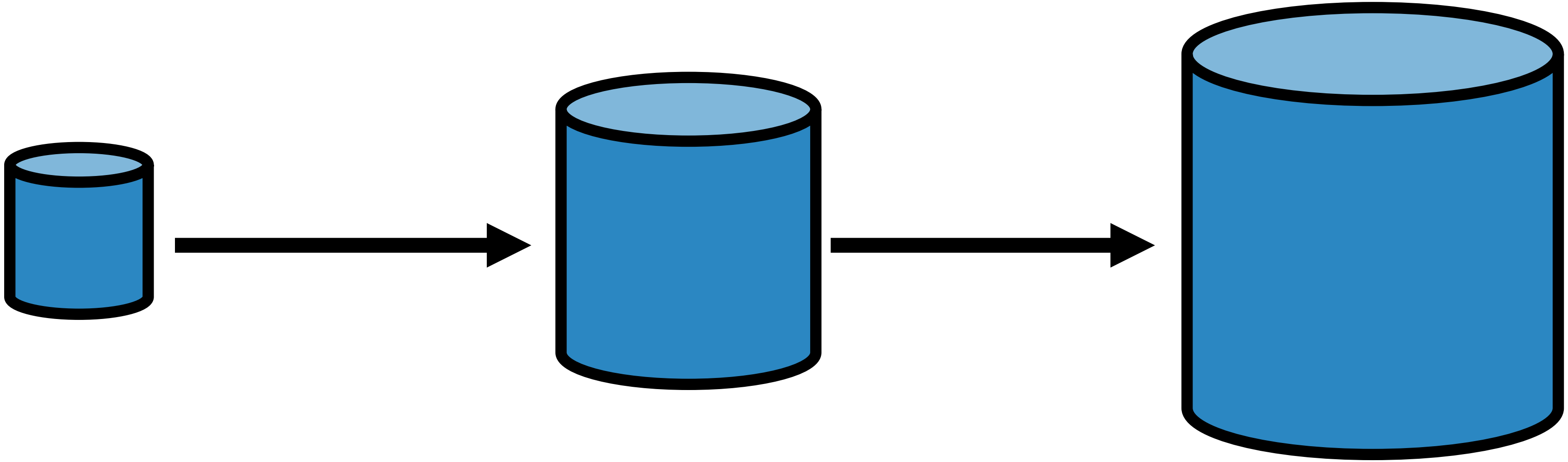
Introduction to NoSQL Databases

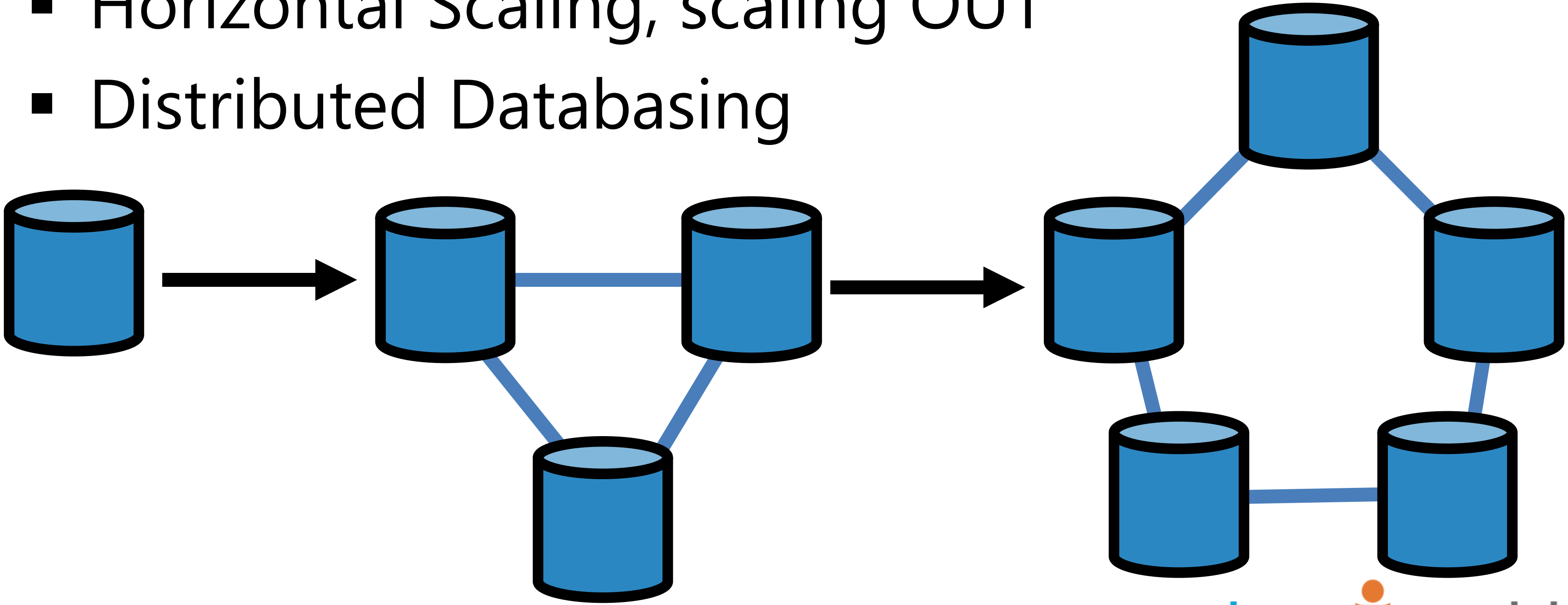
Scaling, Traditional Relational DB

- Vertical Scaling, scaling UP

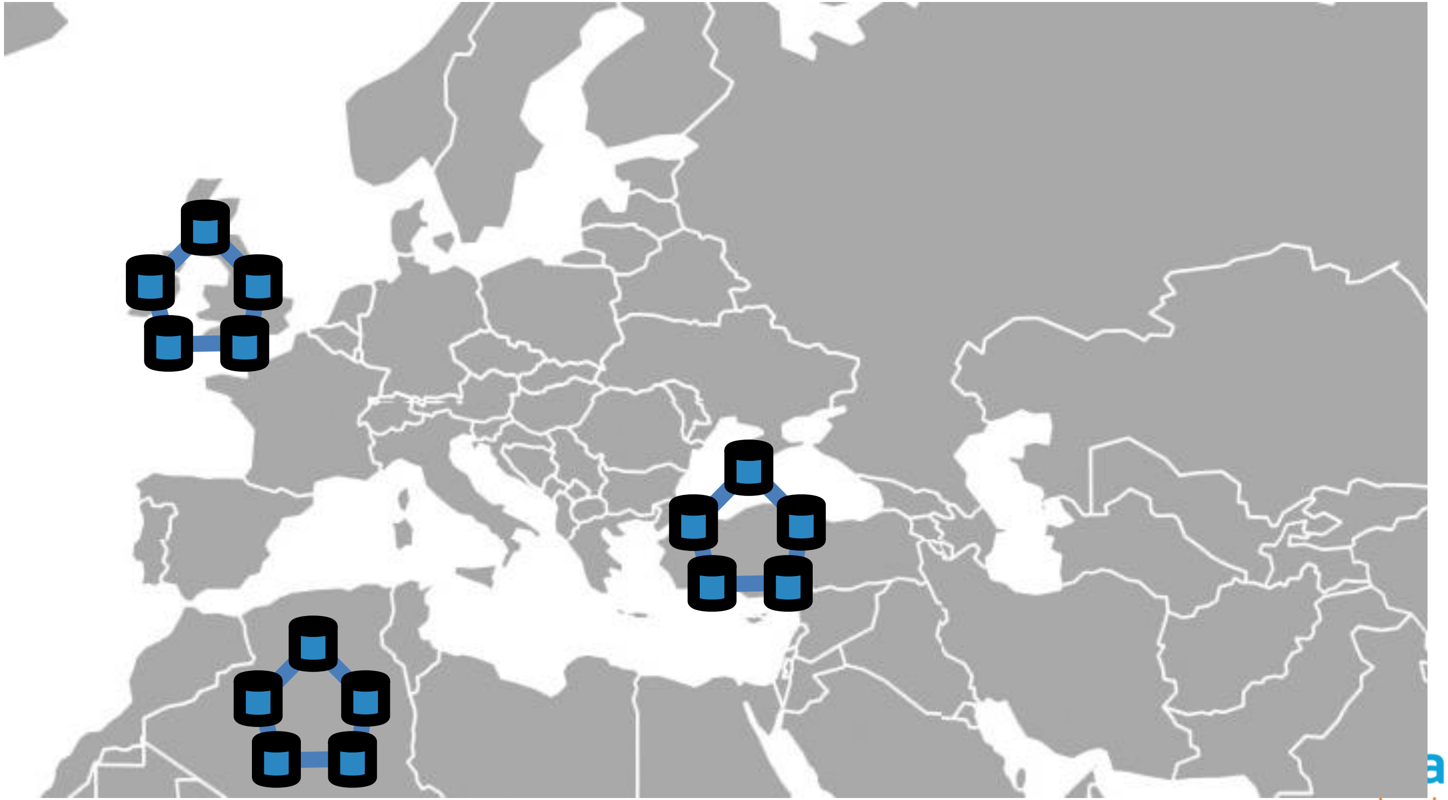


Scaling, NoSQL Era

- Horizontal Scaling, scaling OUT
- Distributed Databasing



