# NoSQL and MongoDB

## NoSQL vs SQL, MongoDB


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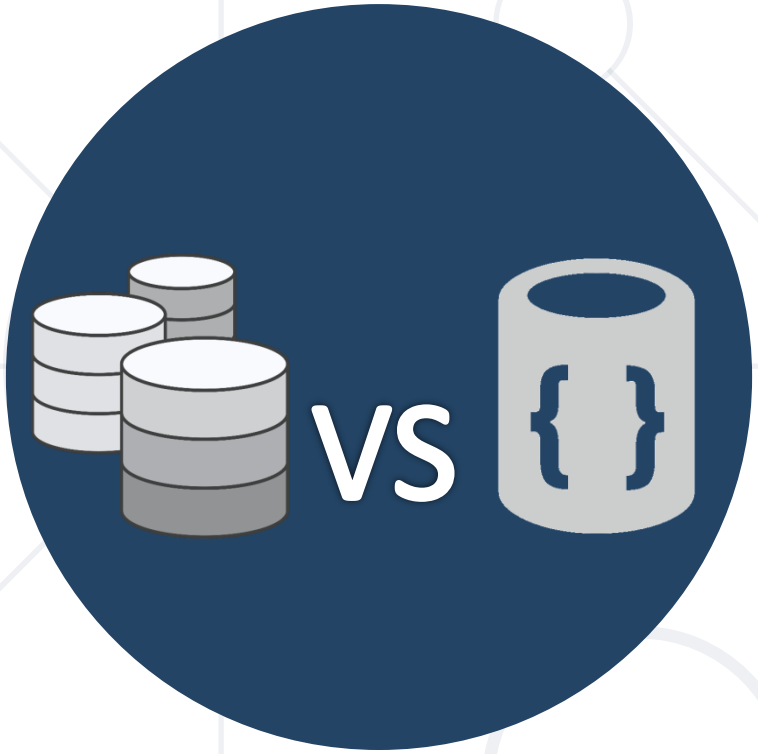
## sli.do

