dev up

Cosmos DB Performance Tuning

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ais APPLIED INFORMATION SCIENCES

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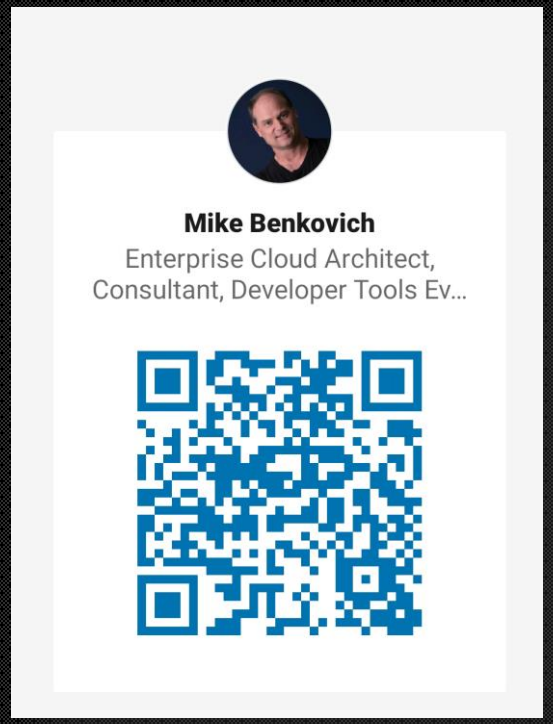


My Sessions … this week!

- Permit to Cloud – Land with Confidence in Azure
  - Tuesday 6/7 11:00 am – Discovery D
- Performance Tuning Strategies for Cosmos DB
  - Tuesday 6/7 4:00 pm – Imagination B
- Infrastructure as Code Bake-off ARM vs Bicep vs TF
  - Wednesday 6/8 4:00 pm – Discovery B

What we'll cover today

Why Cosmos
Provisioning Cosmos
Working with Data
Data Modeling Strategies
Performance and tuning

Cosmos DB Overview

A Simple **Global** Assigned NoSQL Database that can be replicated across regions with a click of a button

High **Scalability** and **Availability**

Guaranteed **low latency** and **provisioned** performance

Multi-**model** Multi-**API**

Configurable **Consistency** Options

Containers and Documents

- Database as collection of Documents in Containers
- Provisioned performance – RU's
- Stored as JSON Document
  - Document Explorer (portal)
  - Storage Explorer
- Supports multiple Record Types in Containers
- No referential rules or constraints
- No enforcement of data types


```
{
  "id": "a40d0078",
  "Title": "Add stuff to the Queue",
  "Description": null,
  “Type": “Chore",
  "Owner": null,
  "IsDone": false,
  "CreatedAt": "2019-09-05T11:40:12.4466765Z",
  "CompleteAt": null,
  "_rid": "vr0UAPQ9W4sDAAAAAAAAAA==",
  "_self": "dbs/vr0UAA==/colls/...",
  "_etag": "\"38001cae-0000-0300-0000-5d70...",
  "_attachments": "attachments/",
  "_ts": 1567683617
}
```

Some Terminology

RELATIONAL

- Database
- Table(s), View(s)
- Row
- Column
- Foreign Key
- Join
- Sharding Key

COSMOS DB (SQL API)

- Account/Database
- Container/Collection
- Item/Document (JSON)
- Property
- Reference
- Embedded Document
- Partition Key

What we'll cover today

Why Cosmos

Provisioning Cosmos

Code patterns & tools

Data Modeling Strategies

Performance and tuning

Provisioning Cosmos

Selecting the API : SQL, Mongo, Cassandra, Gremlin, Table

Capacity model : Provisioned vs Serverless

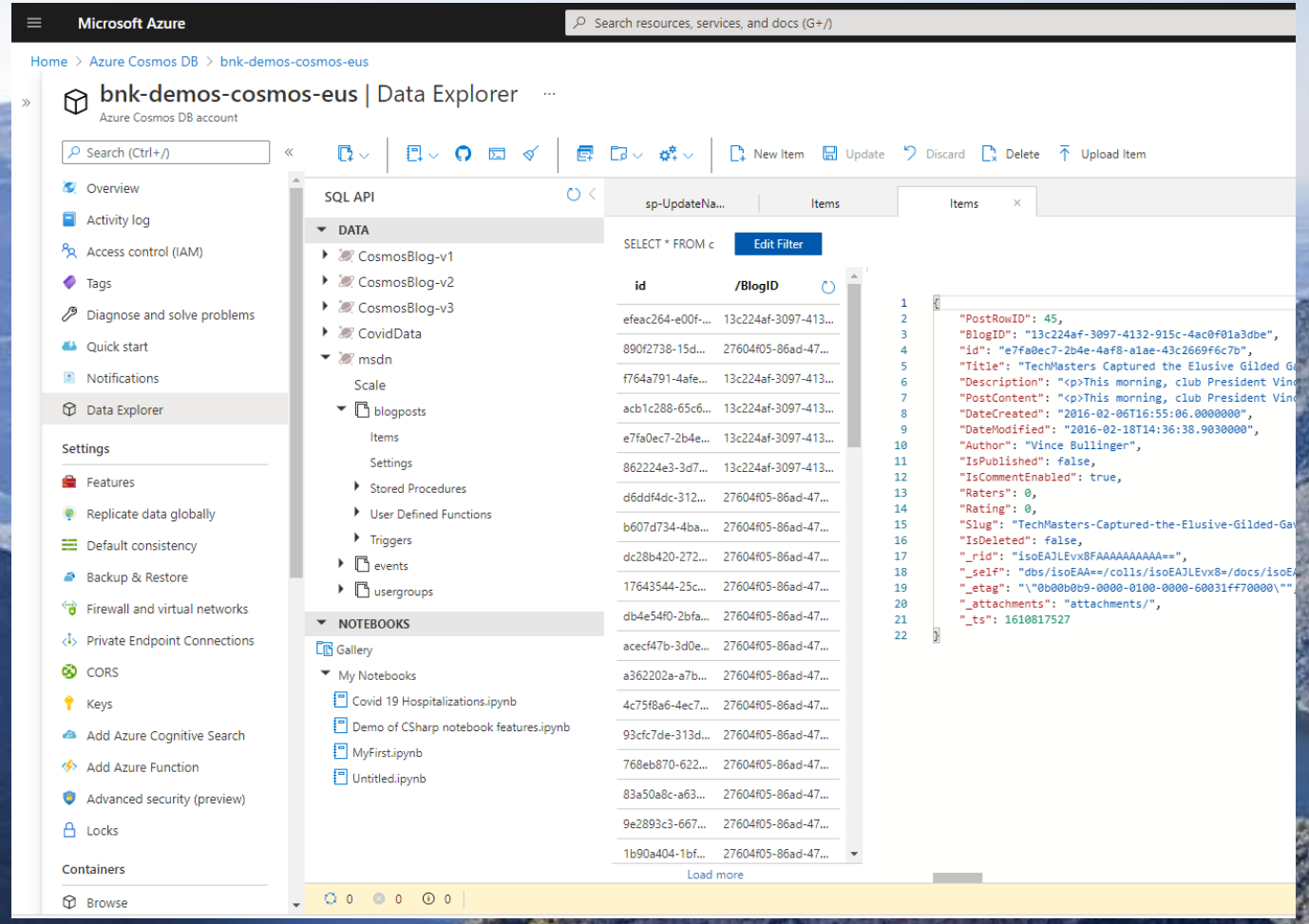
Geo-Redundancy and Multi-region Writes

Networking

Backup

Encryption

Get Started with Cosmos



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Performance and tuning

Tools to work with Cosmos Data

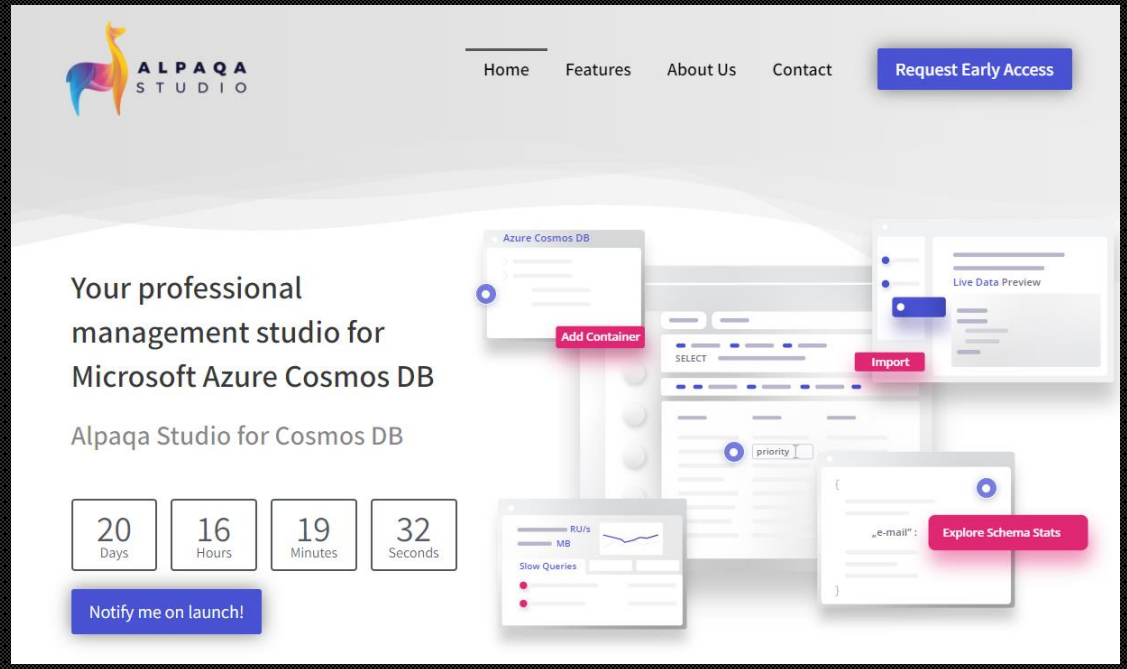
Azure Portal

- Data Explorer
- Jupyter Notebooks

Alpaqa Studio

- Editing Data (in place and bulk)
- Explore Schema
- Background task engine

SDK – Code



https://alpaqastudio.com

[Alpaqa Studio - The IDE for Cosmos DB](#) (preview)

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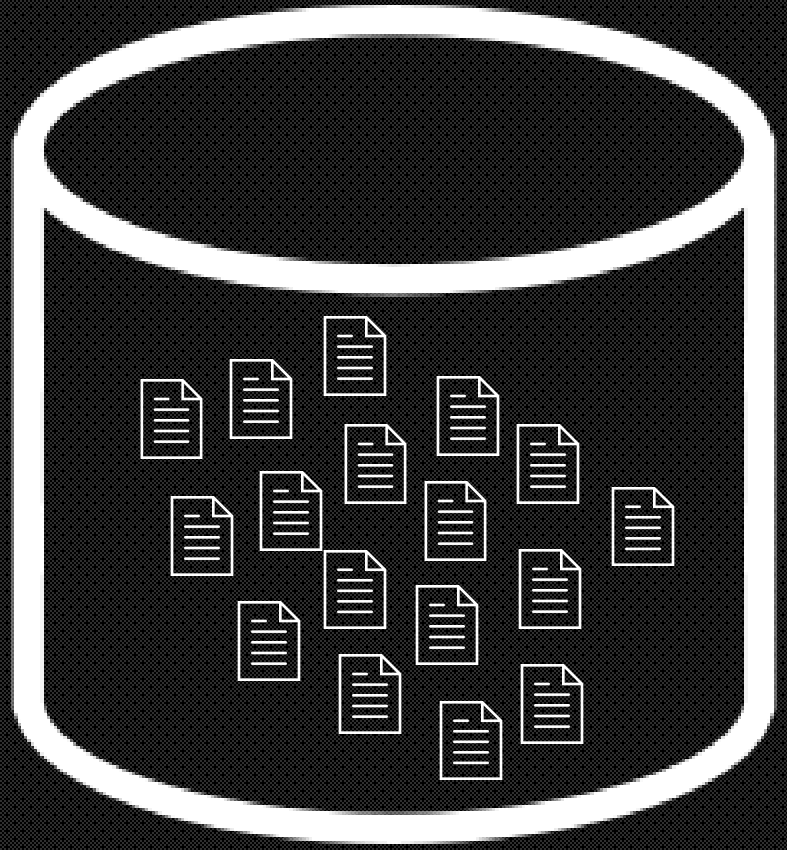
Provisioned Performance

- Expected performance has to be **provisioned**
- Expressed in **Request Units per second** (RU/s)
  - Represents the "cost" of a request in terms of CPU, memory and I/O
- Performance can be provisioned:
  - at the database-level
  - at the collection-level
- Provisioned performance **can be changed programmatically** with API calls