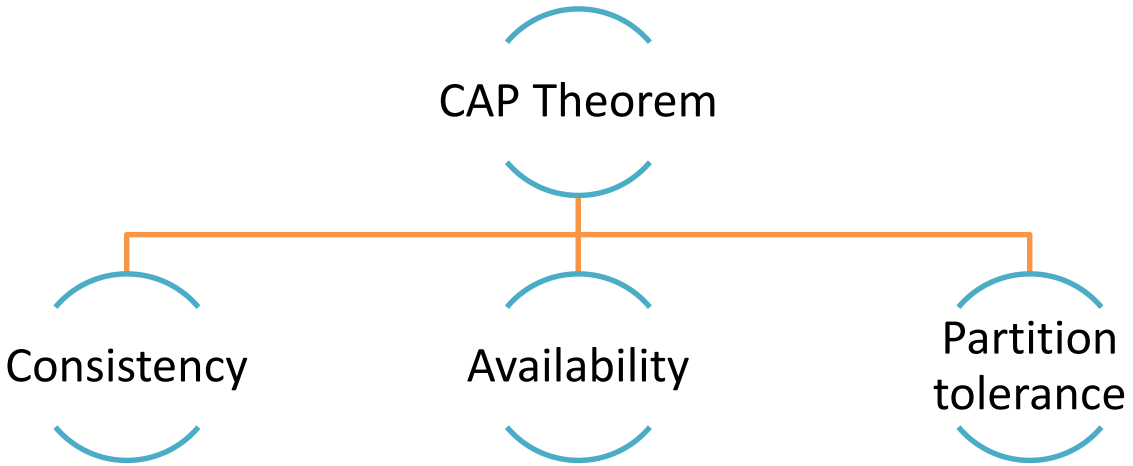
Scaling, NoSQL Era



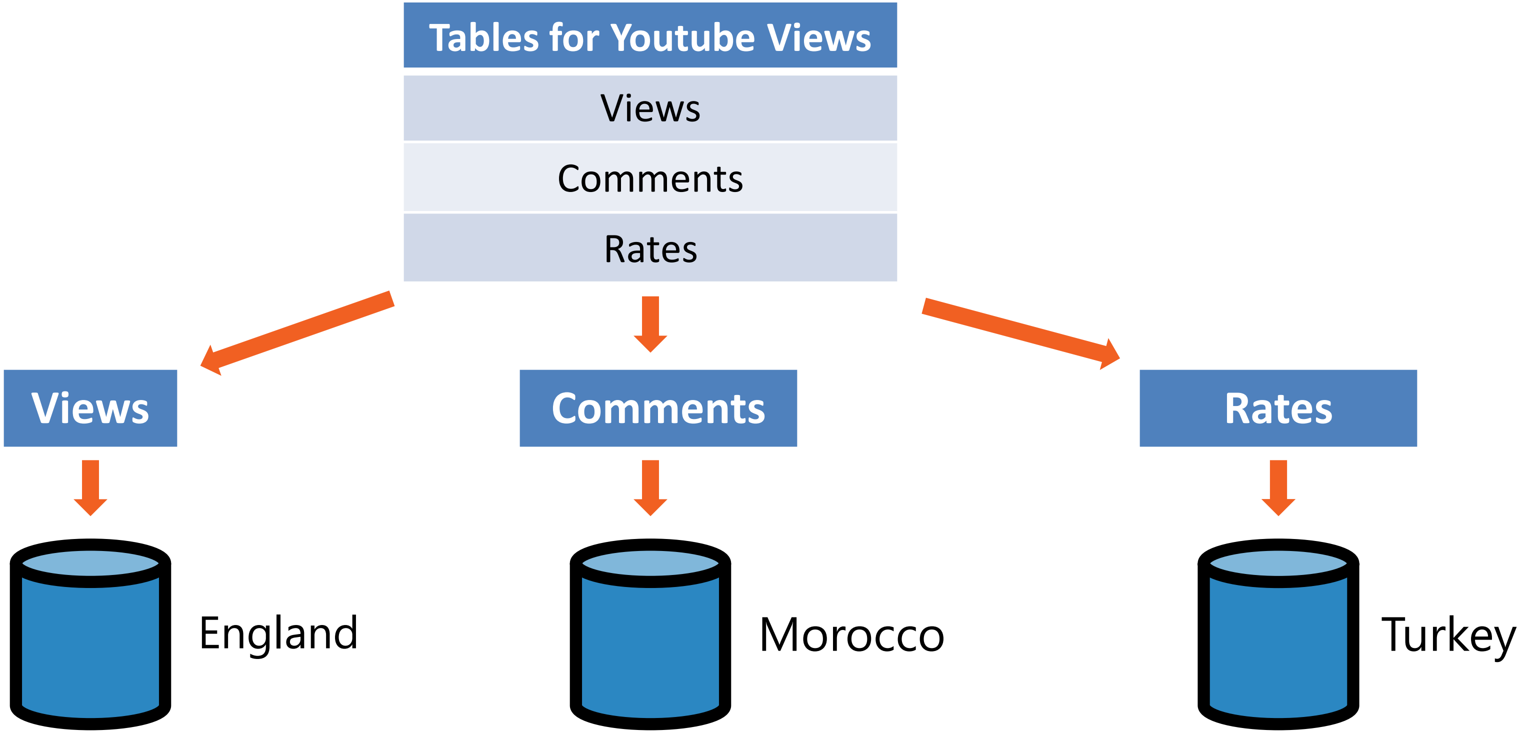
Data Architecture

- No standard solution that fits all
- Business and data defines the architecture
- Multiple databases, different types depending on the characteristics of each data subset