# #csharp-db




# Relational and Non-Relational Databases

## Differences and Examples

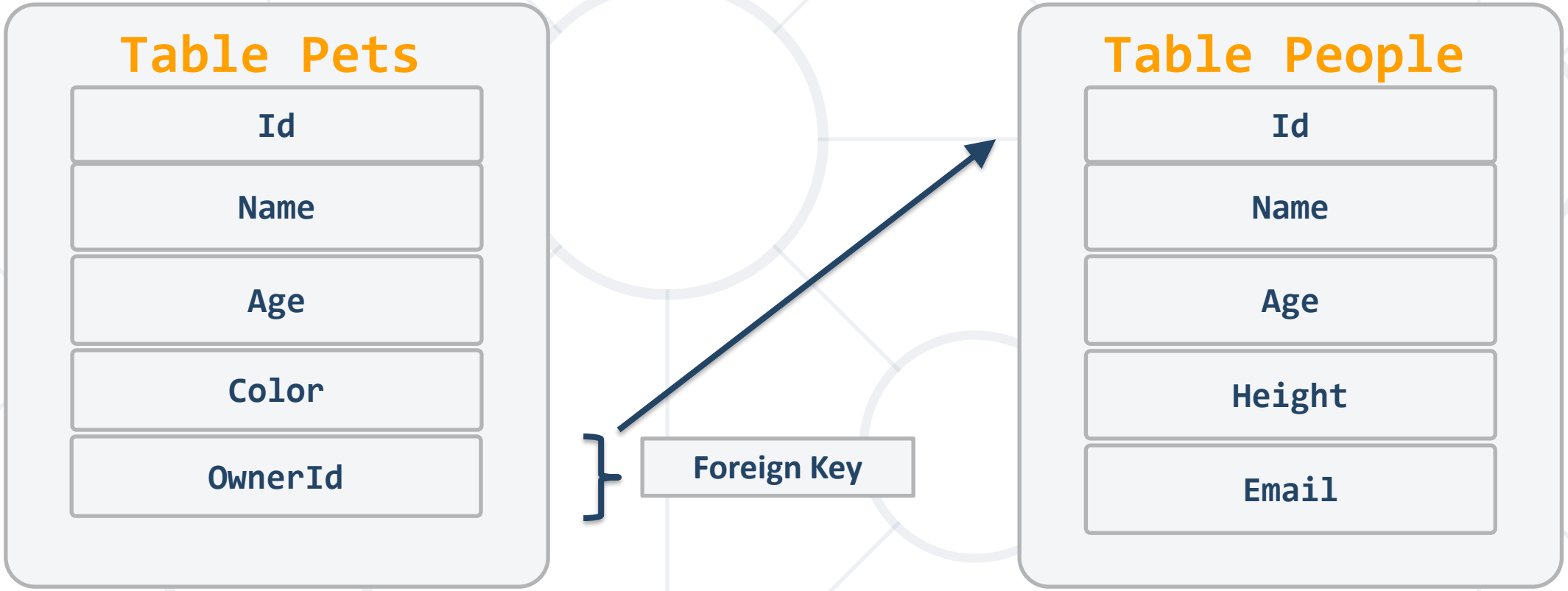
# Relational Database

- Organizes data into one or more **tables** of **columns** and **rows**
- Unique **key** identifying each **row** of data
- Almost all relational databases use **SQL** to **extract** data

```
SELECT * FROM Students
```

- **Relations** between tables are done using **Foreign Keys (FK)**
- Such databases are **Oracle**, **MySQL**, **SQL Server**, etc..

# Relational Database - Example



# Non-relational Database (NoSQL)

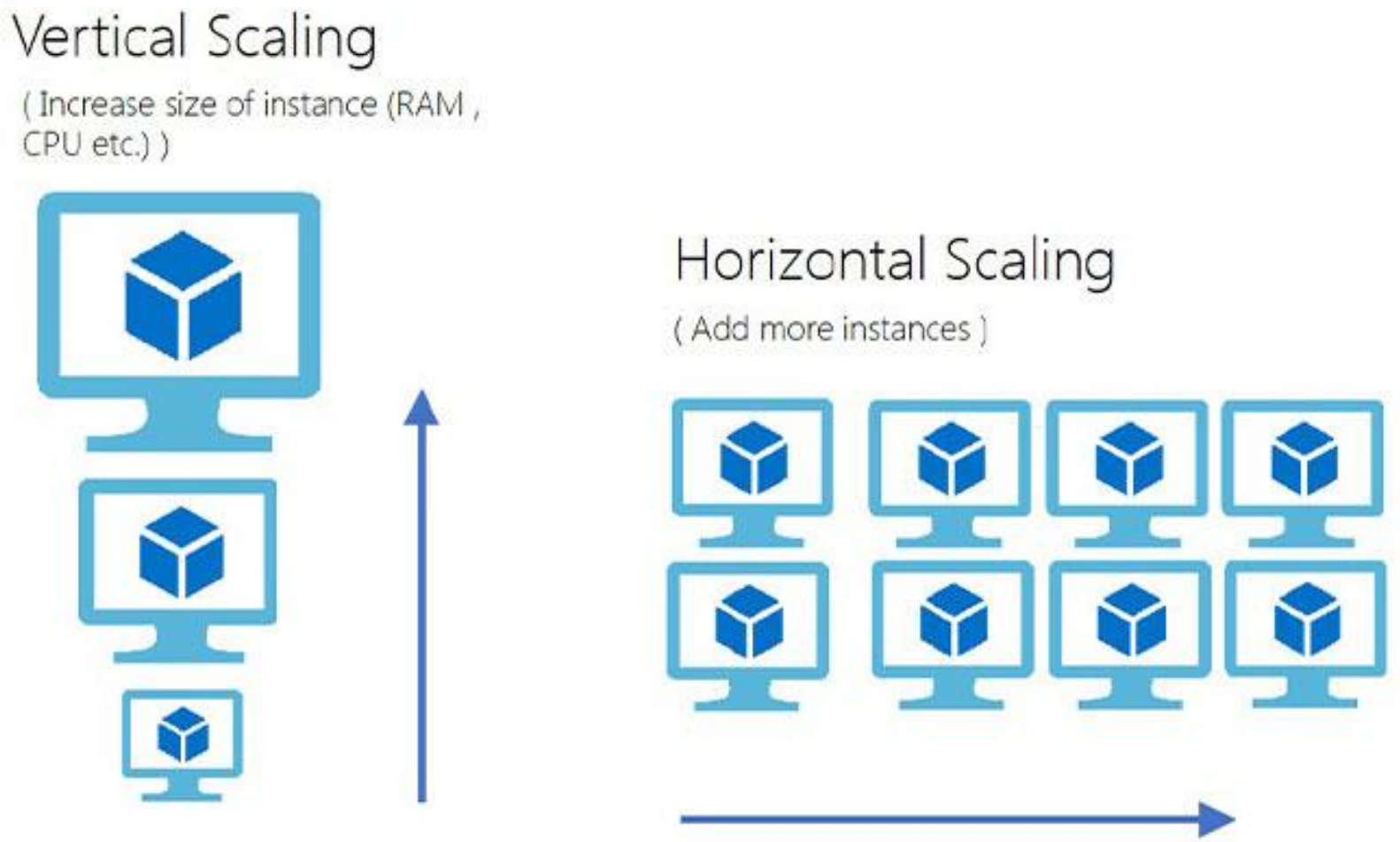
- NoSQL Databases are non tabular, and store data differently than relational tables
- Key-value **stores**

```
{
    "_id": ObjectId("59d3fe7ed81452db0933a871"),
    "email": "peter@gmail.com",
    "age": 22
}
```

