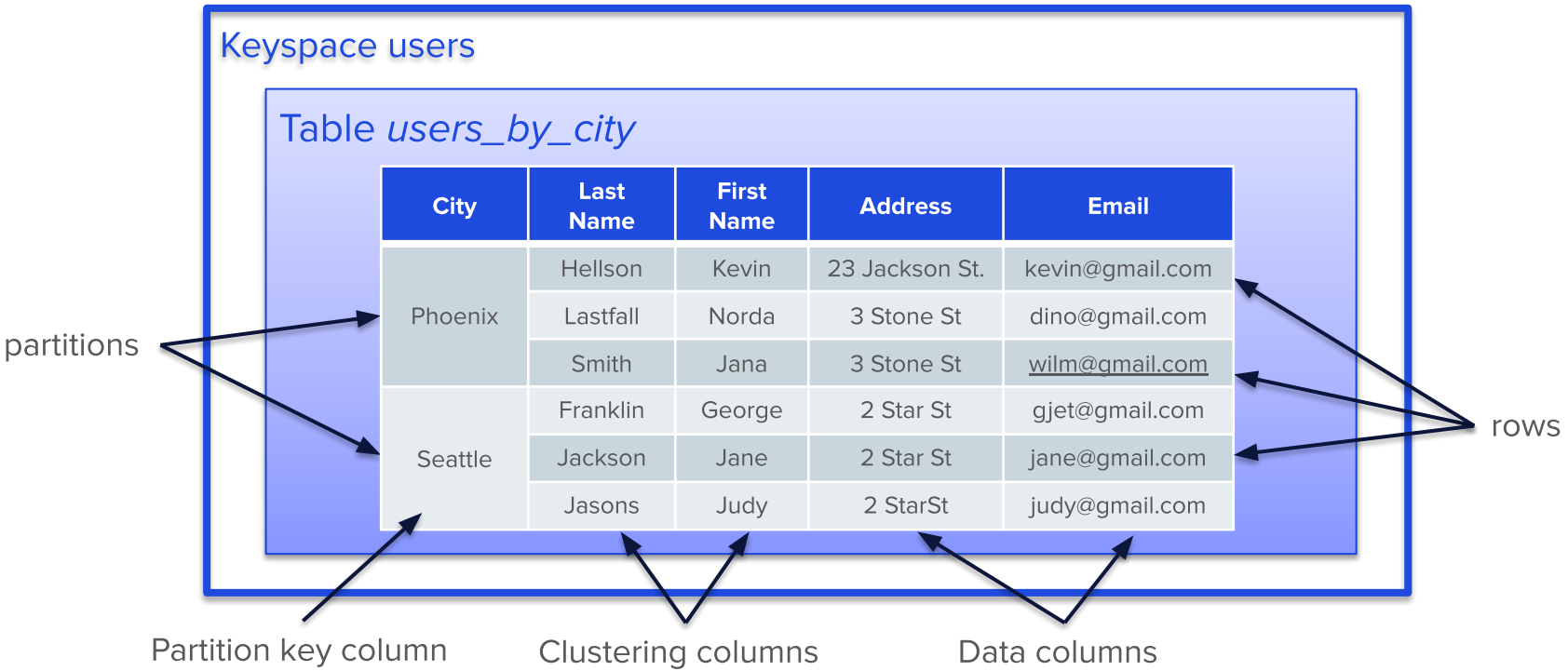
- Design tables around queries
- Use partition key column(s) to group data you would like to be able to get in a single query
- Use clustering columns to guarantee unique rows and control sort order
- Use additional columns to provide the details you need
  - Denormalization - including data that might have been joined from elsewhere in a relational model

Cassandra Structure - Partition



- Tabular data model, with one twist
- *Keyspaces* contain *tables*
- *Tables* are organized in *rows* and *columns*
- Groups of related rows called *partitions* are stored together on the same node (or nodes)
- Each row contains a *partition key*
  - One or more columns that are hashed to determine which node(s) store that data

Example Data – Users organized by city



City	Last Name	First Name	Address	Email
Phoenix	Hellson	Kevin	23 Jackson St.	kevin@gmail.com
	Lastfall	Norda	3 Stone St	dino@gmail.com
	Smith	Jana	3 Stone St	wilm@gmail.com
Seattle	Franklin	George	2 Star St	gjet@gmail.com
	Jackson	Jane	2 Star St	jane@gmail.com
	Jasons	Judy	2 StarSt	judy@gmail.com