CAP

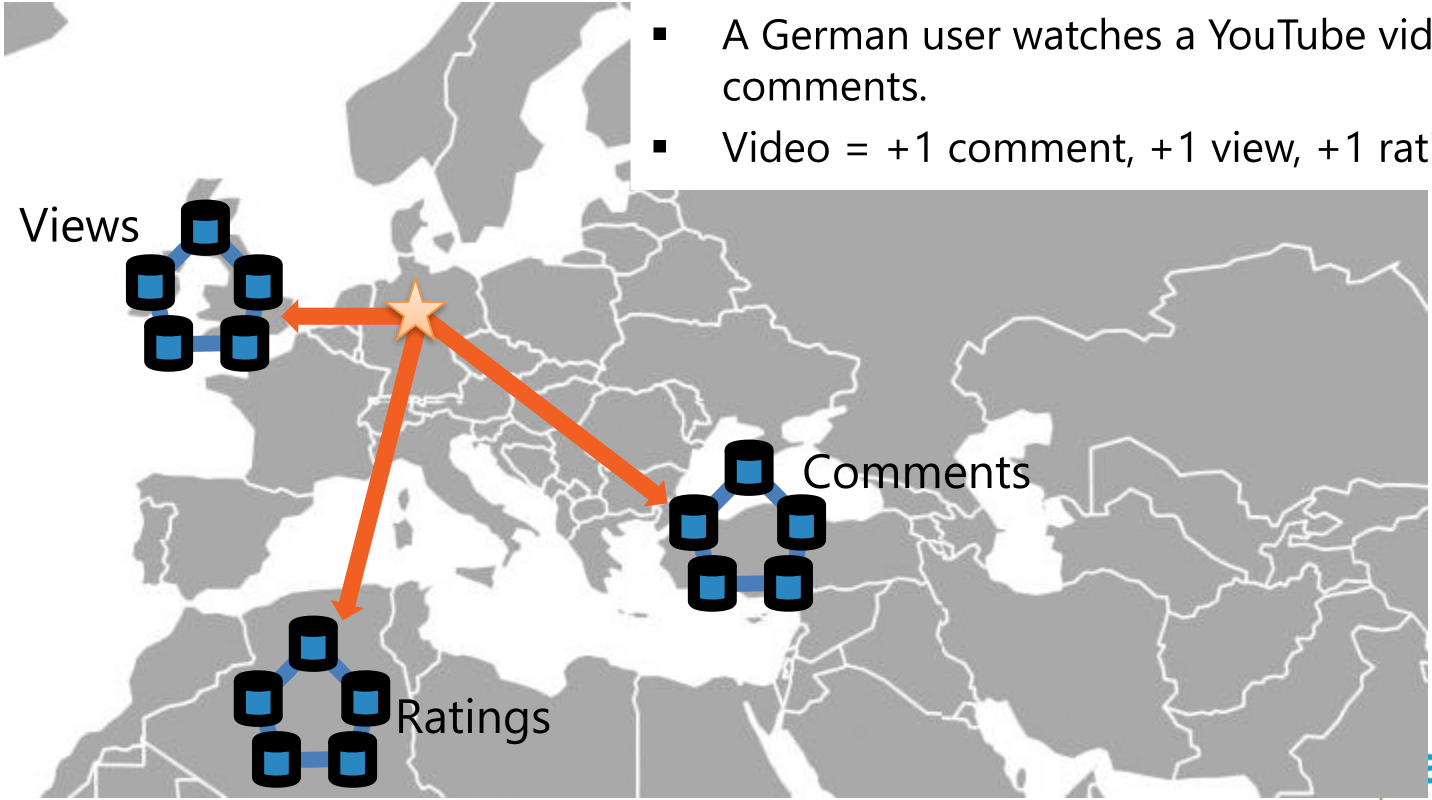

CAP Theorem
Consistency
Availability
Partition tolerance

CAP: Network Partition



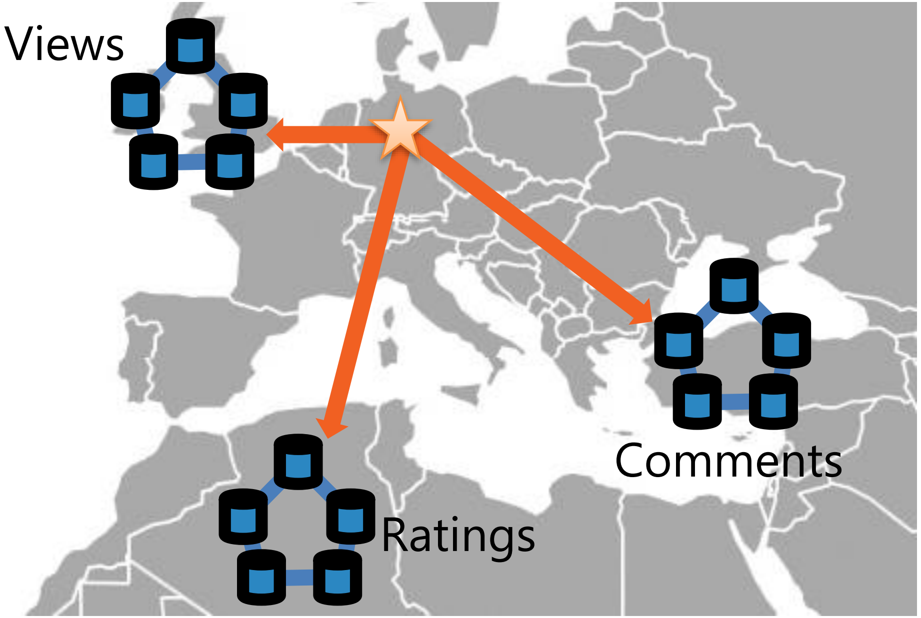
Wide-area Network Partition

- A German user watches a YouTube video, rates it, then comments.
- Video = +1 comment, +1 view, +1 rating



CAP: Partition Tolerance

- A German user watches a YouTube video, rates it, then comments.
- Video = +1 comment, +1 view, +1 rating



- Definition: The system will continue to function when network partitions occur.
- Most important desirable property for wide-area databases (across geographies)
- Rarest of the 3 desirable properties
  - Must have a distributed and partitioned database

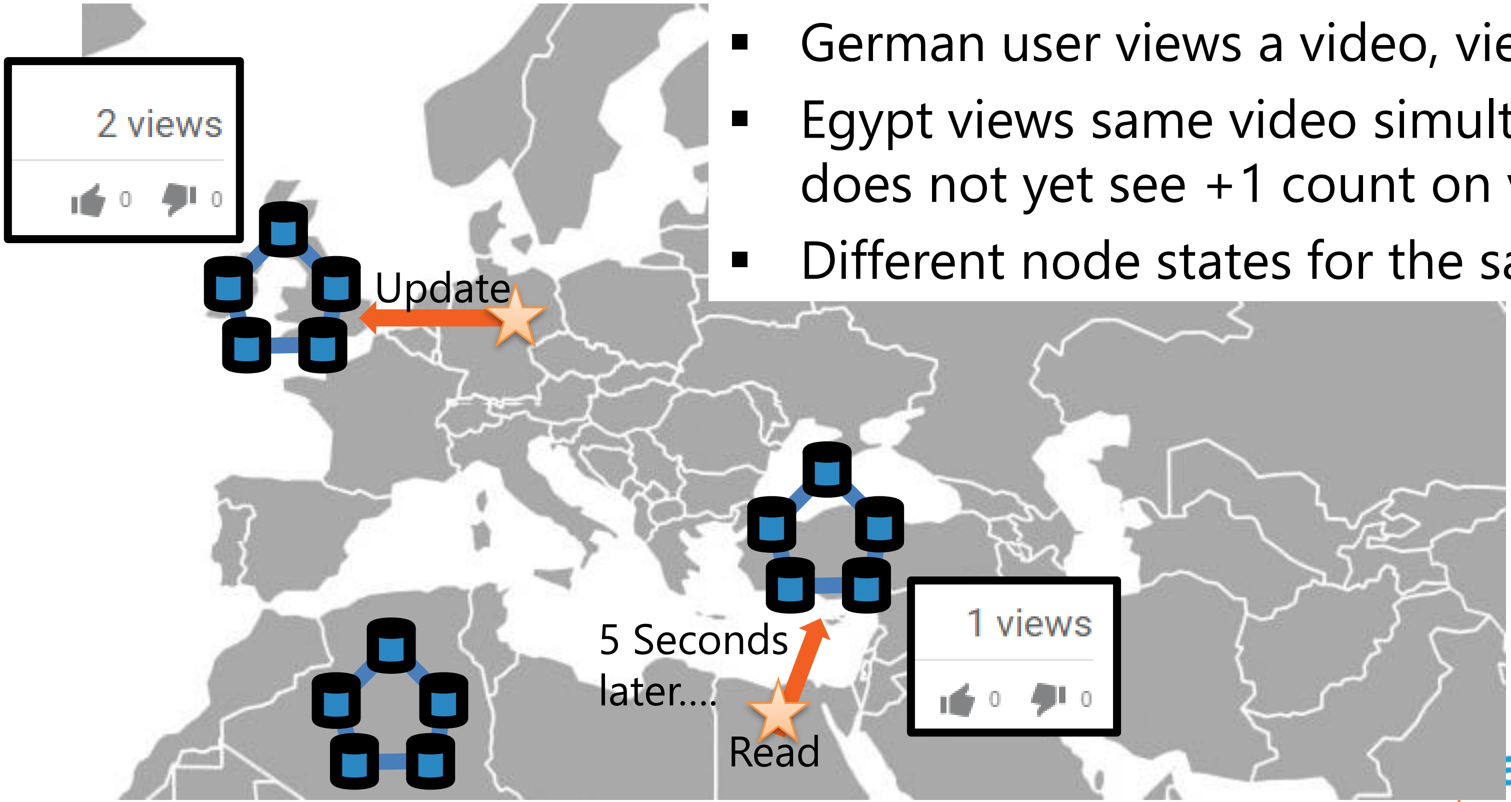
datasciencedojo
unleash the data scientist in you

CAP Theorem

- It is impossible for a distributed processing system to simultaneously provide all three of the following guarantees
  - **Consistency** - A read is guaranteed to return the most recent write for a given client.
  - **Availability** - A non-failing node will return a reasonable response within a reasonable amount of time (no error or timeout).
  - **Partition Tolerance** - The system will continue to function when network partitions occur.

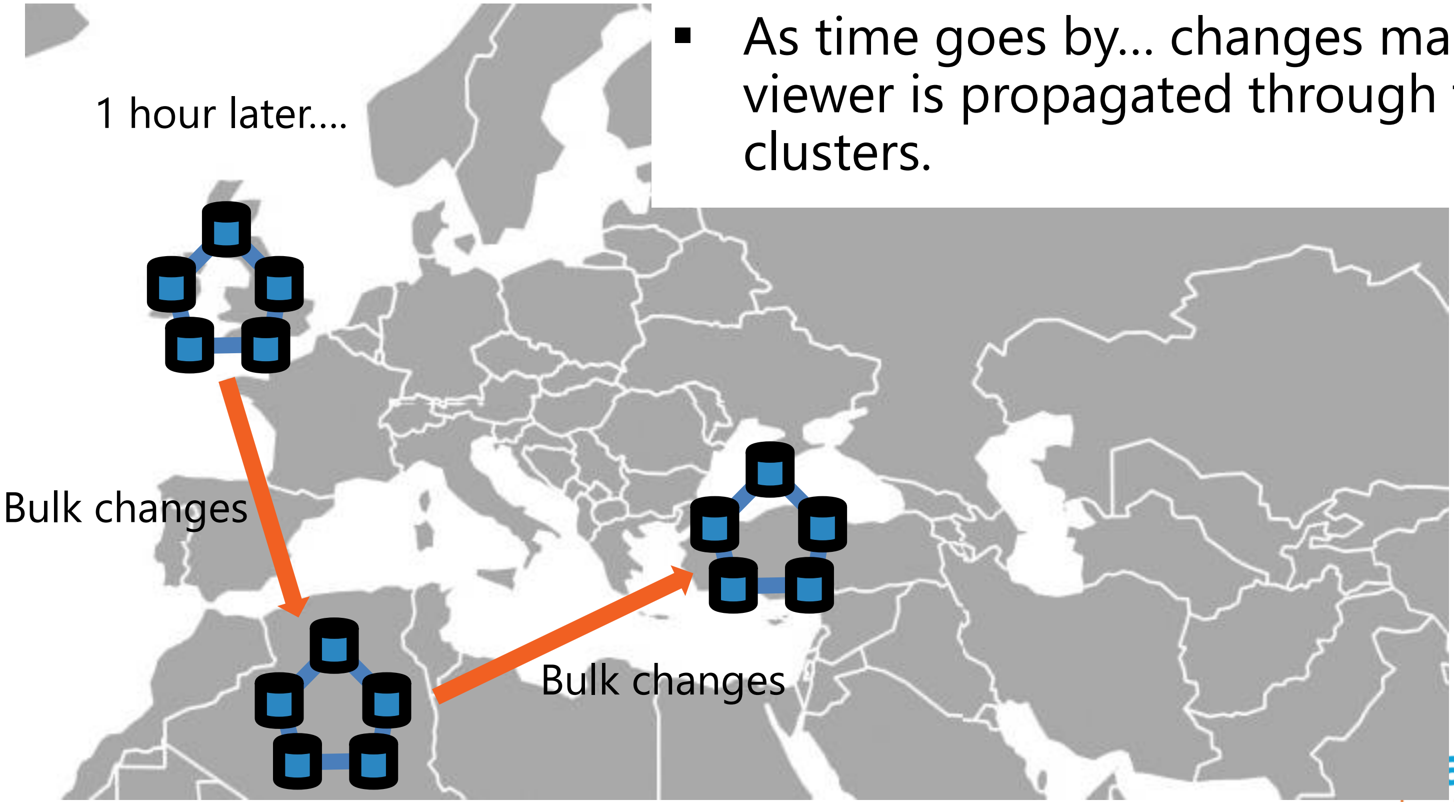
AP – Lack of (Immediate) Consistency

- German user views a video, view count +1
- Egypt views same video simultaneously, does not yet see +1 count on video
- Different node states for the same record



AP – Eventual Consistency

- As time goes by... changes made by German viewer is propagated through the other DB clusters.