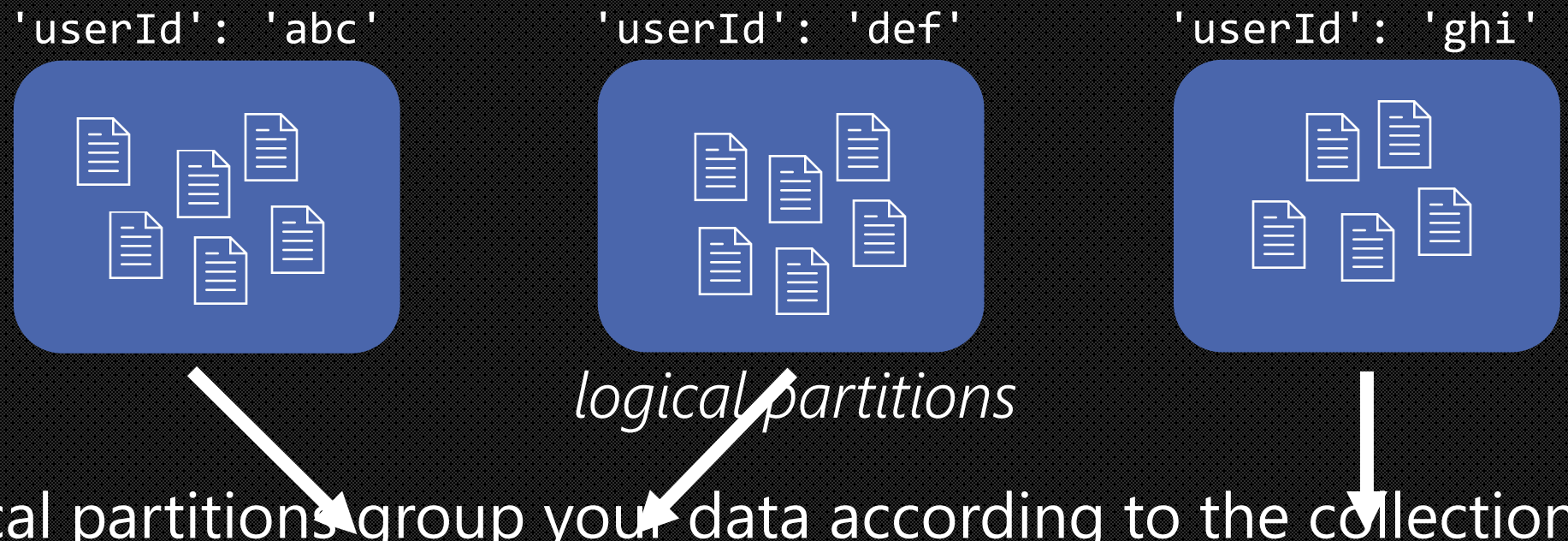
The rules of the game: partitioning

- Cosmos DB achieves horizontal scalability by **partitioning** your data



The rules of the game: partitioning

- Cosmos DB achieves horizontal scalability by **partitioning** your data



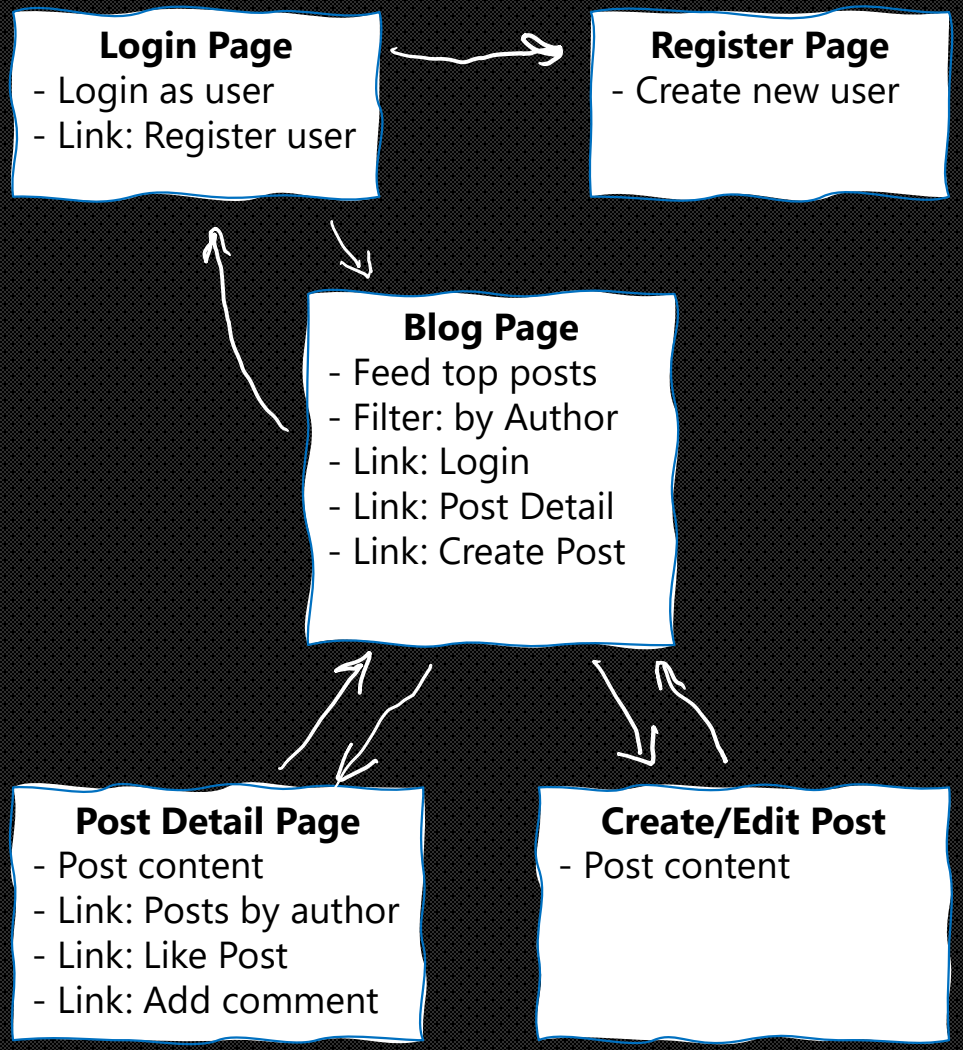
- Logical partitions group your data according to the collection's **partition key**

The rules of the game: partitioning

- A good partition key ensures **well-balanced partitions**
  - Both in terms of storage and in terms of throughput
- Ideally, read queries should get all their results from one partition


```
SELECT * FROM u WHERE u.userId = 'def'
```

Scenario: Rehost Blog in Cosmos



Users can create **posts**. Users can also **like** and add **comments** to posts.

A front page displays a feed of recently created posts. It is possible to list all posts for a particular user. It is also possible to list all comments of a post and all users who have liked a post.

A post is displayed with its author's username and a count of comments and likes. Comments and likes are also displayed with the username of their authors.

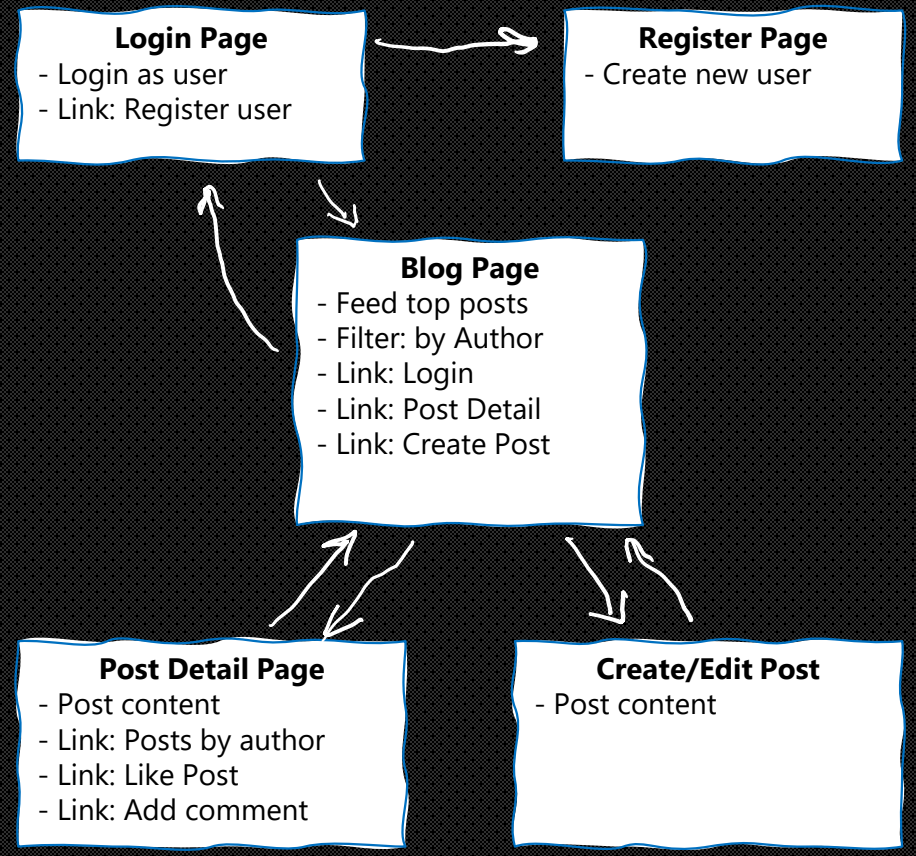
When displayed as lists, posts only present a truncated summary of their content.

Start by identifying the access patterns

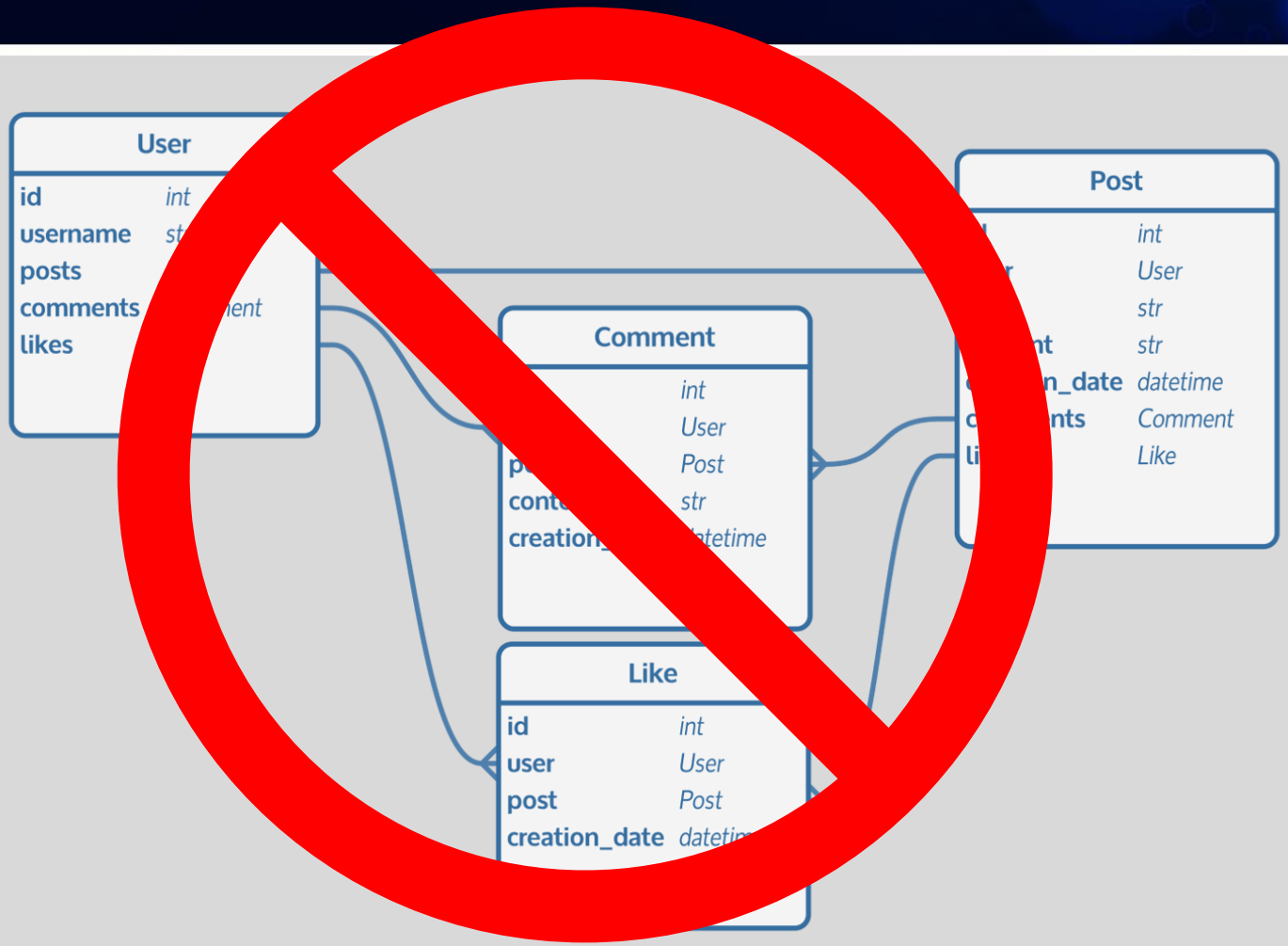
- What are the requests that our design will have to serve?
- To make it easier to follow, categorize them as:
  - **C**ommand (write request)
  - **Q**uery (read-only request)
- Think in terms of data navigation

Start by identifying the access patterns

- **[C1]** Create/edit a user's profile
- **[Q1]** Retrieve a user's profile
- **[C2]** Create/edit a post
- **[Q2]** Retrieve a post
- **[Q3]** List a user's posts in short form
- **[C3]** Create a comment
- **[Q4]** List a post's comments
- **[C4]** Like a post
- **[Q5]** List a post's likes
- **[Q6]** List the *x* most recent posts in short form (feed)



Maybe you instantly think about...