- **SQL** query is **not** used in NoSQL systems
- More **scalable** and **provide** superior **performance**

# Database Scalability

# Database Scalability (1)



# Database Scalability (2)

- The ability of a system's database to **scale up or down**, depending on the requirements
  - Enables the database to grow to a larger size to support more transactions
  - There are two types of database scalability
    - Vertical Scaling or Scale-up
    - Horizontal Scaling or Scale-out

# Vertical Scaling

- Refers to the process of adding more physical resources to the existing database server for improving the performance such as
  - Storage
  - Memory
  - CPU
- Helps in upgrading the capacity of the existing database server

# Vertical Scaling Pros and Cons

- **Pros**
  - It consumes less power
  - You need to handle and manage just one system
  - Cooling costs are less than horizontal scaling
  - Implementation isn't difficult
- **Cons**
  - Risk of hardware failure which can cause bigger outages
  - Limited scope of upgradeability in the future

# Horizontal Scaling

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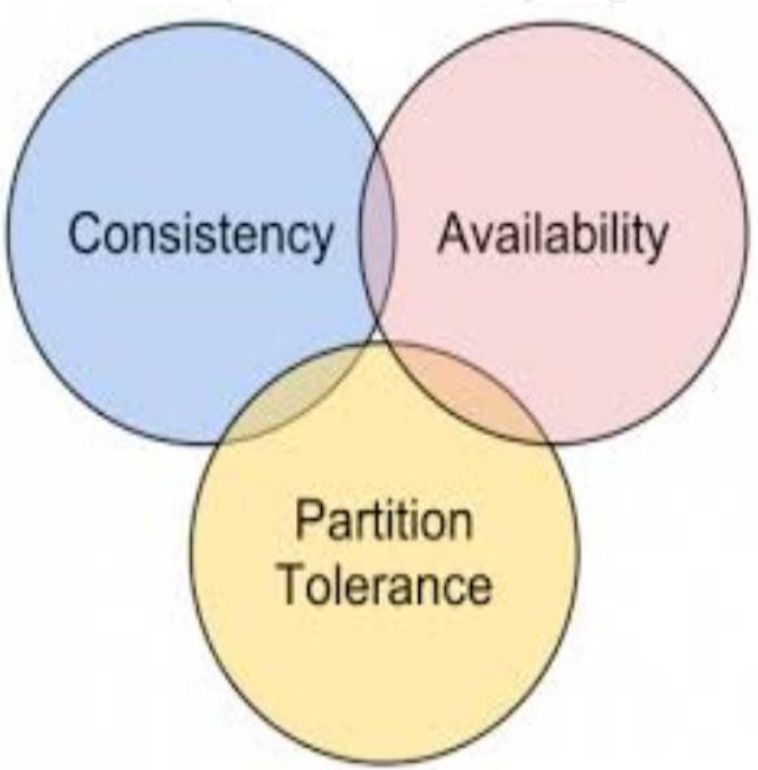
- Adds more servers with less RAM and processors
  - The ability to **increase the capacity** by connecting multiple software or hardware entities in a such manner that they function as a single logical unit
  - If a cluster requires more resources to improve its performance and provide high availability, then **the administrator can scale-out by adding more servers** to the cluster