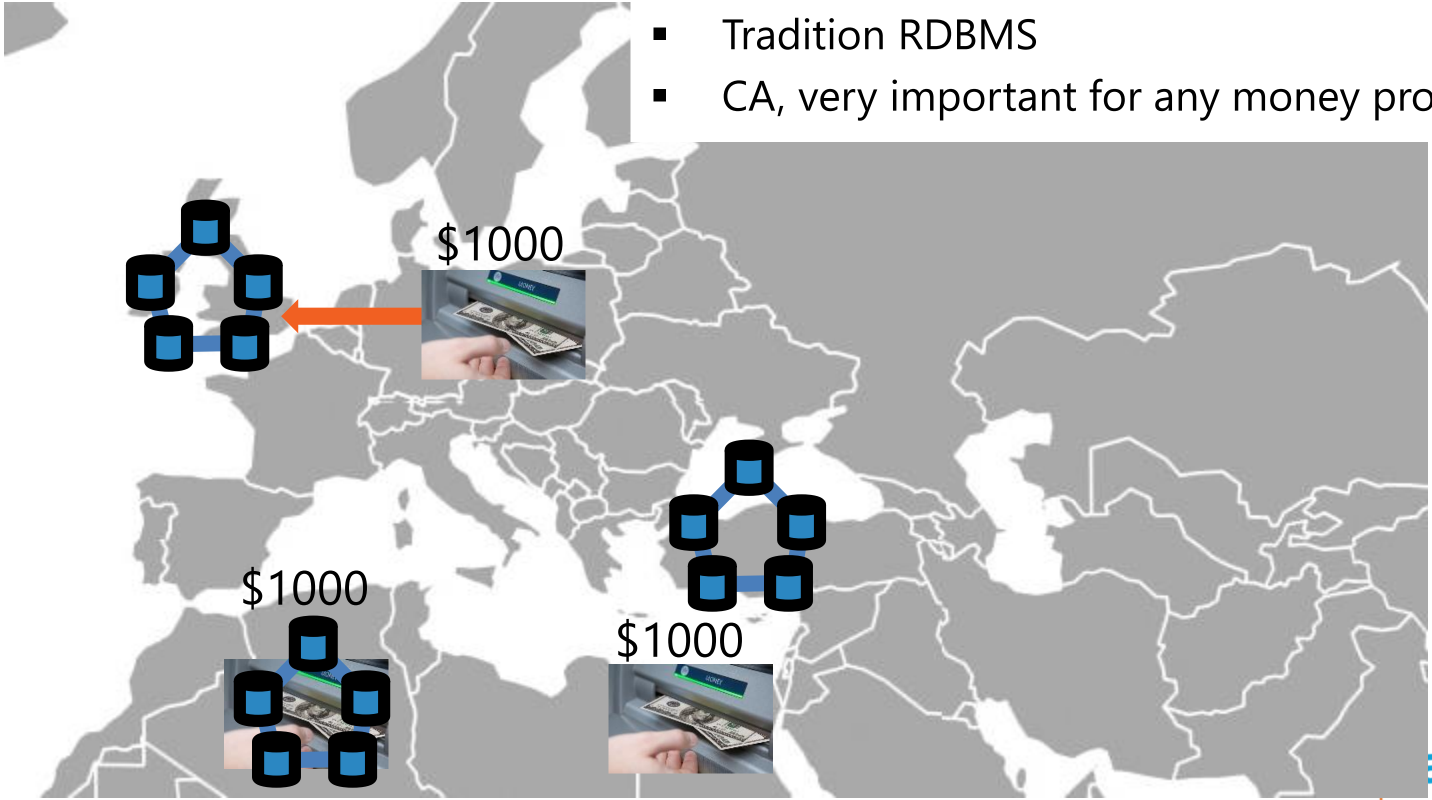


ATMs

unleash the data scientist in you

Why Consistency Matters

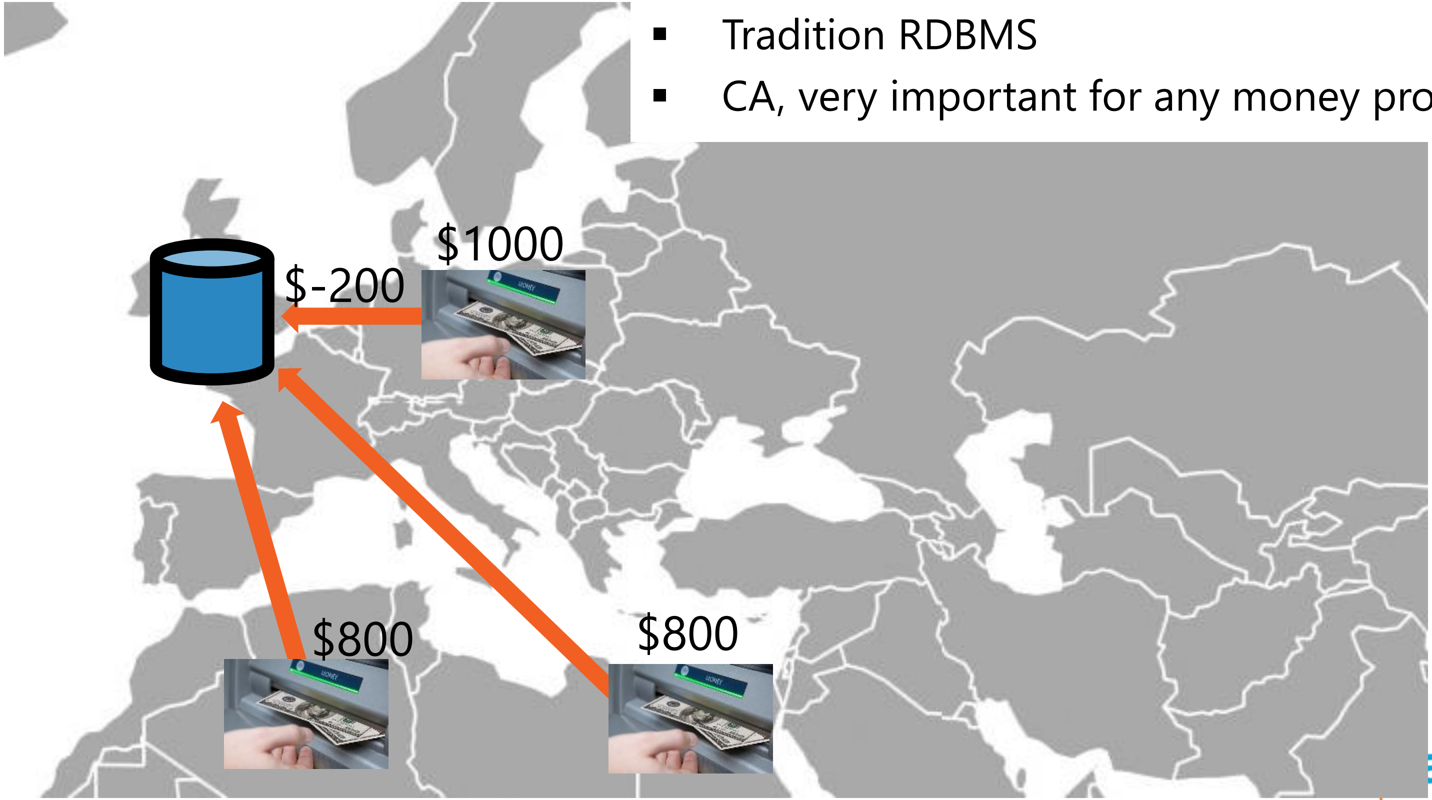
- Tradition RDBMS
- CA, very important for any money processing