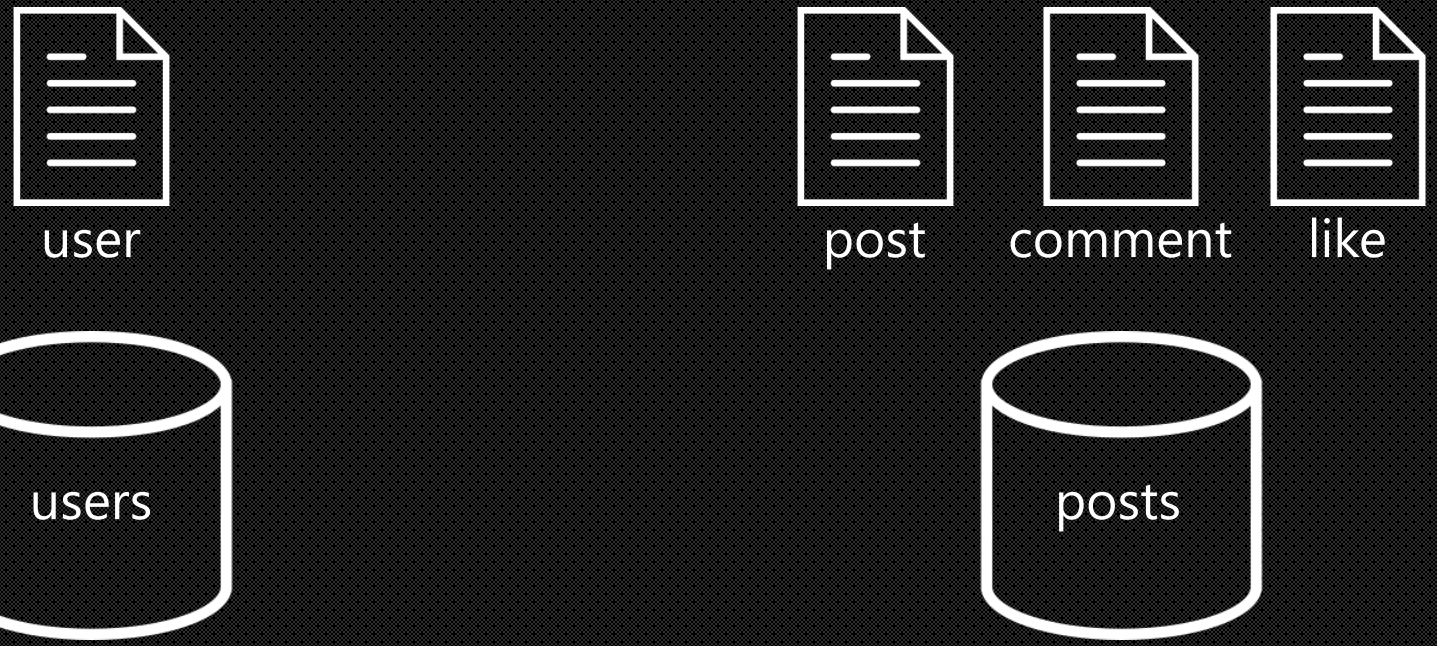


The rules of the game: data model

- In a Cos DB database, store **doc ts** in **ctions**
  - like rows ?

The rules of the game: data model

- In a Cosmos DB database, we store **documents** in **collections**



V1: a first shot

```
{
  "id": "<user-id>",
  "username": "<user-username>"
}
```

```
{
  "id": "<post-id>",
  "userId": "<post-author-id>",
  "title": "<post-title>",
  "content": "<post-content>",
  "creationDate": "<post-creation-date>"
}
```

```
{
  "id": "<comment-id>",
  "postId": "<post-id>",
  "userId": "<comment-author-id>",
  "content": "<comment-content>",
  "creationDate": "<comment-creation-date>"
}
```

```
{
  "id": "<like-id>",
  "postId": "<post-id>",
  "userId": "<liker-id>",
  "creationDate": "<like-creation-date>"
}
```

To embed or to reference?

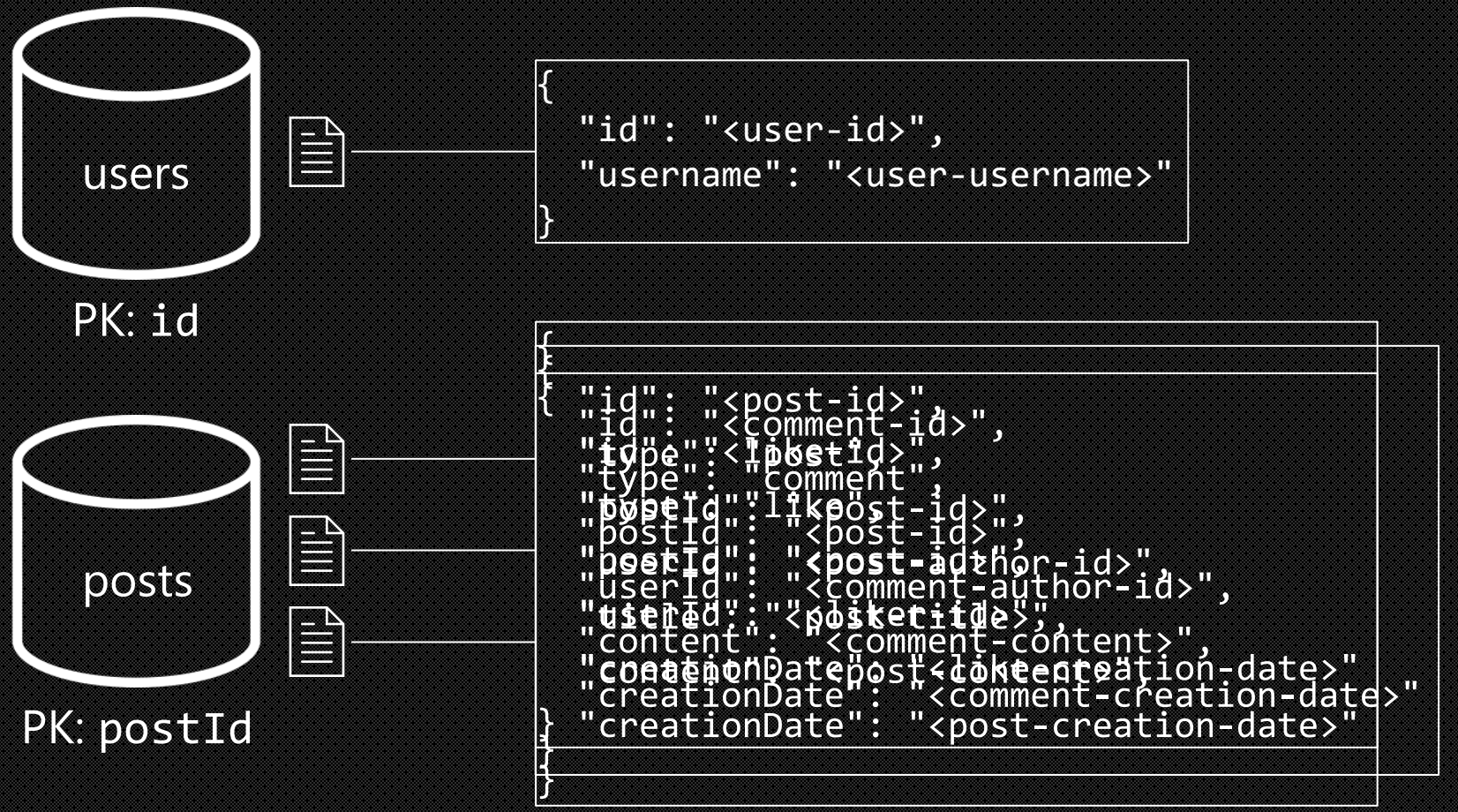
Embed when:

- 1:1
- 1:few
- Items queried together
- Items updated together

Reference when:

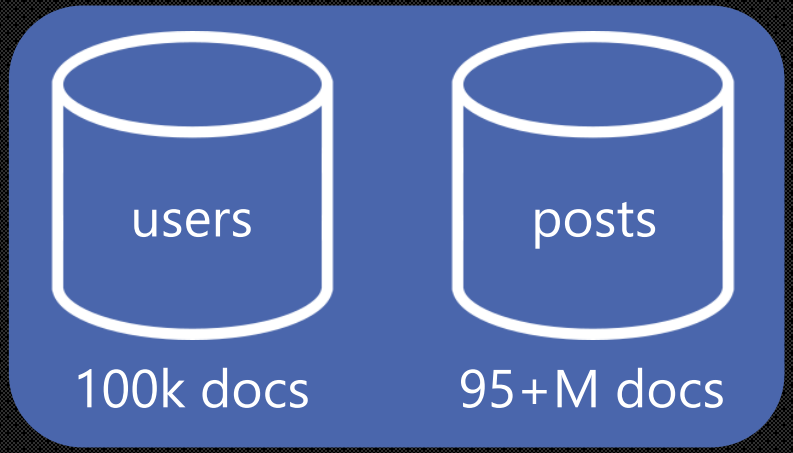
- 1:many (unbounded)
- Many:many
- Items updated independently

V1: a first shot



How well does our model perform?

- Benchmarked against a dummy dataset
  - 100,000 users
  - 5 – 50 posts / user
  - 0 – 25 comments / post
  - 0 – 100 likes / post