Tables Hold Many Partitions

City	Last Name	First Name	Address	Email
Phoenix	Hellson	Kevin	23 Jackson St.	kevin@gmail.com
	Lastfall	Norda	3 Stone St	dino@gmail.com
	Smith	Jana	3 Stone St	wilm@gmail.com

Table *users_by_city*

Tables Hold Many Partitions

City	Last Name	First Name	Address	Email
Seattle	Franklin	George	2 Star St	gjet@gmail.com
	Jackson	Jane	2 Star St	jane@gmail.com
	Jasons	Judy	2 StarSt	judy@gmail.com

Table *users_by_city*

City	Last Name	First Name	Address	Email
Phoenix	----	----	----	----
	----	----	----	----
	----	----	----	----

Tables Hold Many Partitions

City	Last Name	First Name	Address	Email
Charlotte	Azrael	Chris	5 Blue St	chris@gmail.com
	Stilson	Brainy	7 Azure ln	brain@gmail.com
	Smith	Cristina	4 Teal Cir	clu@gmail.com
	Sage	Grant	9 Royal St	grant@gmail.com
	Seterson	Peter	2 Navy Ct	peter@gmail.com

Table *users_by_city*

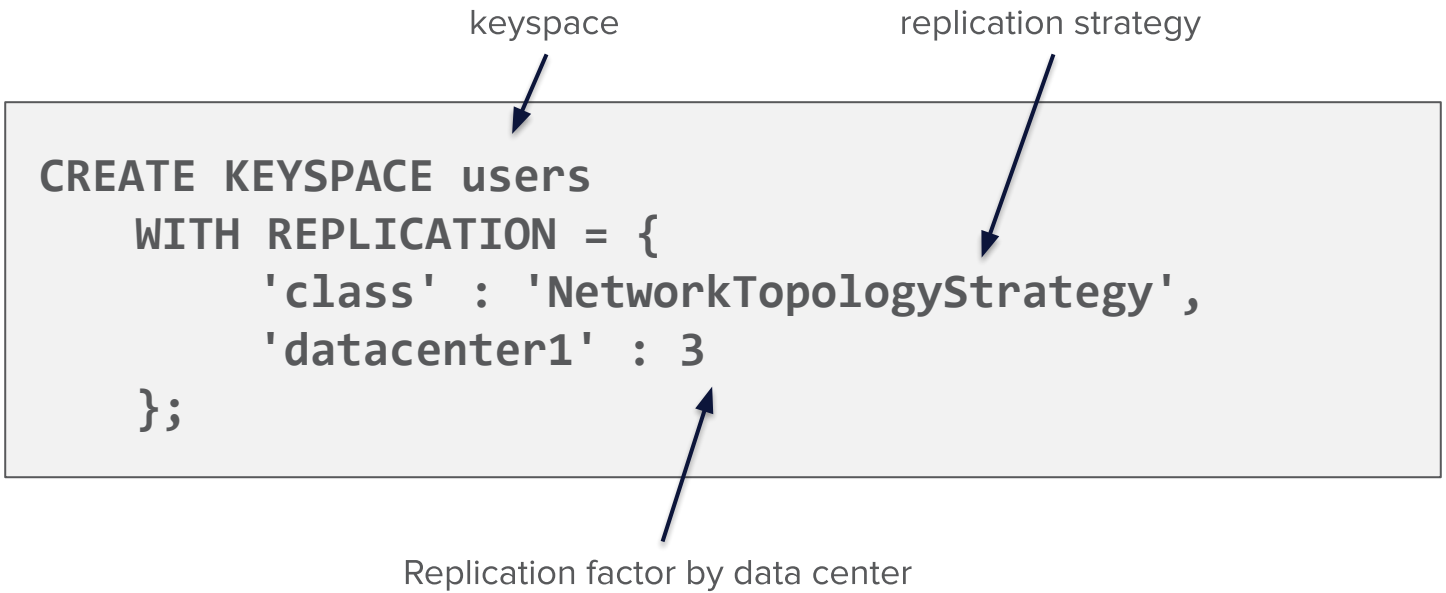
City	Last Name	First Name	Address	Email
Phoenix	----	----	----	----
	----	----	----	----
	----	----	----	----
Seattle	----	----	----	----
	----	----	----	----
	----	----	----	----