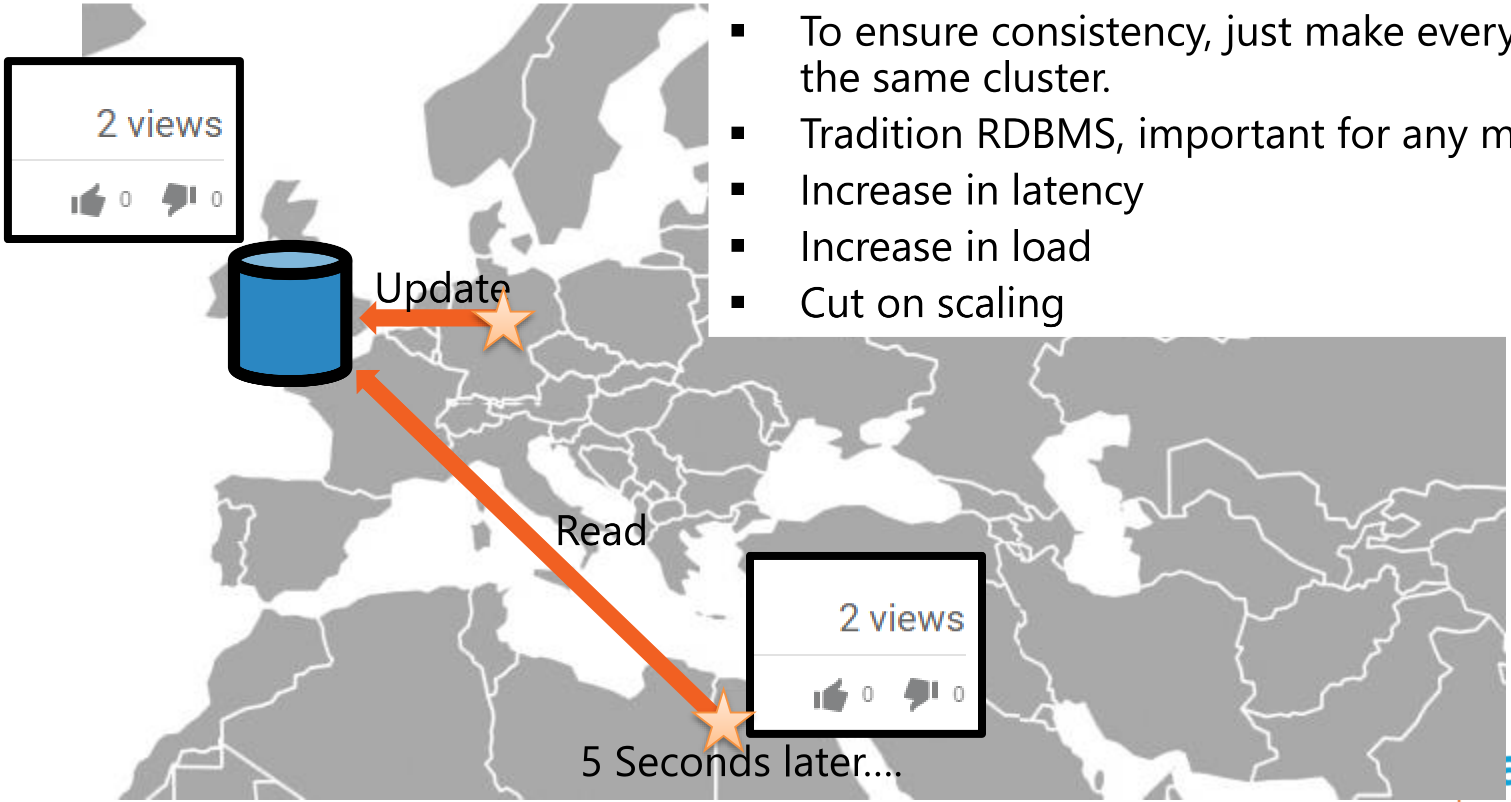
asciencedojo
unleash the data scientist in you

Why Consistency Matters

- Tradition RDBMS
- CA, very important for any money processing

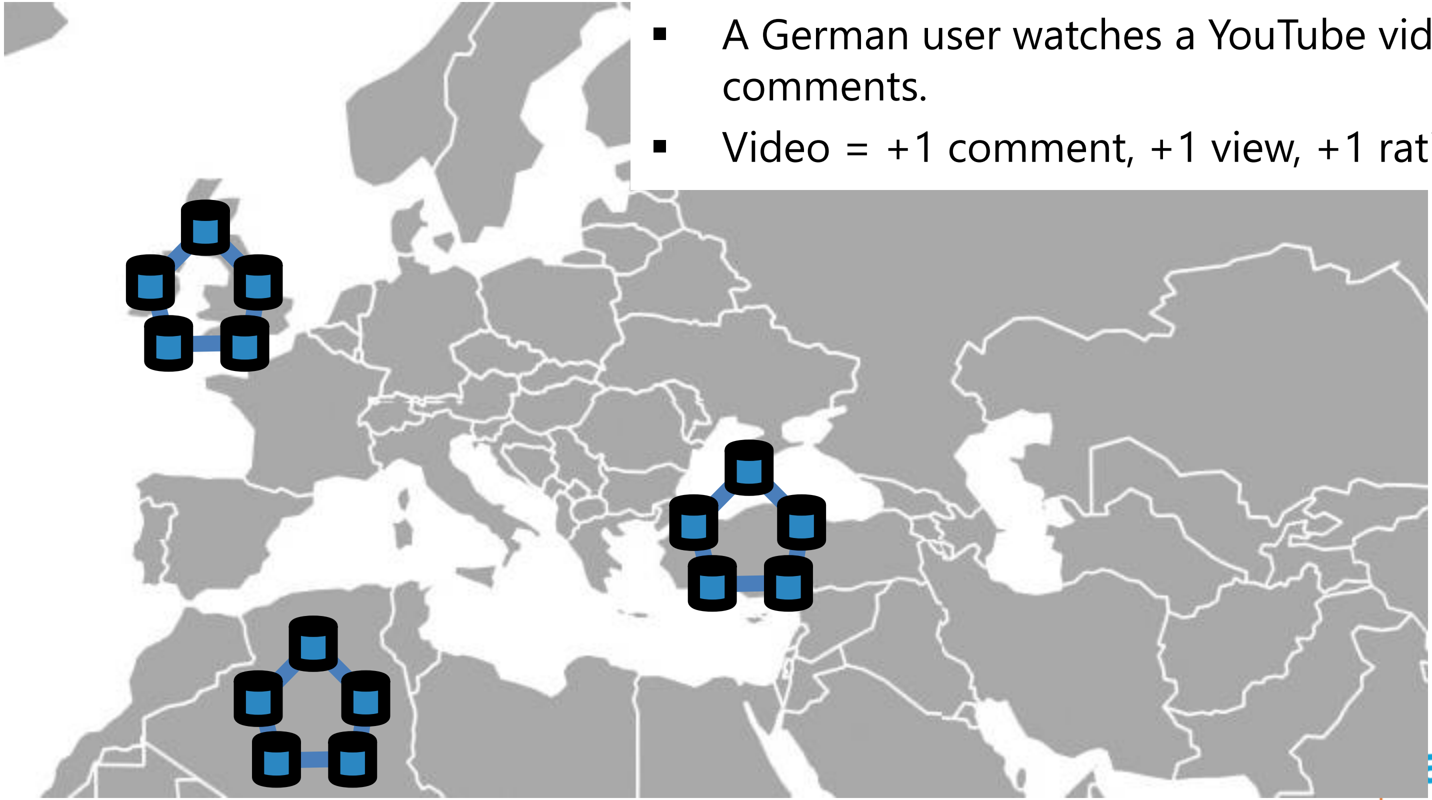


CA – Lack of Partition Tolerance



- To ensure consistency, just make everyone read from the same cluster.
- Tradition RDBMS, important for any money processing
- Increase in latency
- Increase in load
- Cut on scaling

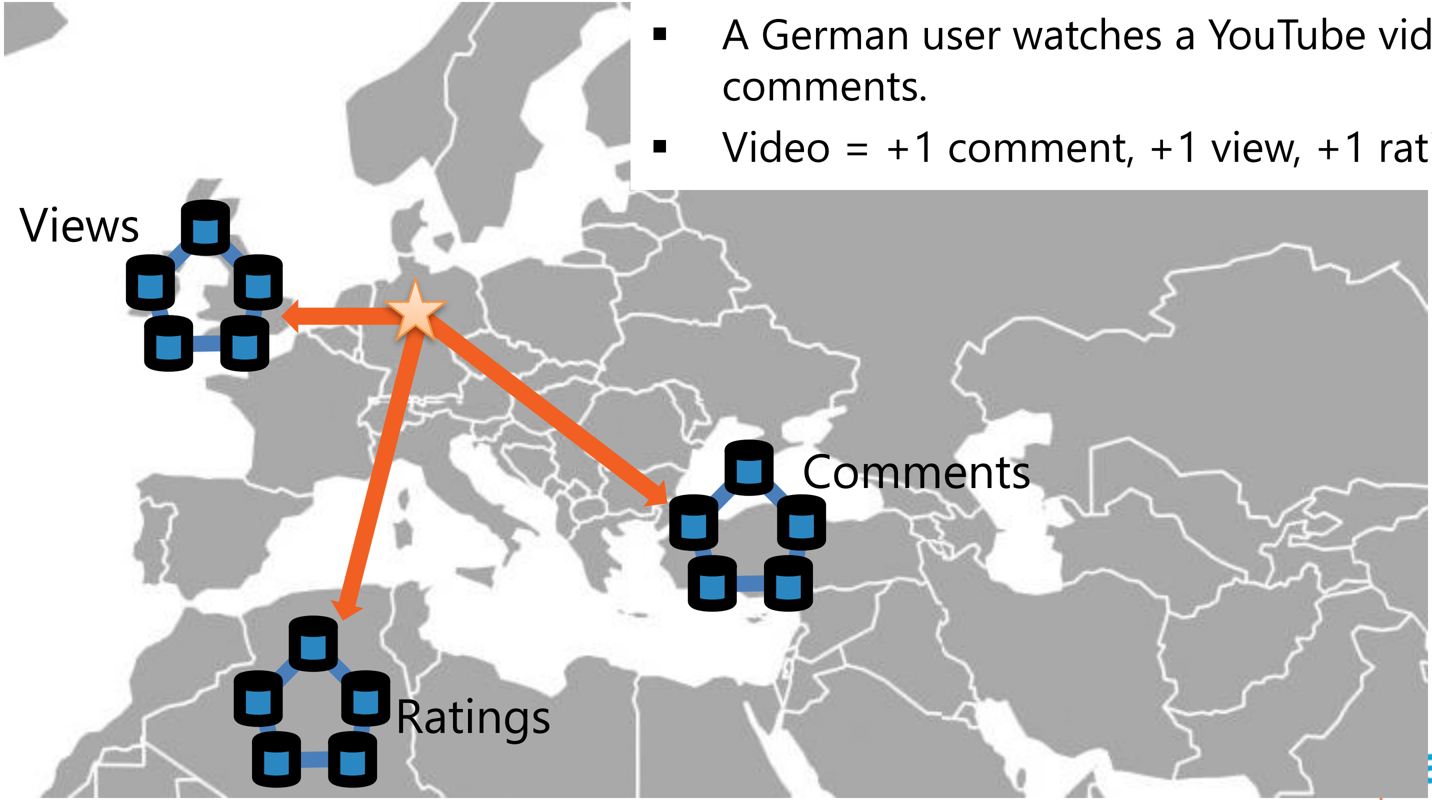
Consistency + Partitions?