100 GB

Create/edit a user's profile

C1

Q1

C2

Q2

Q3

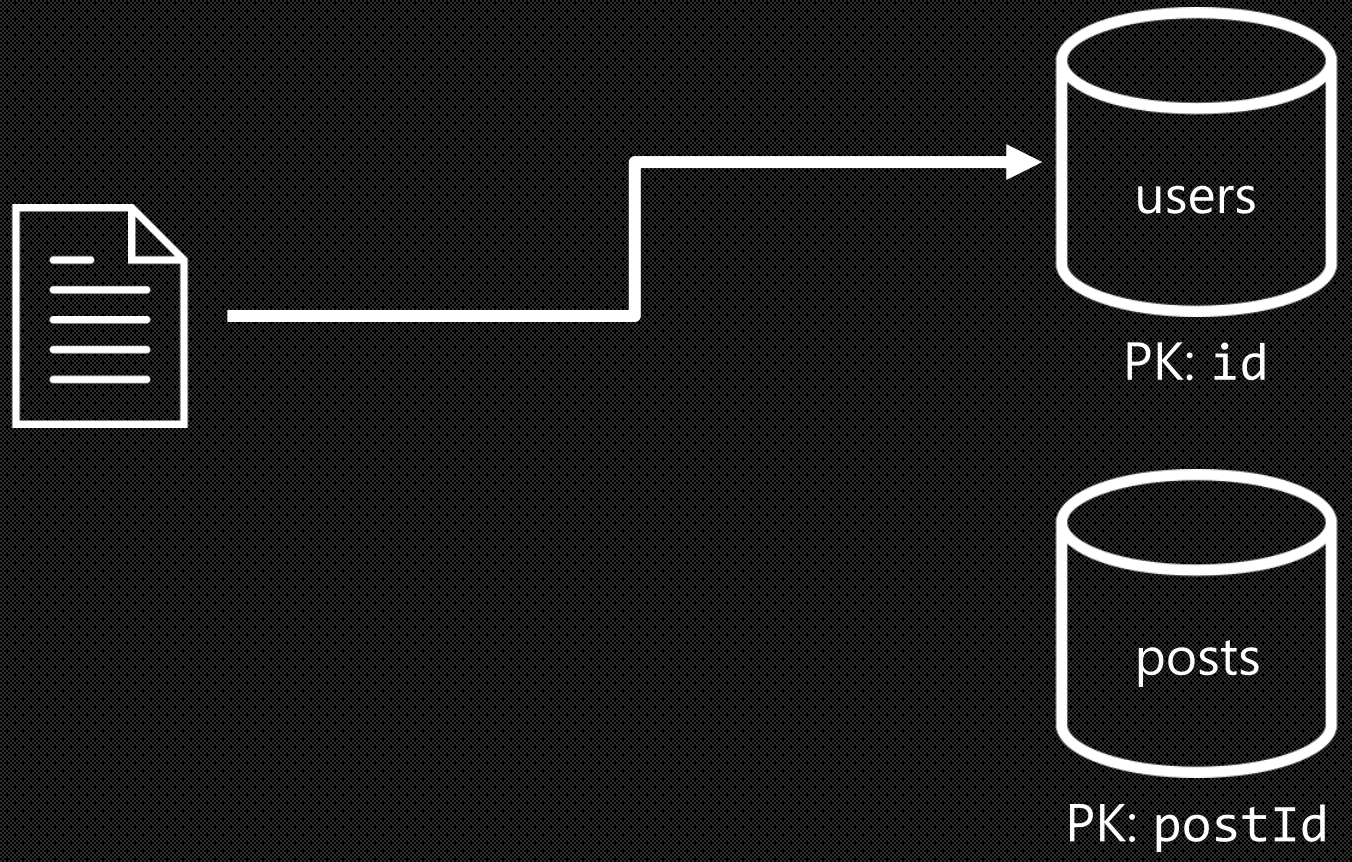
C3

Q4

C4

Q5

Q6



7 ms / 5.71 RU

Retrieve a user's profile

C1 ✓

Q1 ✓

C2

Q2

Q3

C3

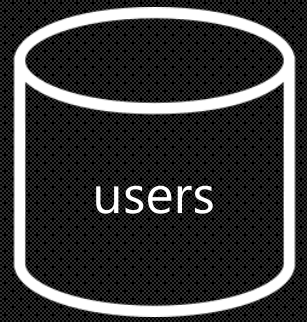
Q4

C4

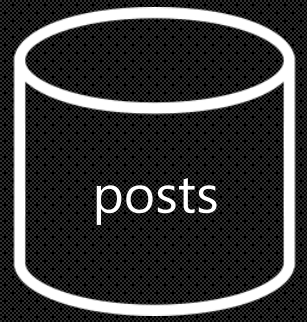
Q5

Q6

```
SELECT * FROM u WHERE u.id = '<user-id>'
```



PK: `id`

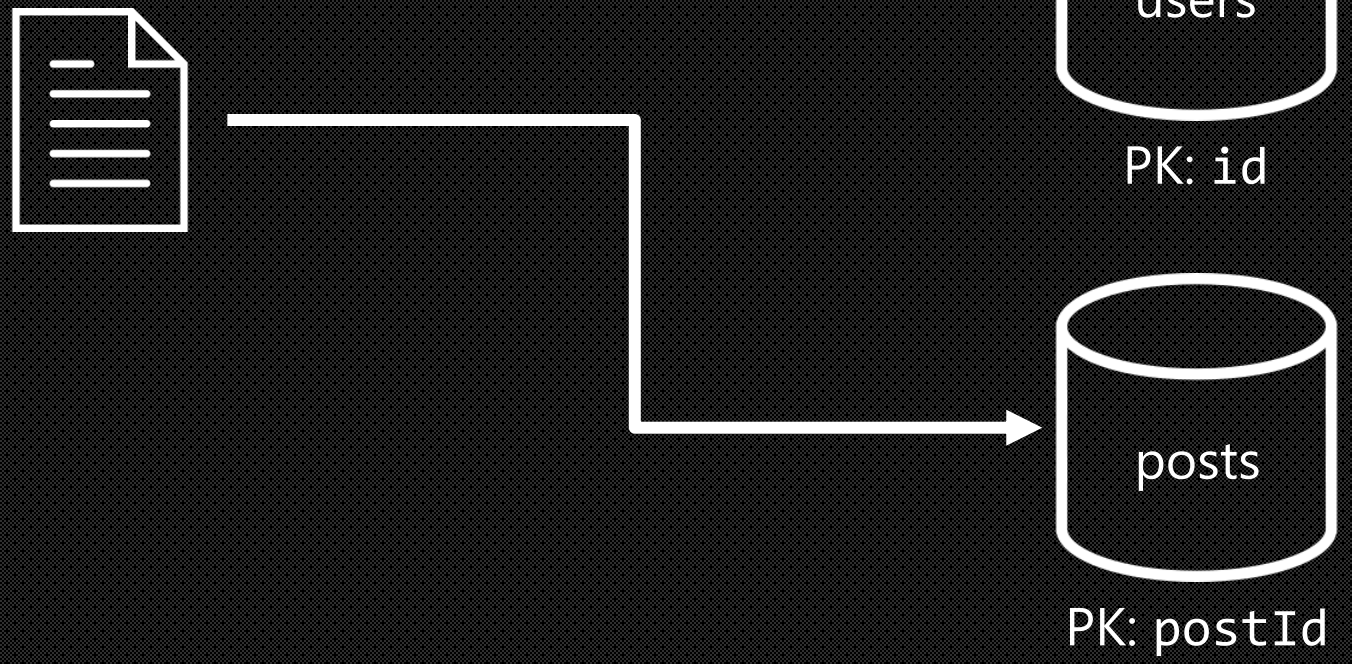


PK: `postId`

3 ms / 2.90 RU

Create/edit a post

C1 ✓
Q1 ✓
C2 ✓
Q2
Q3
C3
Q4
C4
Q5
Q6



9 ms / 8.76 RU

Retrieve a post

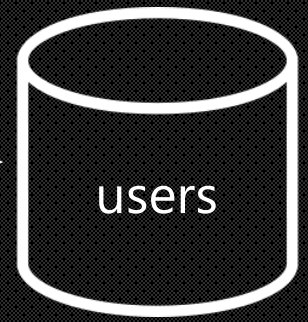
C1 ✓
Q1 ✓
C2 ✓
Q2 ⚠
Q3
C3
Q4
C4
Q5
Q6

```
SELECT u.username FROM u
WHERE u.id = '<post-author-id>'
```

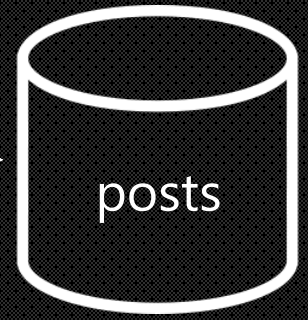
```
SELECT * FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'post'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```



PK: id



PK: postId

9 ms / 19.54 RU

List a user's posts in short form

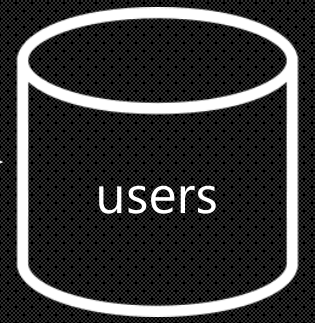
C1 ✓
Q1 ✓
C2 ✓
Q2 ⚠
Q3 ⚠
C3
Q4
C4
Q5
Q6

```
SELECT u.username FROM u
WHERE u.id = '<post-author-id>'
```

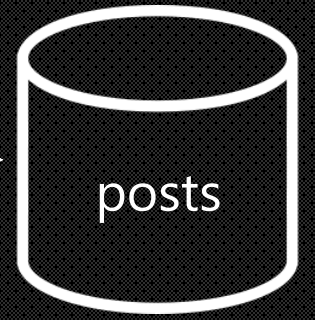
```
SELECT * FROM p
WHERE p.userId = '<author-id>'
AND p.type = 'post'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```



PK: id

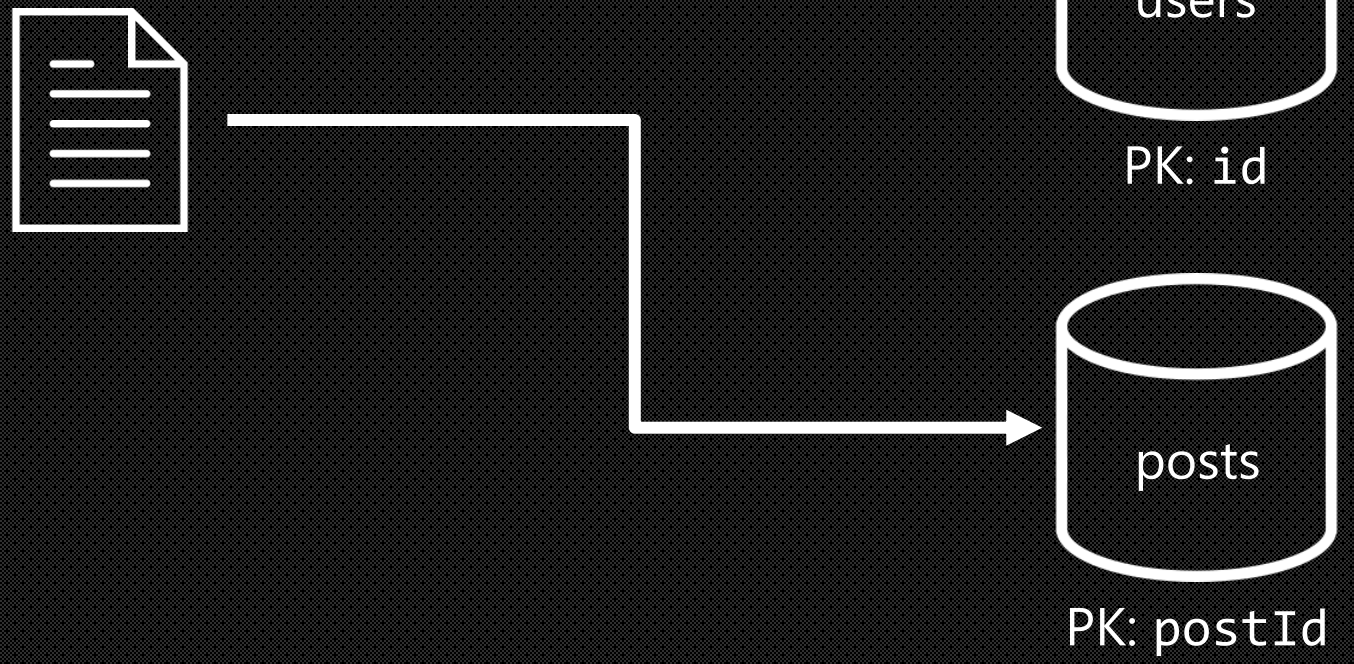


PK: postId

130 ms / 619.41 RU

Create a comment

C1 ✓
Q1 ✓
C2 ✓
Q2 ⚠
Q3 ⚠
C3 ✓
Q4
C4
Q5
Q6



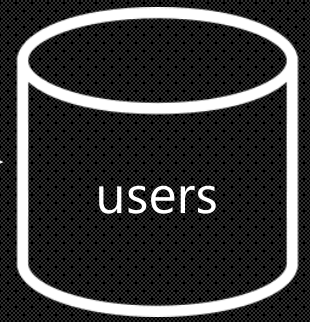
7 ms / 8.57 RU

List a post's comments

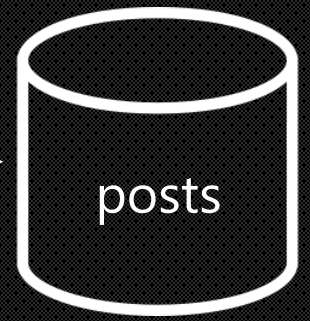
C1 ✓
Q1 ✓
C2 ✓
Q2 ⚠
Q3 ⚠
C3 ✓
Q4 ⚠
C4
Q5
Q6

```
SELECT * FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT u.username FROM u
WHERE u.id = '<comment-author-id>'
```