Tables Hold Many Partitions

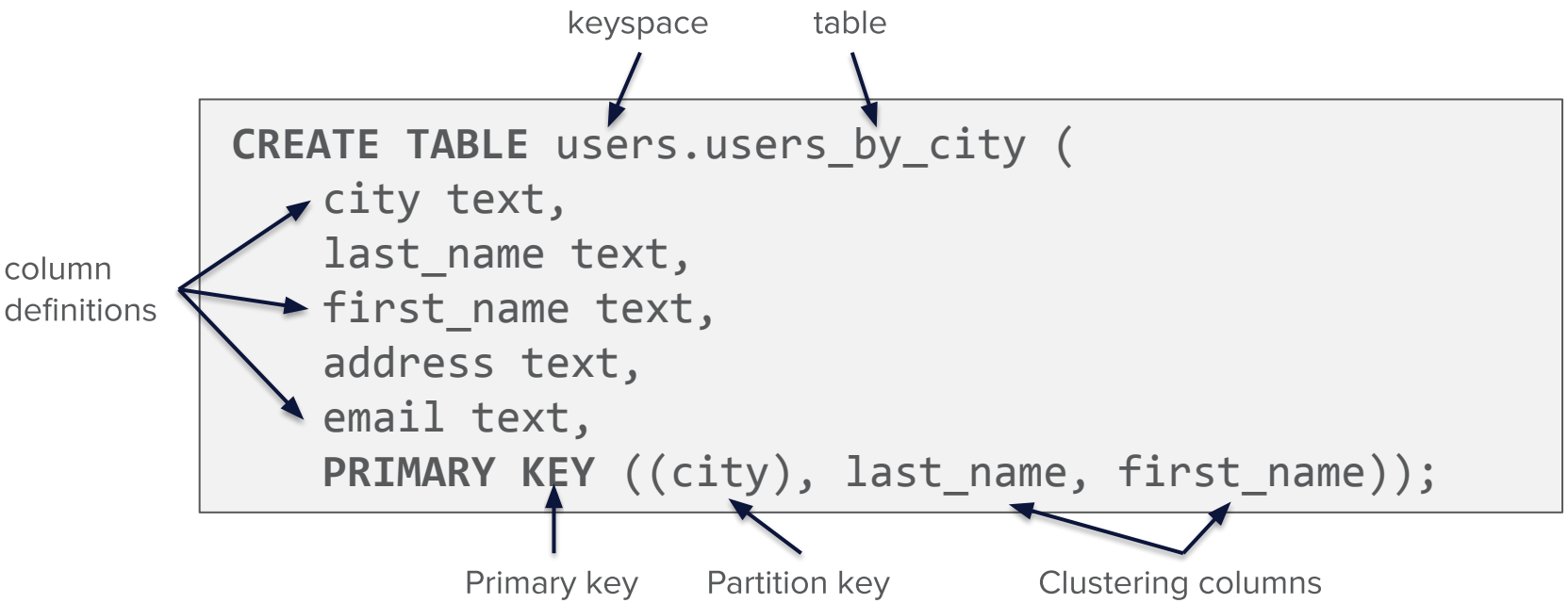
Table *users_by_city*

City	Last Name	First Name	Address	Email
Phoenix	----	----	----	----
	----	----	----	----
	----	----	----	----
Seattle	----	----	----	----
	----	----	----	----
	----	----	----	----
Charlotte	----	----	----	----
	----	----	----	----
	----	----	----	----