- A German user watches a YouTube video, rates it, then comments.
- Video = +1 comment, +1 view, +1 rating

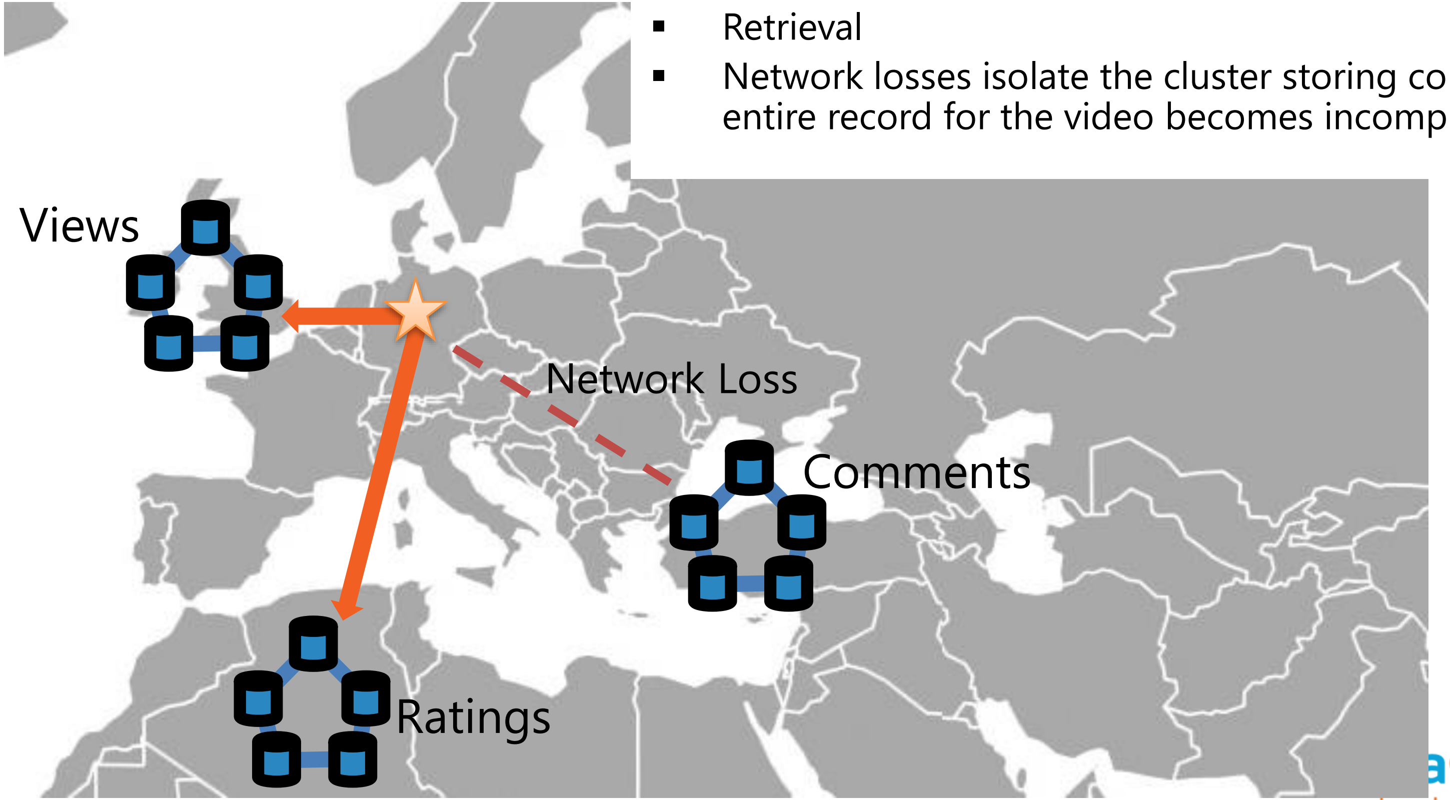
Consistency + Partitions?

- A German user watches a YouTube video, rates it, then comments.
- Video = +1 comment, +1 view, +1 rating



CP: Loss of Availability

- Retrieval
- Network losses isolate the cluster storing comments. The entire record for the video becomes incomplete (temporarily)



CAP Theorem

CAP provides the basic requirements for a distributed system to follow **2 of the 3 requirements.**

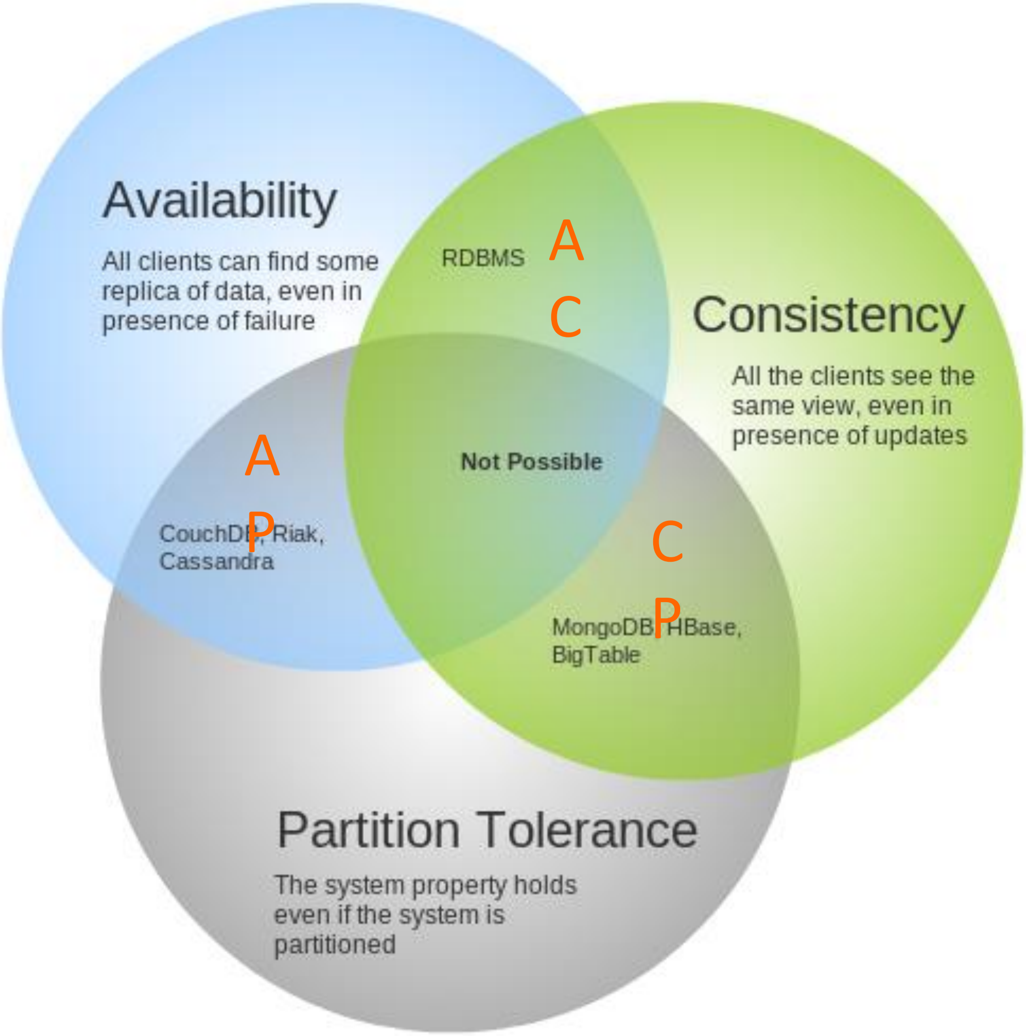
In theoretically it is **impossible** to fulfill all 3 requirements.