# Horizontal Scaling Pros and Cons

- **Pros**
  - Easy to upgrade
  - Resilience is improved due to the presence of discrete, multiple systems
  - Supports linear increases in capacity

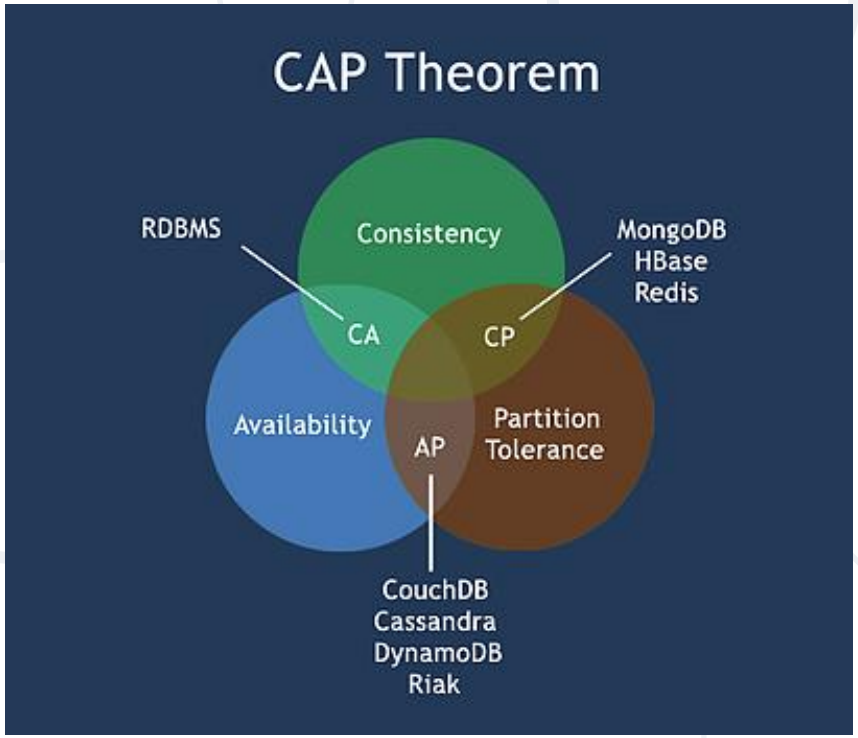
- **Cons**
  - It has a bigger footprint in the Data Center
  - Adds complexity to the system
  - Introduces data syncing problems
  - Dependent on the CAP theorem