PK: id

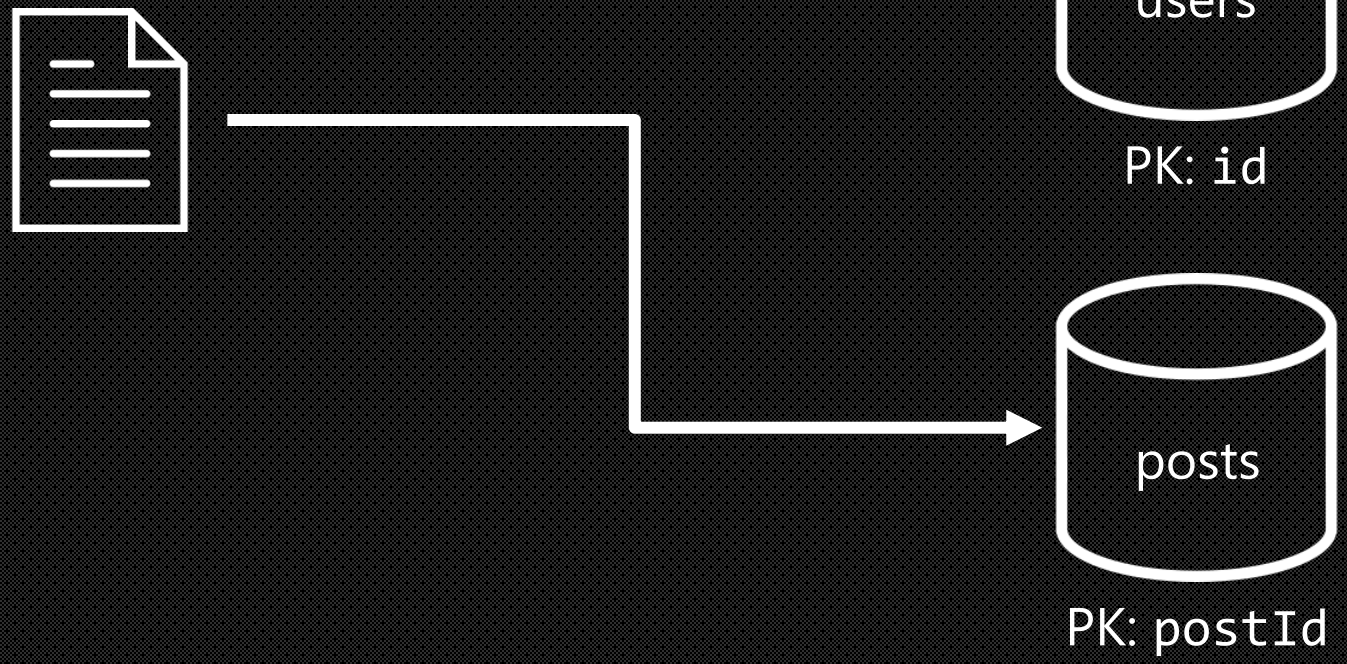


PK: postId

23 ms / 27.72 RU

Like a post

C1
Q1
C2
Q2
Q3
C3
Q4
C4
Q5
Q6



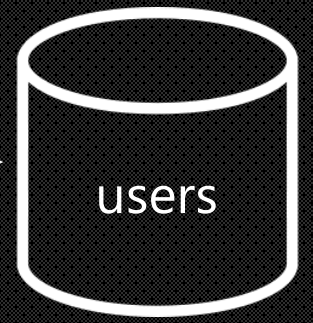
6 ms / 7.05 RU

List a post's likes

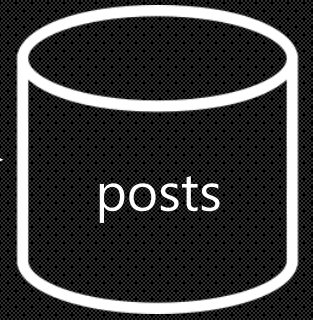
C1 ✓
Q1 ✓
C2 ✓
Q2 ⚠
Q3 ⚠
C3 ✓
Q4 ⚠
C4 ✓
Q5 ⚠
Q6

```
SELECT * FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```

```
SELECT u.username FROM u
WHERE u.id = '<liker-id>'
```



PK: id



PK: postId

59 ms / 58.92 RU

List the *x* most recent posts in short form (feed)

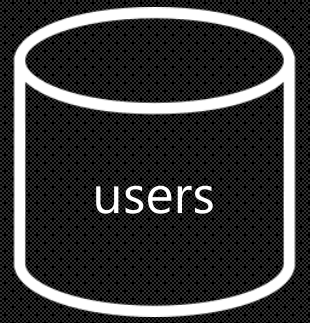
C1 ✓
Q1 ✓
C2 ✓
Q2 ⚠
Q3 ⚠
C3 ✓
Q4 ⚠
C4 ✓
Q5 ⚠
Q6 ⚠

```
SELECT TOP <x> * FROM p
WHERE p.type = 'post'
ORDER BY p.creationDate DESC
```

```
SELECT u.username FROM u
WHERE u.id = '<post-author-id>'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```



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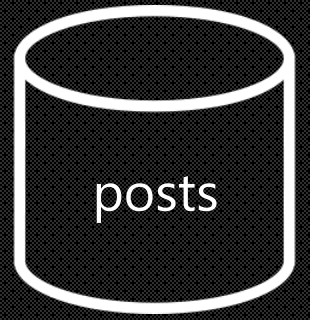

PK: postId

306 ms / 2063.54 RU

Cost in RU's

C1	Create/edit a user's profile	5.71 RU
Q1	Retrieve a user's profile	2.90 RU
C2	Create/edit a post	8.76 RU
Q2	Retrieve a post	19.54 RU
Q3	List a user's post in short form	619.41 RU
C3	Create a comment	8.57 RU
Q4	List a post's comments	27.72 RU
C4	Like a post	7.05 RU
Q5	List a post's likes	58.92 RU
Q6	List the x most recent posts in short form (feed)	2,063.54 RU

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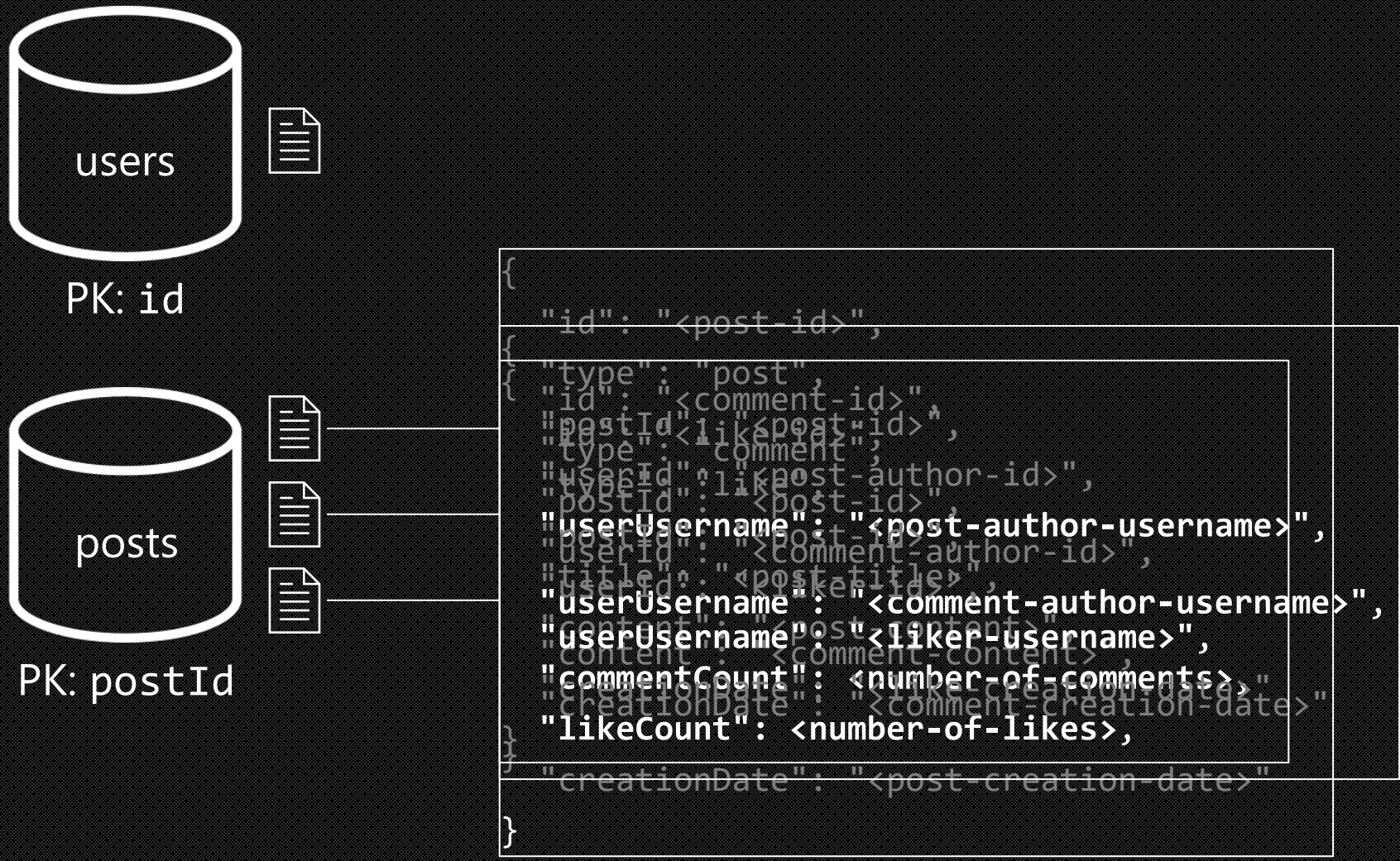
V1: performance issues

- Having to issue multiple queries to handle a single request
- Issuing queries that don't filter on the partition key, leading to a partition scan

V2: introducing denormalization



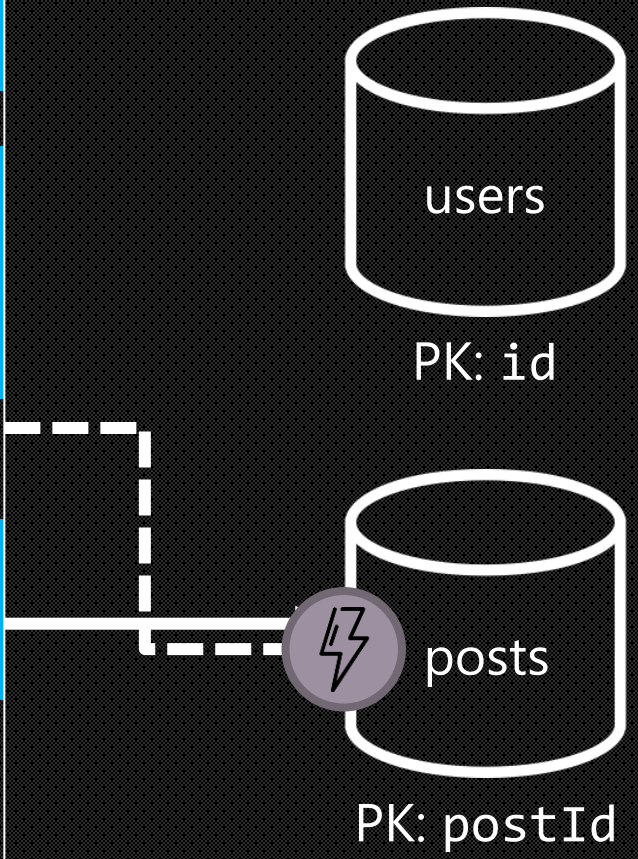
Denormalizing within the same logical partition with stored procedures

- Written in Javascript
- Scoped to a single logical partition
- Executed as atomic transactions

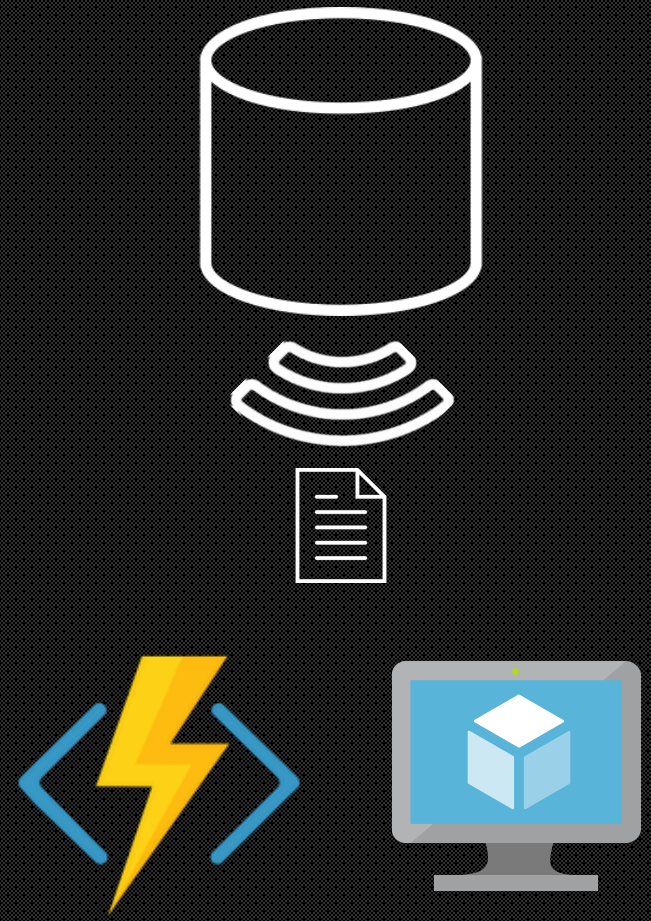
Create a comment

C1
Q1
C2
Q2
Q3
C3
Q4
C4
Q5
Q6

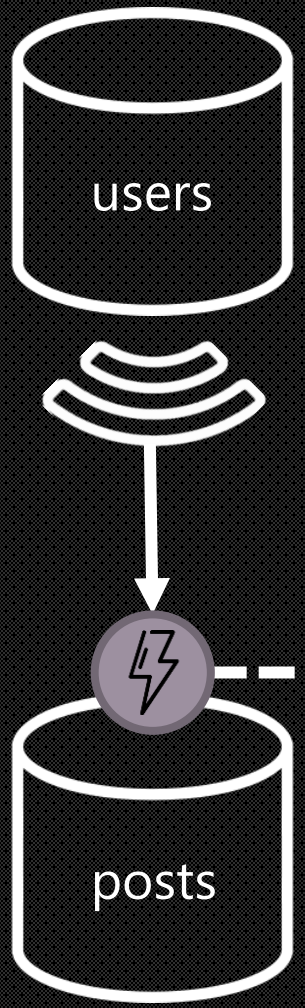
```
function createComment(postId, comment) {
  var collection = getContext().getCollection();
  collection.readDocument(
    `${collection.getAltLink()}/docs/${postId}`,
    function (err, post) {
      post.commentCount++;
      collection.replaceDocument(
        post._self,
        post,
        function (err) {
          comment.postId = postId;
          collection.createDocument(
            collection.getSelfLink(),
            comment
          );
        }
      );
    });
}
```