Therefore all the current NoSQL database follow the different **combinations of the C, A, P** from the CAP theorem.

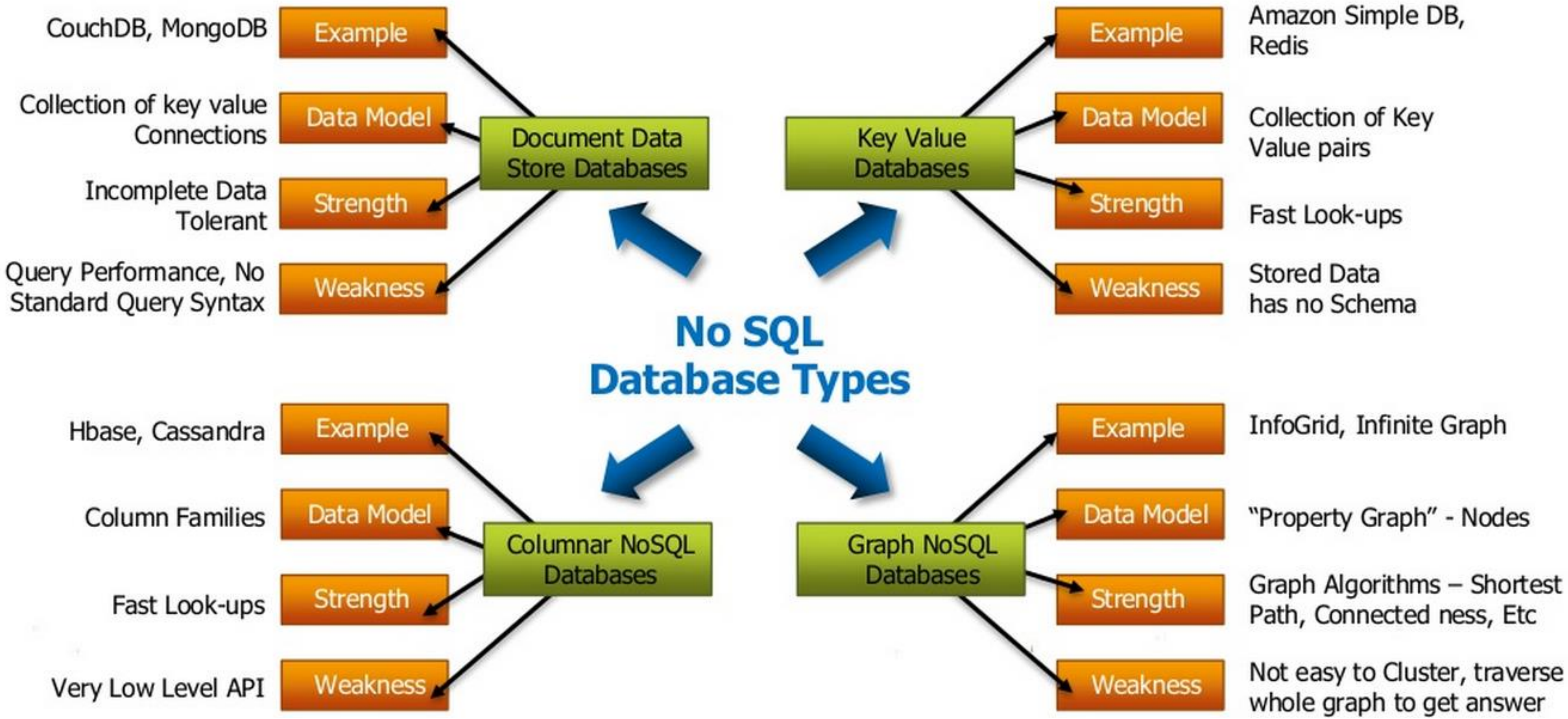
datasciencedojo
unleash the data scientist in you

NoSQL vs. SQL

- NoSQL
  - Availability first (Consistency second)
- SQL (Traditional RDBS databases)
  - Consistency first (Availability second)



Availability
All clients can find some replica of data, even in presence of failure
RDBMS
A
C
Consistency
All the clients see the same view, even in presence of updates
A
P
Not Possible
CouchDB, Riak, Cassandra
C
P
MongoDB, HBase, BigTable
Partition Tolerance
The system property holds even if the system is partitioned



datasciencedojo
unleash the data scientist in you

What is HBase

- Distributed, non-relational database
  - Columnar, schema-free data model
  - NoSQL on top of Hadoop
- Large scale
  - Linear scalability
  - Billions of rows X millions of columns
  - Many deployments with 1000+ nodes, PBs of data
- Low latency
  - Real-time random read/writes
- Open Source
  - Modeled after Google's BigTable
  - Started in 2006

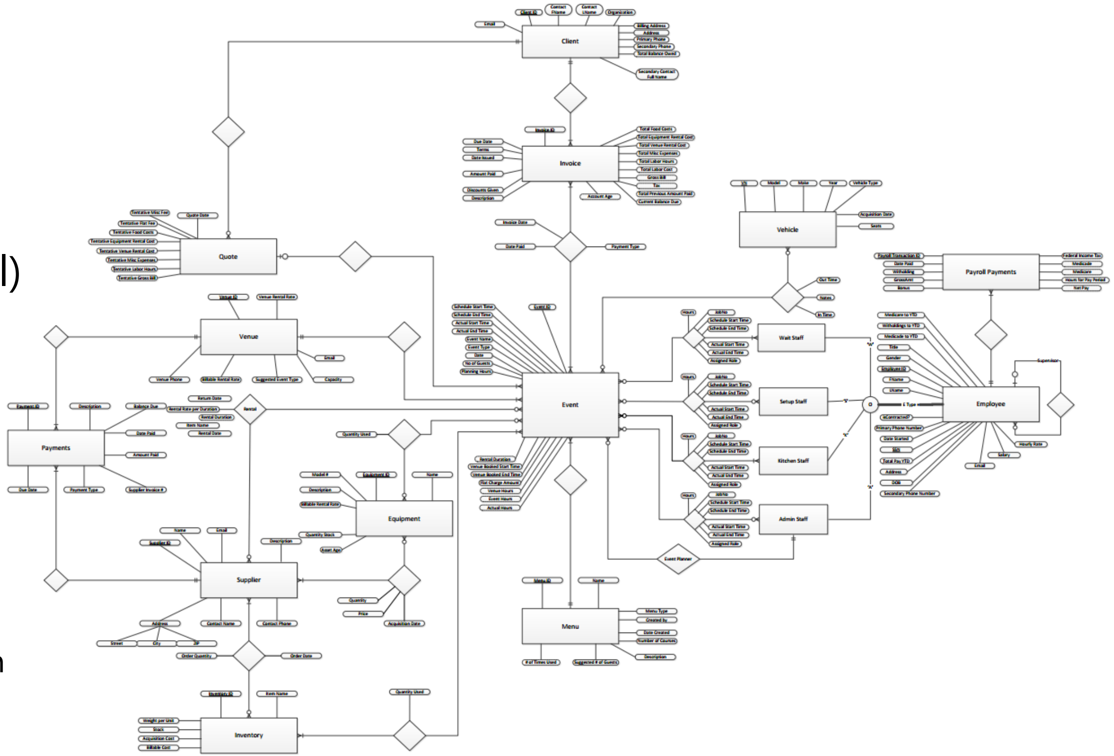
Problems with Schema

Pros:

- Relationships
- Consistency: Reading is easier to develop for (each column is guaranteed to be there, even null)

Cons:

- Records everything, even null
- Writes take longer
  - Schema validation against each insert
  - Writes can be rejected
- Rigid by design
  - Business processes change faster than databases can be architected and migrated



Row Store

Table

	Country	Product	Sales
Row 1	India	Chocolate	1000
Row 2	India	Ice-cream	2000
Row 3	Germany	Chocolate	4000
Row 4	US	Noodle	500

Pros:

- Fast record query
- Relationships
- Less redundancy
- Single line insert

Cons:

- Thin tables
- Getting a single column value, retrieves the entire record (even null)
  - Terrible with wide tables
- Aggregations must sift through all columns for each row

Columnar

Table

	Country	Product	Sales
Row 1	India	Chocolate	1000
Row 2	India	Ice-cream	2000
Row 3	Germany	Chocolate	4000
Row 4	US	Noodle	500

Pros

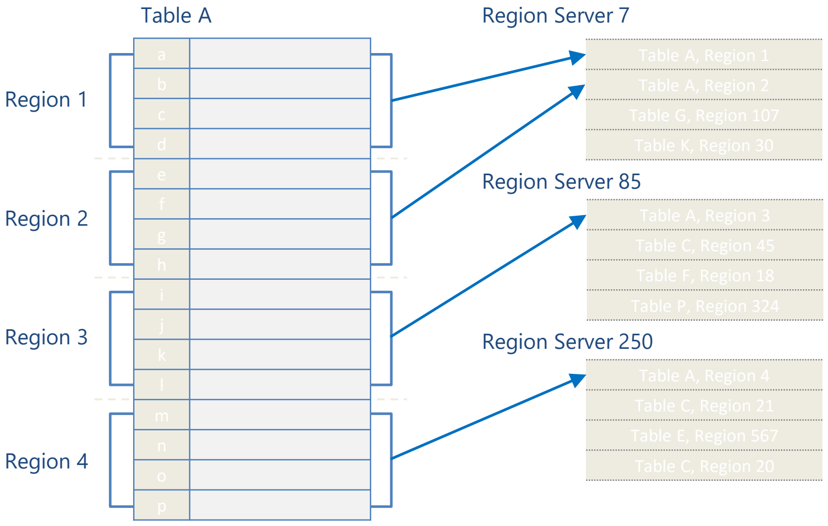
- High speed aggregations
- Compression
- Wide tables are now possible (billions of columns, instead of hundreds)
- High speed snap shot retrieval
- Easily Distributable