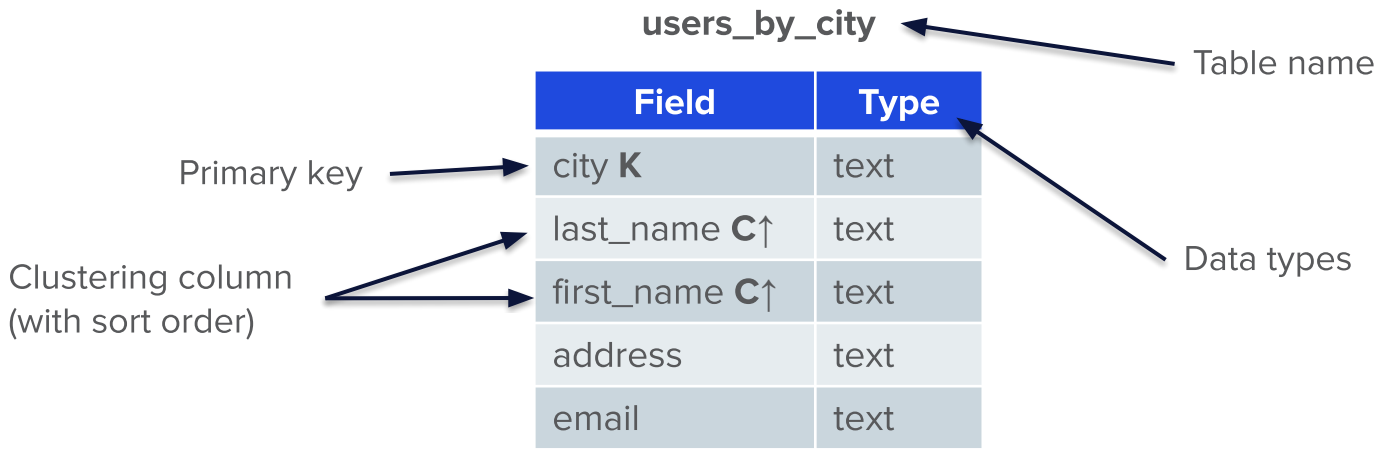
Creating a Keyspace in CQL



Creating a Table in CQL



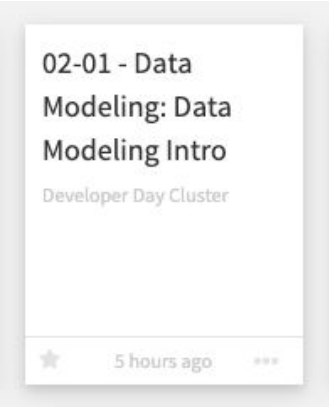
Cassandra Table Design Notation - Chebotko Diagram



Time for an exercise!

DATASTAX

“Data Modeling Intro” Notebook



Data Modeling – Key Concepts

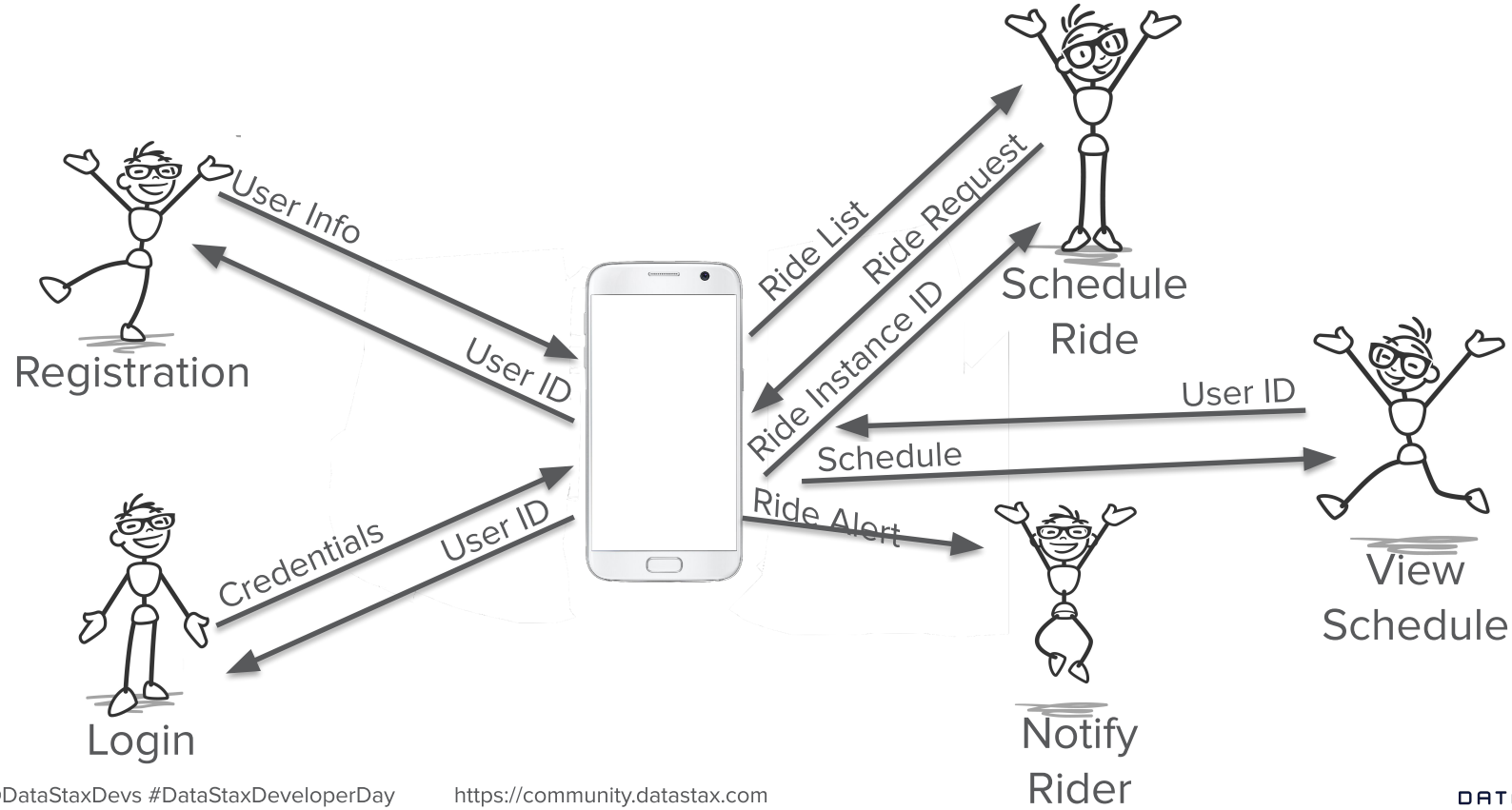
- Keyspace – contains tables
- Table – contains partitions
- Row – has a primary key and data columns
- Partition – basic unit of storage/retrieval
  - Identified by partition key embedded within primary key
  - Contains one or more rows
- Primary key – intra-table row identifier
  - Consists of partition key and clustering columns
  - Partition key – partition identifier, hashes to partition token
  - Clustering column – intra-partition key for sorting rows within partition