Denormalizing across logical partitions and containers with the change feed



Denormalizing usernames into posts




```
function updateUsername(userId, username) {
  var collection = getContext().getCollection();
  collection.queryDocuments(
    collection.getSelfLink(),
    `SELECT * FROM p WHERE p.userId = '${userId}'`,
    function (err, results) {
      for (var i in results) {
        var doc = results[i];
        doc.userUsername = username;
        collection.replaceDocument(
          collection.getSelfLink(),
          doc);
      }
    });
}
```

Retrieve a post

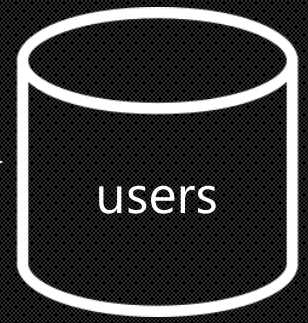
C1 ✓
Q1 ✓
C2 ✓
Q2 ✓
Q3 ⚠
C3 ✓
Q4 ⚠
C4 ✓
Q5 ⚠
Q6 ⚠

```
SELECT * FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'post'
```

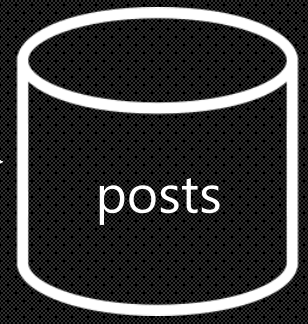
```
SELECT u.username FROM u
WHERE u.id = '<post-author-id>'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```



PK: id



PK: postId

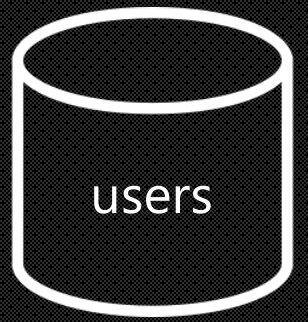
3 ms / 5.40 RU

List a post's comments

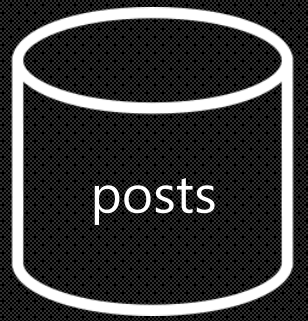
C1 ✓
Q1 ✓
C2 ✓
Q2 ✓
Q3 ⚠
C3 ✓
Q4 ✓
C4 ✓
Q5 ⚠
Q6 ⚠

```
SELECT * FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT u.username FROM u
WHERE u.id = '<comment-author-id>'
```



PK: id



PK: postId

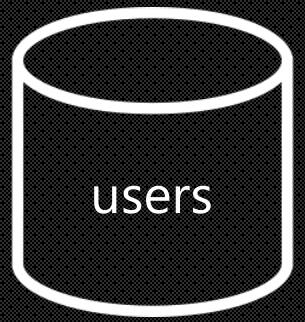
4 ms / 7.72 RU

List a post's likes

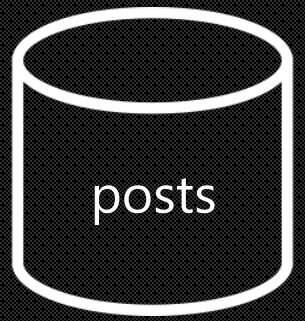
C1 ✓
Q1 ✓
C2 ✓
Q2 ✓
Q3 ⚠
C3 ✓
Q4 ✓
C4 ✓
Q5 ✓
Q6 ⚠

```
SELECT * FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```

```
SELECT u.username FROM u
WHERE u.id = '<liker-id>'
```



PK: id



PK: postId

4 ms / 8.92 RU

List a user's posts in short form

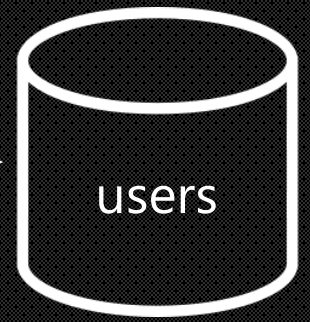
C1 ✓
Q1 ✓
C2 ✓
Q2 ✓
Q3 ⚠
C3 ✓
Q4 ✓
C4 ✓
Q5 ✓
Q6 ⚠

```
SELECT * FROM p
WHERE p.userId = '<author-id>'
AND p.type = 'post'
```

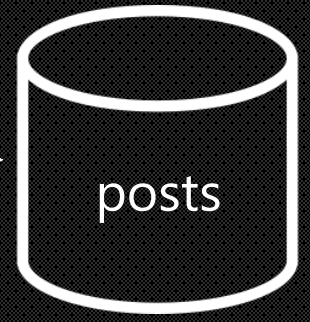
```
SELECT u.username FROM u
WHERE u.id = '<post-author-id>'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```



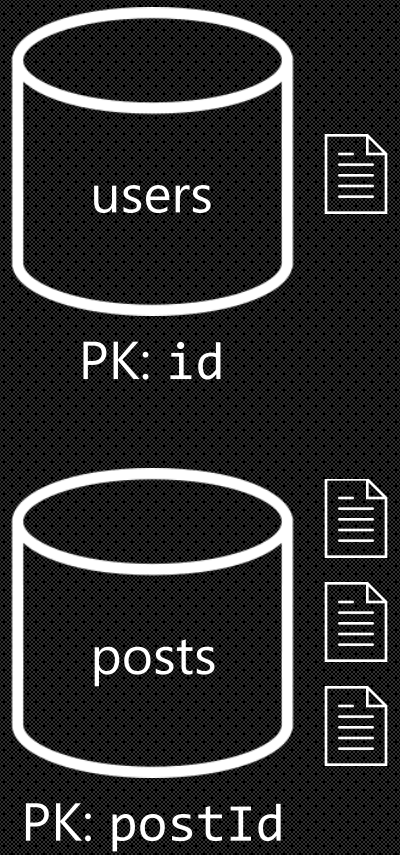
PK: id



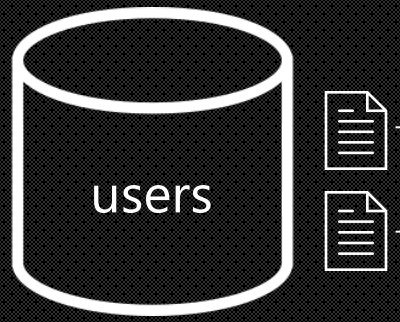
PK: postId

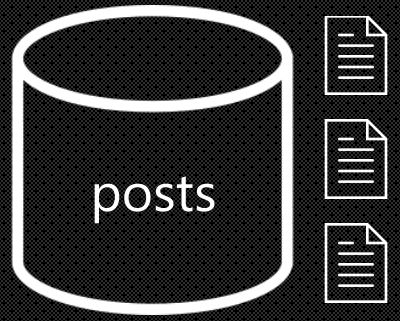
83 ms / 532.33 RU

V3: denormalizing entire documents



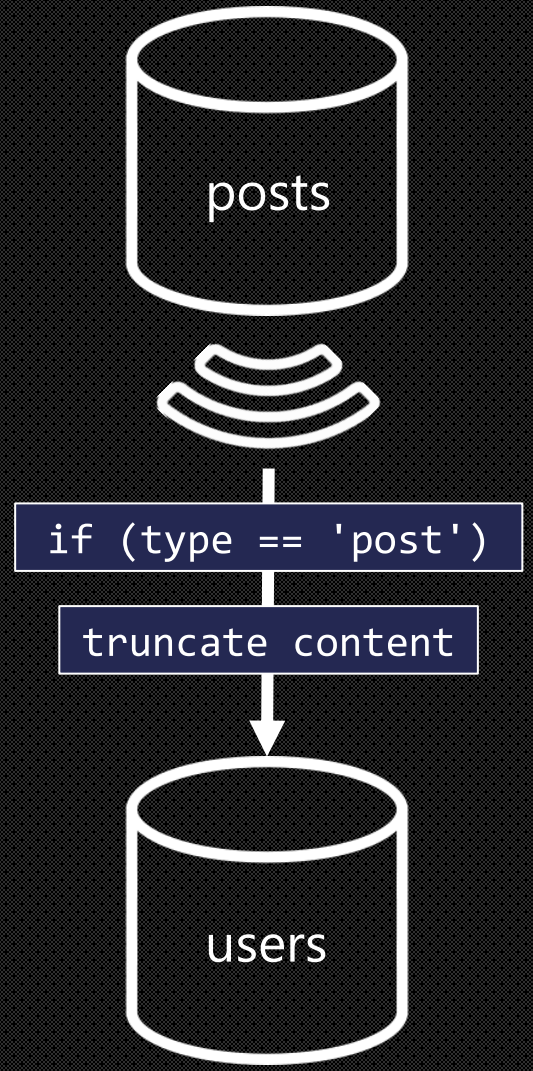
V3: denormalizing entire documents






```
{
  "id": "<post-id>",
  "type": "post",
  "userId": "<post-author-id>",
  "username": "<post-author-username>",
  "title": "<post-title>",
  "content": "<post-content>",
  "commentCount": <number-of-comments>,
  "likeCount": <number-of-likes>,
  "creationDate": "<post-creation-date>"
}
```

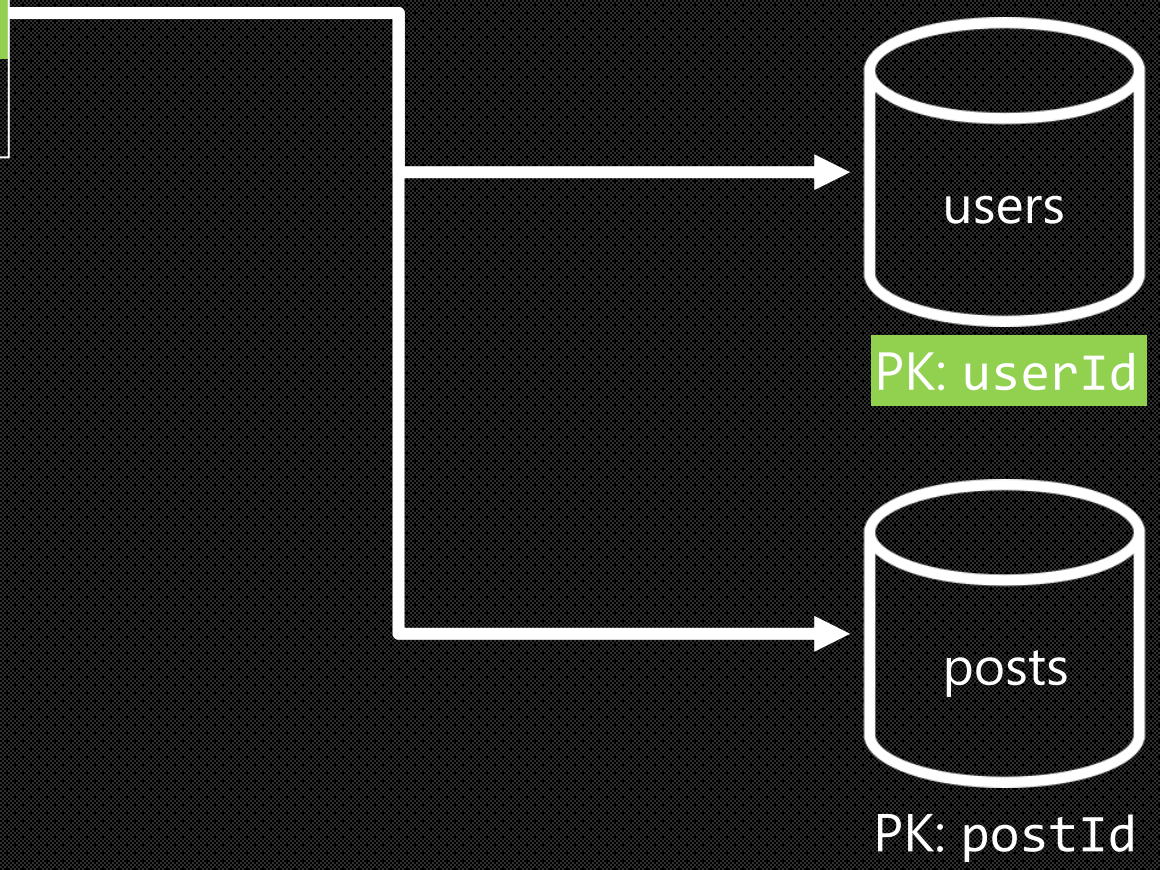
Denormalizing documents with the change feed



List a user's posts in short form

C1 ✓
Q1 ✓
C2 ✓
Q2 ✓
Q3 ✓ ⚠
C3 ✓
Q4 ✓
C4 ✓
Q5 ✓
Q6 ⚠