Cons

- Bad for record retrieval
- Terrible at relationships
- M line insert

Data Model

- Scale-out architecture
  - Automatic sharding of tables
  - Automatic failover
  - Strong consistency for reads and writes
- APIs
  - Get/Put
  - Scan
  - Coprocessors



datasciencedojo
unleash the data scientist in you

Performance Features

- Column Families
- In-memory caching
- High throughput streaming writes

Row Key	Customer		Sales	
Customer Id	Name	City	Product	Amount
101	John White	Los Angeles, CA	Chairs	$400.00
102	Jane Brown	Atlanta, GA	Lamps	$200.00
103	Bill Green	Pittsburg, PA	Desk	$500.00
104	Jack Black	St. Louis, MO	Bed	$1600.00

Column Families

Sharding

- Holding rows of database on different partitions
- Same table divided onto different servers, even different geographies
- Reduces index size

Sharding

- More reliance on interconnection between servers
- Increased latency in querying when more than one shard must be searched
  - Some searches are fast, others are slow
- Often no guarantees about cross shard consistency

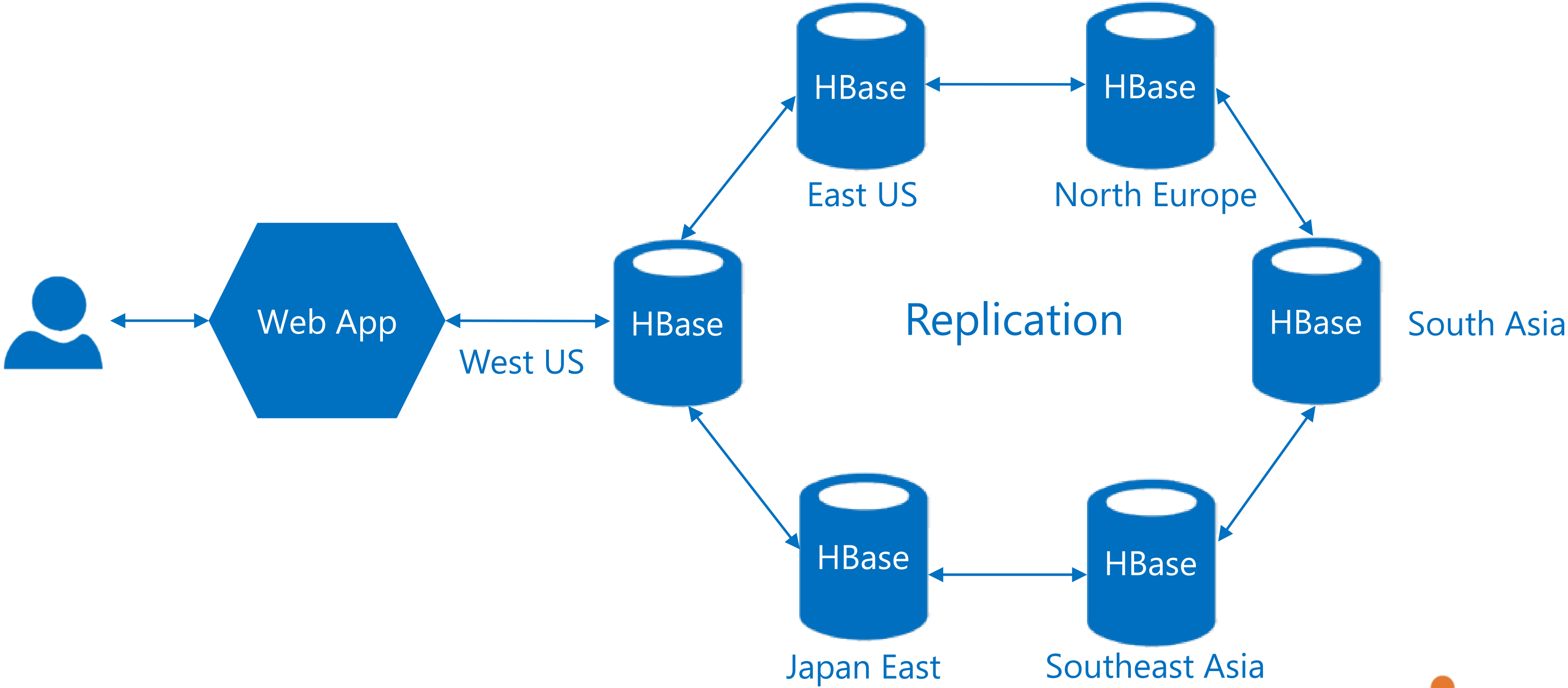
Notable Capabilities

- Integration features
  - Integration with Hadoop MapReduce, Hive, Tez, Spark (hardware pending)
  - Bulk import of large amounts of data
- Client APIs
  - Java, REST, python, node.js, php, .NET

Use case #1: key value store

- Key value store
  - Message systems
  - Content management systems
- Examples
  - Facebook Messages
  - Twitter-like messages
  - Webtable – web crawler/indexer

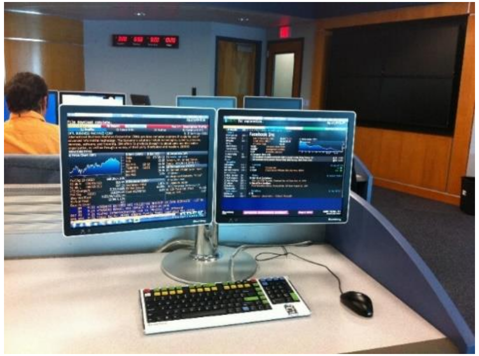
Use case #1: key value store

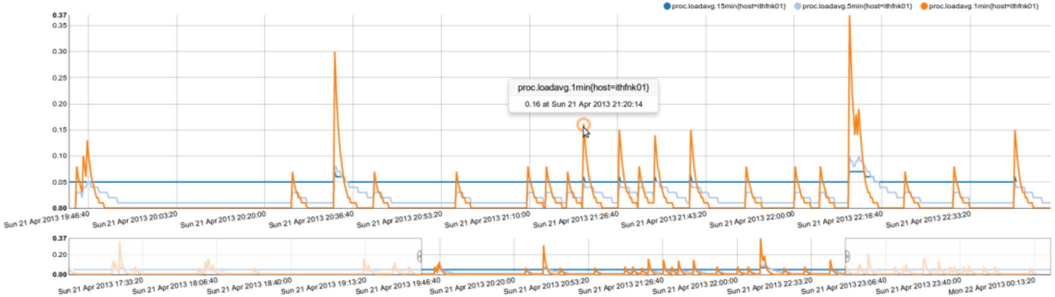


- Architecture

Use case #2: sensor data

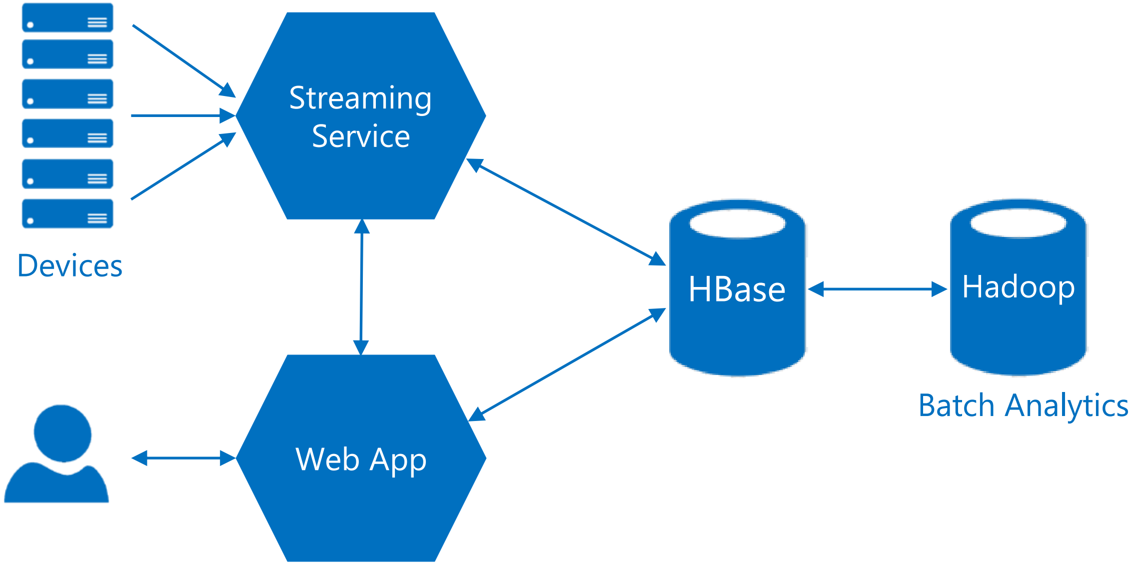
- Sensor data
  - Social analytics
  - Time series databases
  - Interactive dashboards with trends, counters, etc
  - Audit log systems





unleash the data scientist in you

Use case #2: sensor data



- Architecture

Questions?