Welcome to Cassandra-Land

The Theme Park Where You Can Find...

- Distributed & Fault-Tolerant Rides
- Amazing Throughput
- And Fast Response Times

Cassandra-Land Use Cases



Cassandra-Land Use Cases

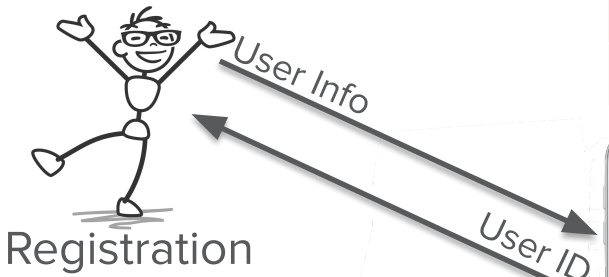
- Creating a Keyspace

```
CREATE KEYSPACE <keyspace name> WITH REPLICATION = {
     'class' : <replication strategy>,
    <datacenter name> : <replication factor>, ... };
```

- For example

```
CREATE KEYSPACE park WITH REPLICATION = {
     'class' : NetworkTopologyStrategy,
    'USWestDC': 3, 'USEastDC’: 3 };
```

Cassandra-Land Registration Use Case



User Info

Field	Type
Phone number	text
Password	text

User ID

Field	Type
User ID	UUID

users_by_phone_number

Field	Type
phone_number **K**	text
user_id	UUID
password	text

Cassandra-Land Registration Use Case

- Creating a table

```
CREATE TABLE <keyspace name>.<table name> (
    <field name> <field type>,
    // Add additional field descriptions here
    PRIMARY KEY ( <primary key descriptor> )
);
```

Cassandra-Land Registration Use Case

- Inserting a row into a table

```
INSERT INTO <keyspace name>.<table name>
    ( <column list> )
    VALUES ( <column values> );
```

Cassandra-Land Registration Use Case

- Selecting all rows from a table
  - Typically wouldn't do this in production

```
SELECT * FROM <keyspace name>.<table name>;
```

Cassandra's Upsert Behavior

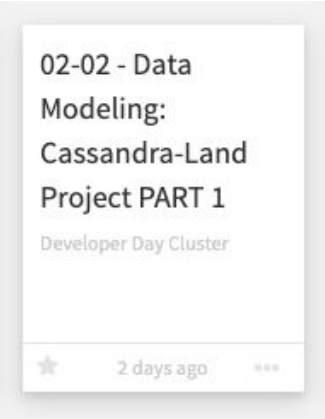
- Cassandra does NOT read before writing
- Inserting a row with the same primary key causes an update called an "upsert"
- Similarly, updates to non-existent rows cause an insert
  - Can use a lightweight transaction to prevent an upsert as it does perform a read before writing

```
INSERT INTO keyspace.table IF NOT EXISTS ...
```