```
SELECT * FROM p
WHERE p.userId = '<author-id>'
AND p.type = 'post'
```



4 ms / 6.46 RU

List the *x* most recent posts in short form (feed)

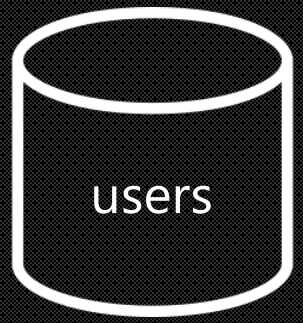
C1 ✓
Q1 ✓
C2 ✓
Q2 ✓
Q3 ✓
C3 ✓
Q4 ✓
C4 ✓
Q5 ✓
Q6 ⚠

```
SELECT TOP <x> * FROM p
WHERE p.type = 'post'
ORDER BY p.creationDate DESC
```

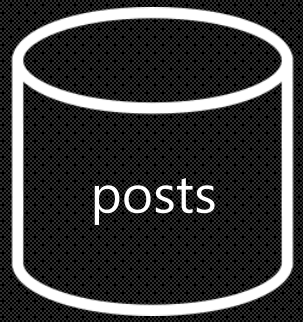
```
SELECT u.username FROM u
WHERE u.id = '<post-author-id>'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'comment'
```

```
SELECT COUNT(1) FROM p
WHERE p.postId = '<post-id>'
AND p.type = 'like'
```



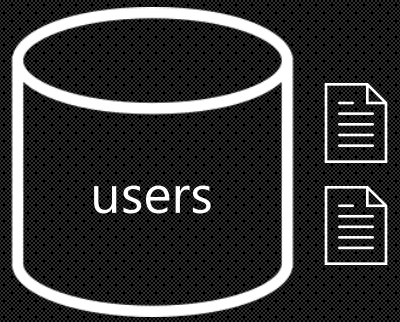
PK: id



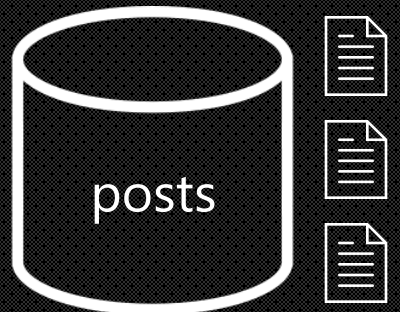
PK: postId

9 ms / 16.97 RU

V3: denormalizing entire documents

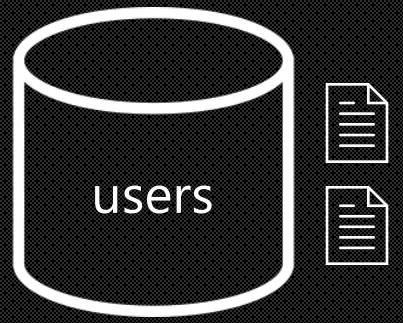


PK: userId

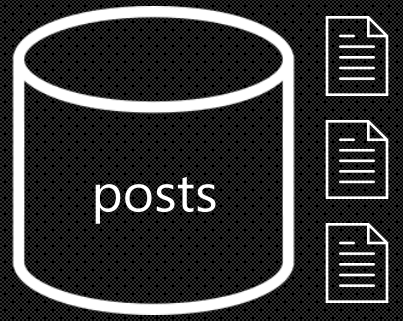


PK: `postId`

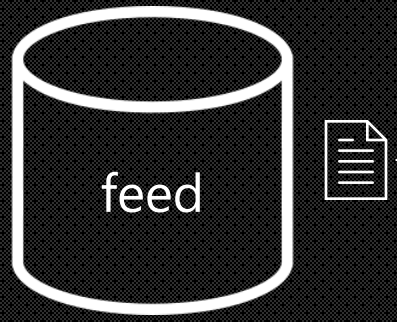
V3: denormalizing entire documents



PK: userId



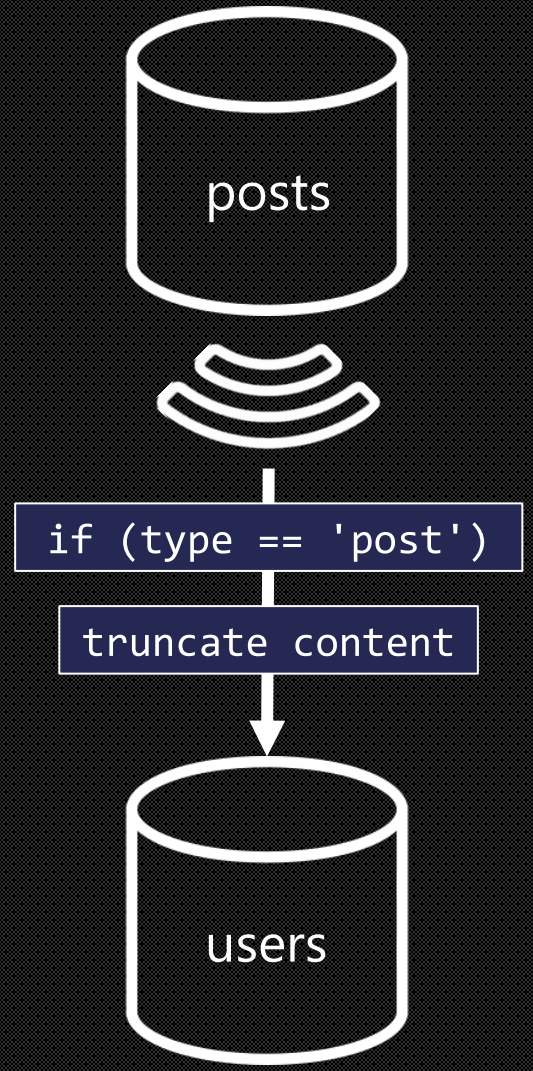
PK: postId



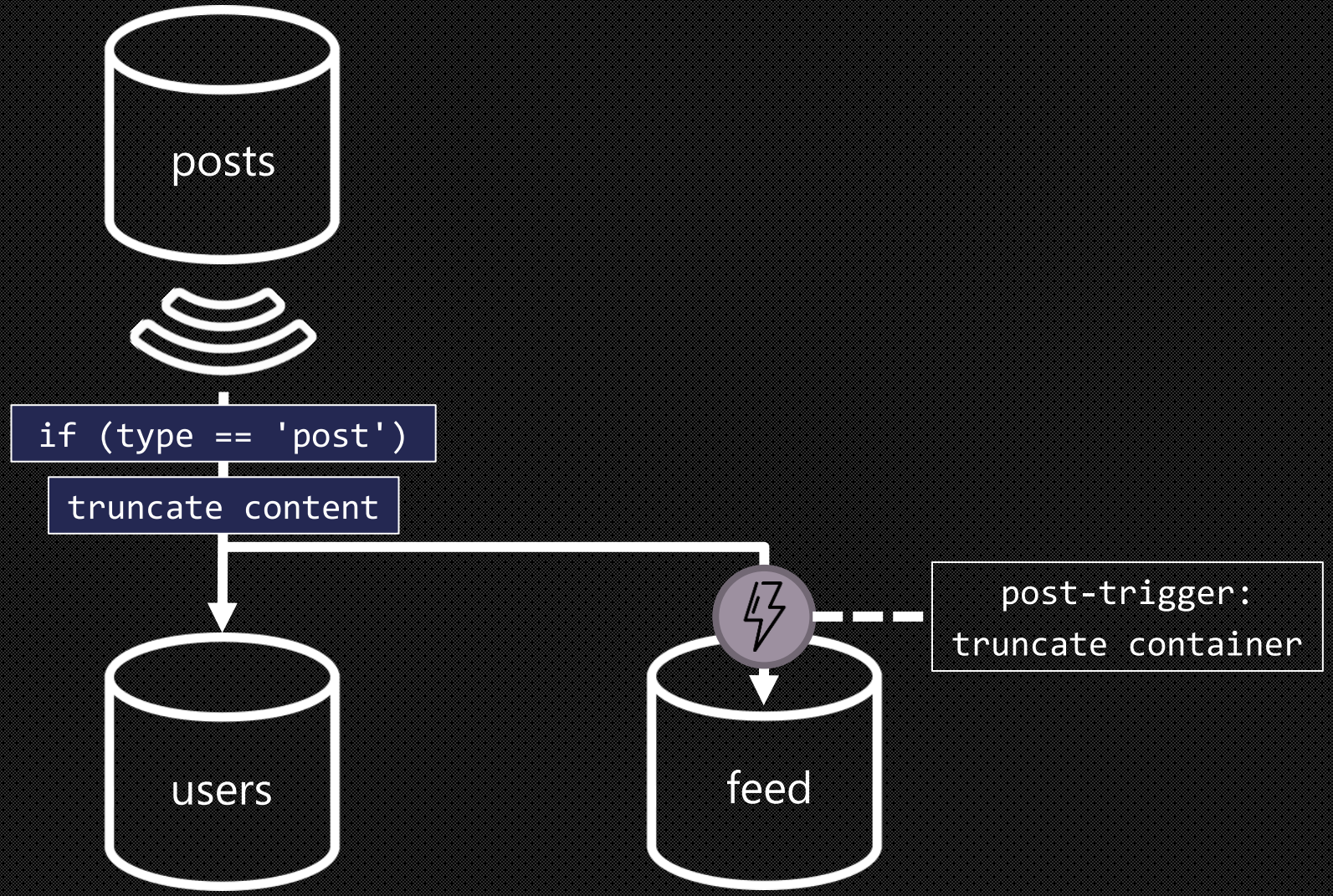
PK: type

```
{
  "id": "<post-id>",
  "type": "post",
  "userId": "<post-author-id>",
  "userUsername": "<post-author-username>",
  "title": "<post-title>",
  "content": "<post-content>",
  "commentCount": <number-of-comments>,
  "likeCount": <number-of-likes>,
  "creationDate": "<post-creation-date>"
}
```

Denormalizing documents with the change feed



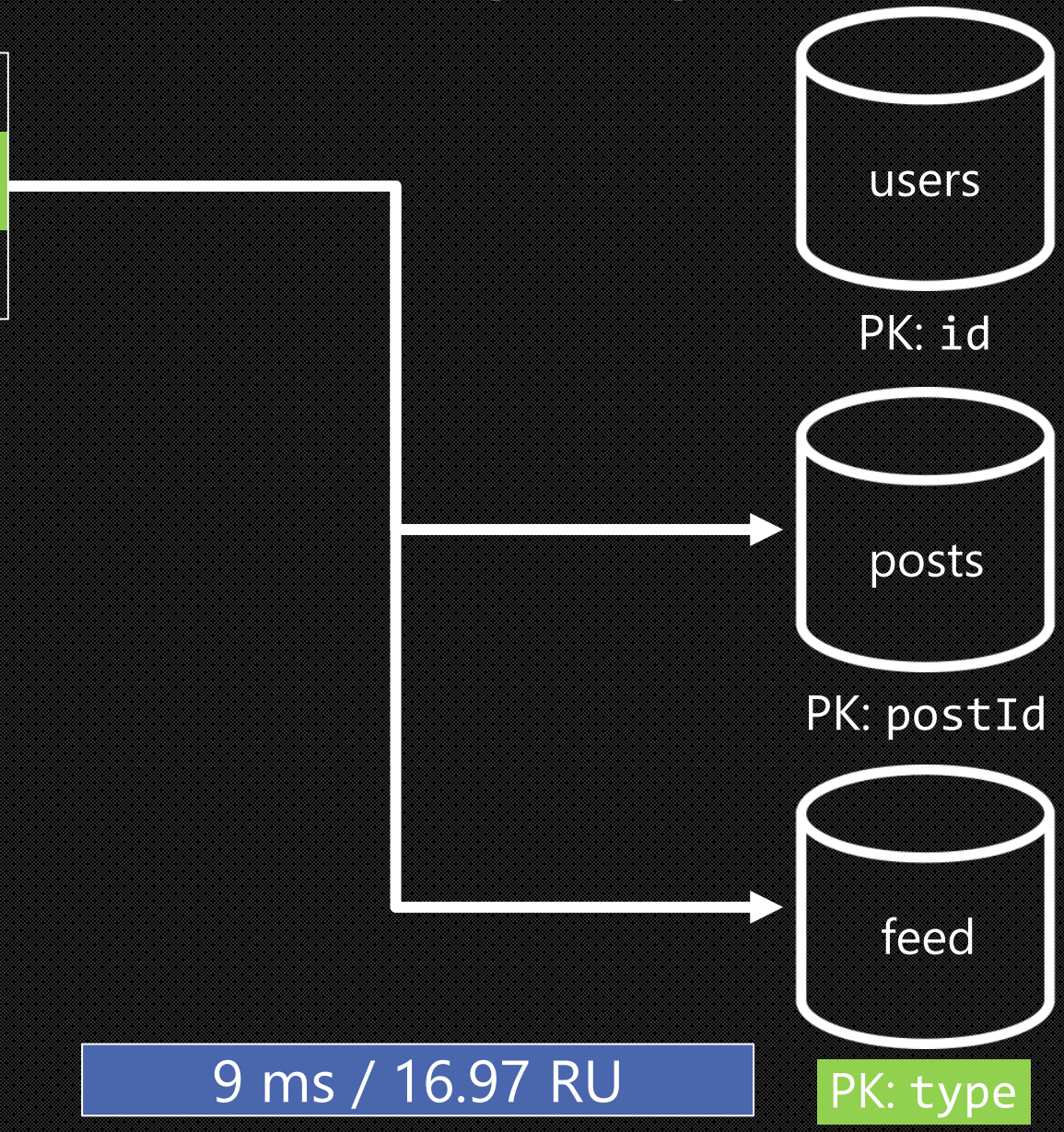
Denormalizing documents with the change feed



List the *x* most recent posts in short form (feed)

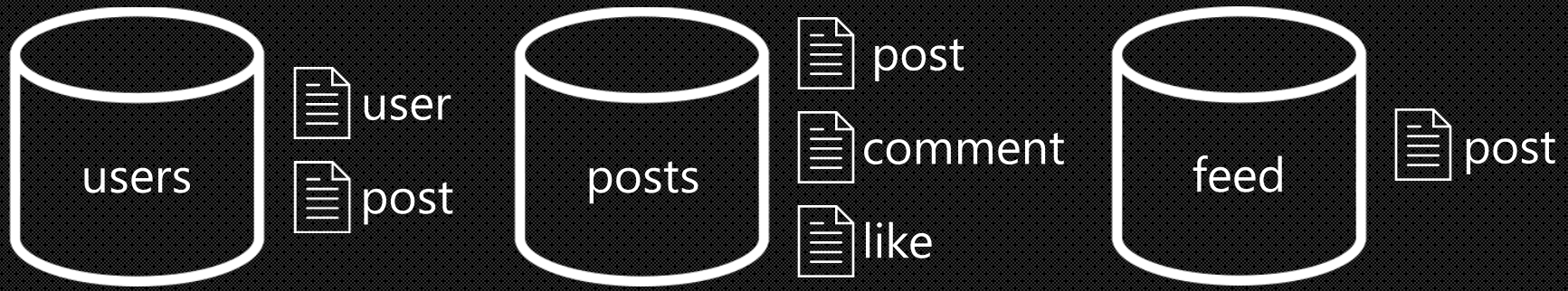
C1 ✓
Q1 ✓
C2 ✓
Q2 ✓
Q3 ✓
C3 ✓
Q4 ✓
C4 ✓
Q5 ✓
Q6 ✓

```
SELECT TOP <x> * FROM p
WHERE p.type = 'post'
ORDER BY p.creationDate DESC
```

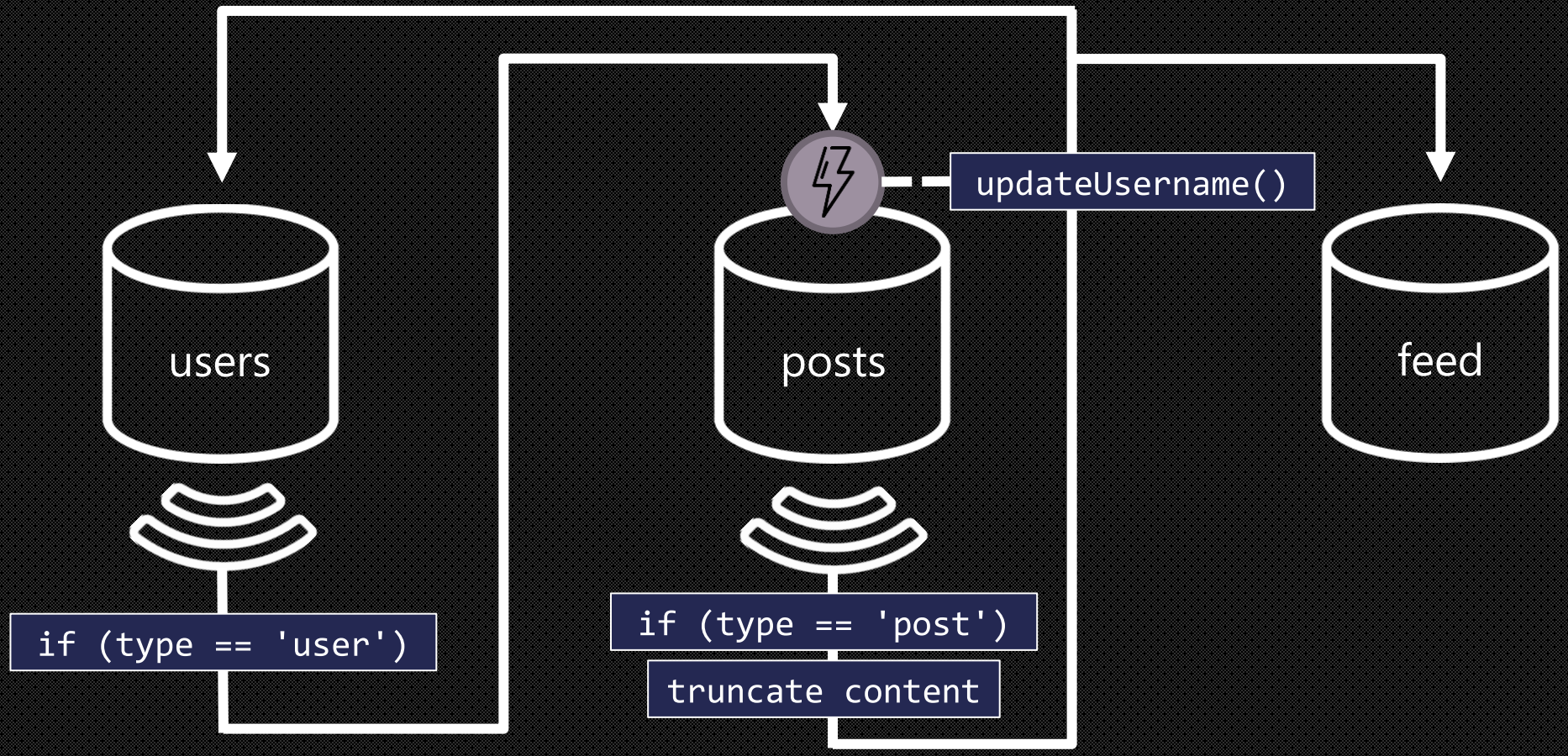


9 ms / 16.97 RU

Our final design



Our final design



Denormalization can be added later

- V1 was not that bad!
- You can add denormalization later
  - The **change feed is persistent**
  - Run a one-time catch-up operation
- **Monitor** your database performance and setup **alerts**

	V1
C1	7 ms / 5.71 RU
Q1	3 ms / 2.90 RU
C2	9 ms / 8.76 RU
Q2	9 ms / 19.54 RU
Q3	130 ms / 619.41 RU
C3	7 ms / 8.57 RU
Q4	23 ms / 27.72 RU
C4	6 ms / 7.05 RU
Q5	59 ms / 58.92 RU
Q6	306 ms / 2063.54 RU

An overall look at performance

	V1	V2	V3
C1	7 ms / 5.71 RU	7 ms / 5.71 RU	7 ms / 5.71 RU
Q1	3 ms / 2.90 RU	3 ms / 2.90 RU	3 ms / 2.90 RU
C2	9 ms / 8.76 RU	9 ms / 8.76 RU	9 ms / 8.76 RU
Q2	9 ms / 19.54 RU	3 ms / 5.11 RU	3 ms / 5.11 RU
Q3	130 ms / 619.41 RU	28 ms / 201.54 RU	4 ms / 6.46 RU
C3	7 ms / 8.57 RU	7 ms / 15.27 RU	7 ms / 15.27 RU
Q4	23 ms / 27.72 RU	4 ms / 7.72 RU	4 ms / 7.72 RU
C4	6 ms / 7.05 RU	7 ms / 14.67 RU	7 ms / 14.67 RU
Q5	59 ms / 58.92 RU	4 ms / 8.92 RU	4 ms / 8.92 RU
Q6	306 ms / 2063.54 RU	83 ms / 532.33 RU	9 ms / 16.97 RU

What about the cost of denormalization?

- We optimized for a read-heavy scenario
  - Reads >> writes
- Q6 went from 2,000+ to 17 RUs (120x optimization)
  - Saved 1920 RUs by denormalizing posts at ~10 RUs / document
- All depends on your specific scenario and access patterns

What else do you get?

- Multi-model APIs
- Flexibility of the change feed
- Turnkey global distribution
- Industry-leading SLA

Most importantly: what's our scalability?

- V3: limitless!
- Performance will ***not*** depend on
  - number of documents
  - number of users
  - number of posts
- Whether you have 10 or 10M users, query latency will always be **the same**

	V3
C1	7 ms / 5.71 RU
Q1	3 ms / 2.90 RU
C2	9 ms / 8.76 RU
Q2	3 ms / 5.11 RU
Q3	4 ms / 6.46 RU
C3	7 ms / 14.67 RU
Q4	4 ms / 7.72 RU
C4	7 ms / 14.67 RU
Q5	4 ms / 8.92 RU
Q6	9 ms / 16.97 RU

What we'll cover today

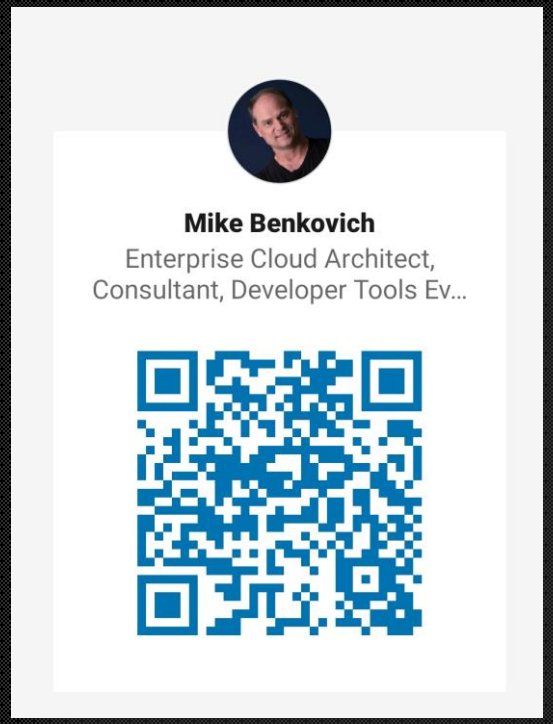
Why Cosmos
Provisioning Cosmos
Working with Data
Data Modeling Strategies
Performance and tuning

Thanks to the following

- **Thomas Weiss** presentation on Cosmos Performance in 2019
- **Alpaqa Studio**
  https://alpaqastudio.com
- **Jeff Widmer** github code example of scenario
  https://github.com/jwidmer/AzureCosmosDbBlogExample
- **Jane Chen** - Cosmos Jupyter Notebooks
- **Mark Brown's** Cosmos TV
  https://gotcosmos.com
- **James Serra**'s Blog
  https://www.jamesserra.com

Mike Benkovich

- **Developer**
- Cloud **Architect** & **Consultant**
- Live in **Minneapolis**
- Founder of **Imagine Technologies**, Inc.
- Developing Courses for **LinkedIn** Learning
- Blog www.**benkoTIPS**.com
- Follow **@mbenko** on **Twitter**
- Send me **Feedback**! mike@benkotips.com



Going further

Questions? I'm mike@benko.com - www.benko**TIPS**.com

- aka.ms/PracticalCosmosDB
- cosmosdb.com
- https://github.com/jwidmer/AzureCosmosDbBlogExample