Notebook Data Modeling

DATASTAX

Cassandra-Land Project

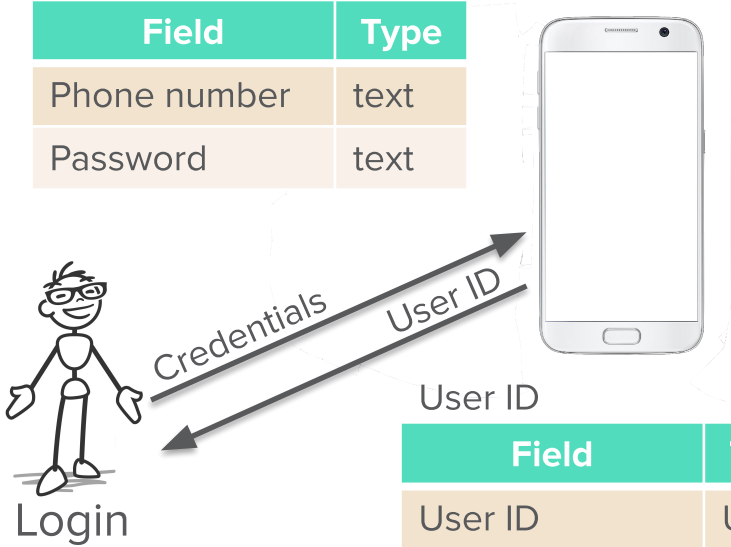


Part 1

Cassandra-Land Login Use Case

Credentials

Field	Type
Phone number	text
Password	text



User ID

Field	Type
User ID	UUID

users_by_phone_number

Field	Type
phone_number **K**	text
user_id	UUID
password	text

Cassandra-Land Login Use-Case

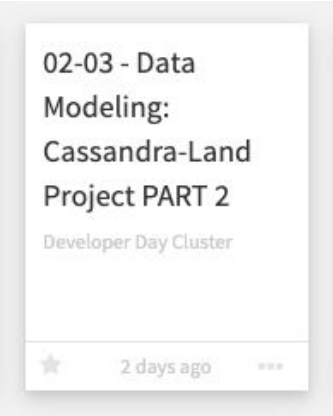
- Writing a SELECT statement
  - Must include full partition key
  - Partition keys do NOT support inequalities
  - Not all clustering columns need be specified, but…
  - Any preceding clustering columns MUST be specified

```
SELECT * FROM <keyspace name>.<table name>
    WHERE <query constraints>;
```

Notebook Data Modeling

DATASTAX

Cassandra-Land Project

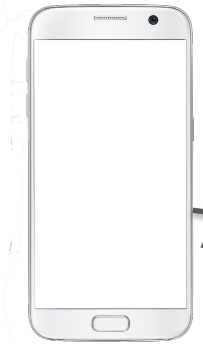


Part 2

Cassandra-Land Ride Alert Use-Case

ride_instances_by_start_time

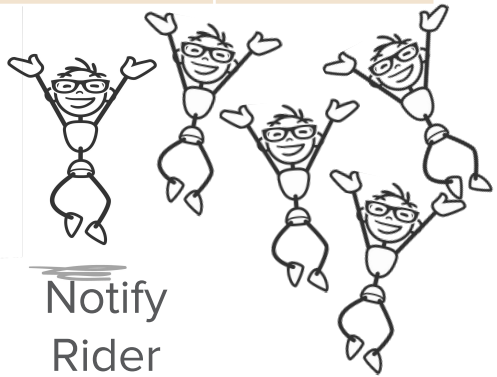
Field	Type
start_time **K**	timestamp
ride_id **C↑**	UUID
user_id **C↑**	UUID
ride_name	text
phone_number	text



Ride Alert

Ride Alert

Field	Type
phone_number	text
ride_name	text
start_time	timestamp



Notify
Rider

Cassandra-Land View Schedule Use-Case

ride_instances_by_user_id

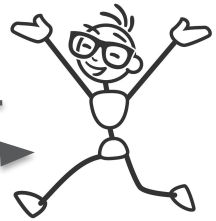
Field	Type
user_id **K**	UUID
start_time **C↑**	timestamp
ride_id	UUID
ride_name	text

User ID

Field	Type
User ID	UUID

User ID

Schedule



View Schedule

Schedule

Field	Type
start_time	timestamp
ride_name	text

Cassandra-Land Schedule Ride Use-Case

ride_list_by_location

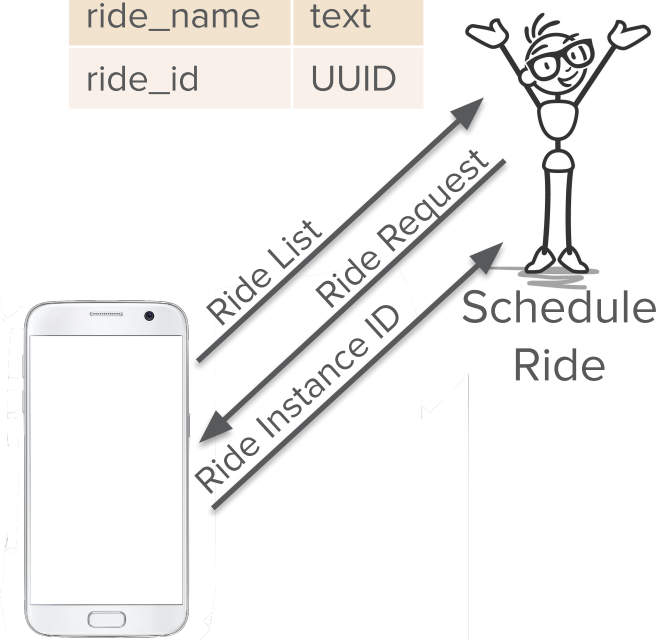
Field	Type
location **K**	text
ride_id **C↑**	UUID
ride_name	text
capacity	int

rider_count_by_time_and_ride

Field	Type
start_time **K**	timestamp
ride_id **K**	UUID
rider_count	int

Ride List

Field	Type
ride_name	text
ride_id	UUID



Ride Request

Field	Type
user_id	UUID
ride_id	UUID
start_time	timestamp

Ride Instance ID

Field	Type
ride_instance_id	UUID

Cassandra-Land Table Summary

users_by_phone_number

Field	Type
phone_number **K**	text
user_id	UUID
password	text

rider_count_by_time_and_ride

Field	Type
start_time **K**	timestamp
ride_id **K**	UUID
rider_count	int

ride_instances_by_start_time

Field	Type
start_time **K**	timestamp
ride_id **C↑**	UUID
user_id **C↑**	UUID
ride_name	text
phone_number	text

ride_list_by_location

Field	Type
location **K**	text
ride_id **C↑**	UUID
ride_name	text
capacity	int

ride_instances_by_user_id

Field	Type
user_id **K**	UUID
start_time **C↑**	timestamp
ride_id	UUID
ride_name	text

Primary Key - What you need to know

- Must have one or more partition key columns
- May have zero or more clustering columns

```
PRIMARY KEY(( <partition key column>,…), <clustering column>,...)
```

Timestamps

- Format:

```
‘YYYY-MM-DDTHH:MM:SS[.fff]’
```

- Notice the quotes
- Milliseconds are optional
- Examples:

```
‘2020-01-09T11:45:23’
‘2020-01-09T11:45:23.898’
```

Update Statement

- Can have multiple <assignment>
- IF is optional – causes a lightweight transaction

```
UPDATE <keyspace name>.<table name>
    SET <assignment>
    WHERE <row specification>
IF <condition>
```

Batch Statement

- What you need to know – BATCH

```
BEGIN BATCH
    INSERT statement
    INSERT statement
    ...
APPLY BATCH
```

- Once a statement succeeds, Cassandra will ensure all the others succeed
- Can use for inserting into multiple tables

Notebook Data Modeling

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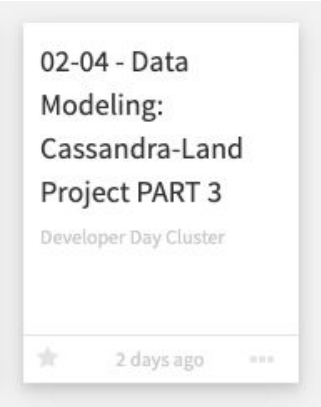
Cassandra-Land Project



Part 3

Cassandra-Land

- How to analyze use-cases to derive a data model
- How to denormalize to maintain performance
- How to use lightweight transactions
- How to leverage batch operations

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Thank You