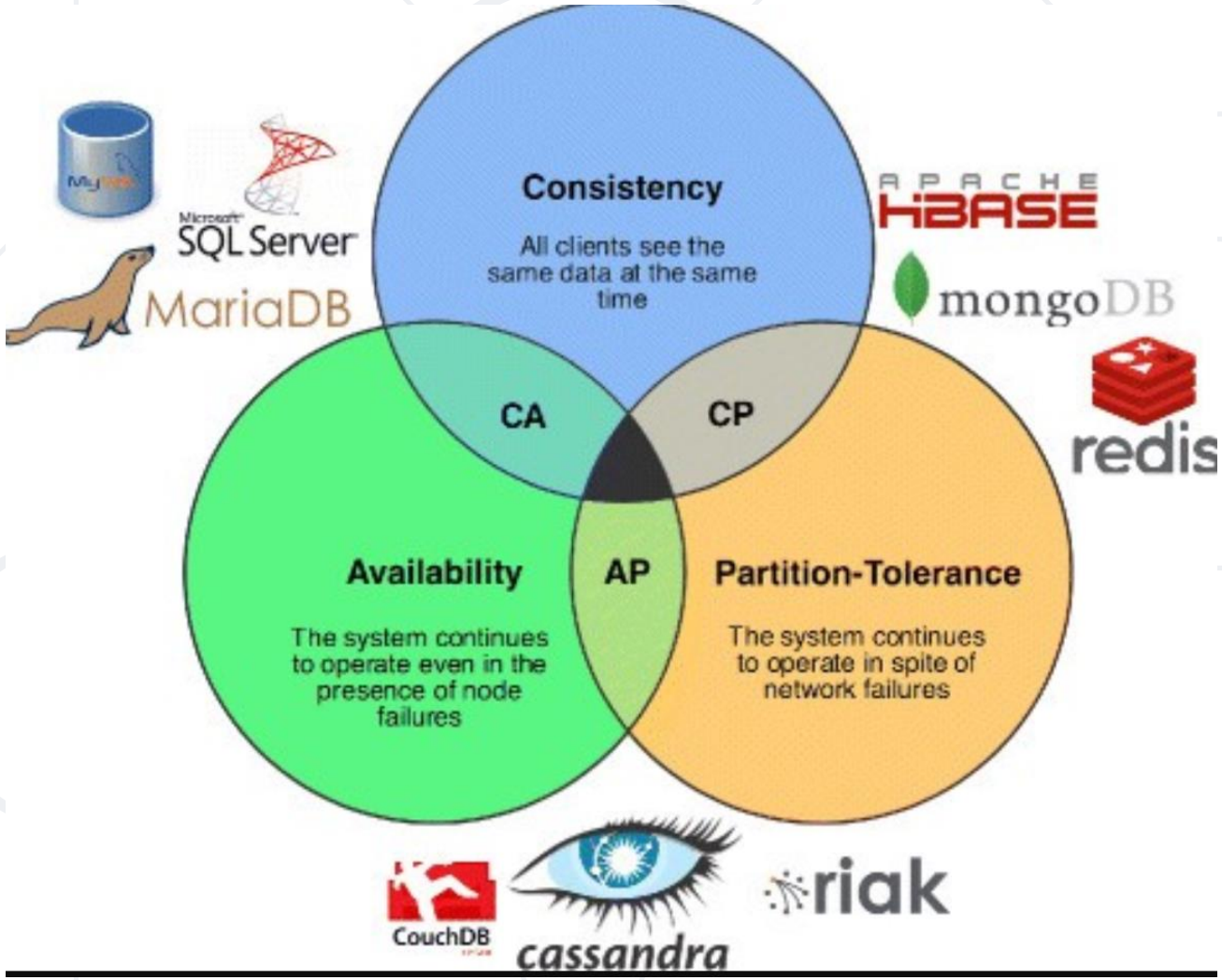

# CAP Theorem

# What is the CAP Theorem?

- The CAP theorem states that a distributed system can deliver **only two of three** desired characteristics
  - Consistency
  - Availability
  - Partition tolerance



# CAP


Consistency
All clients see the same data at the same time
Availability
The system continues to operate even in the presence of node failures
Partition-Tolerance
The system continues to operate in spite of network failures
CA
CP
AP
MariaDB
SQL Server
APACHE HBASE
mongoDB
redis
CouchDB
cassandra
riak

# The 'CAP' in the CAP Theorem, Explained (1)

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- Consistency
  - All clients see the same data at the same time, no matter which node they connect to
    - Whenever data is written to one node, it must be instantly forwarded or replicated to all the other nodes in the system before the write is deemed 'successful'

# The 'CAP' in the CAP Theorem, Explained (2)

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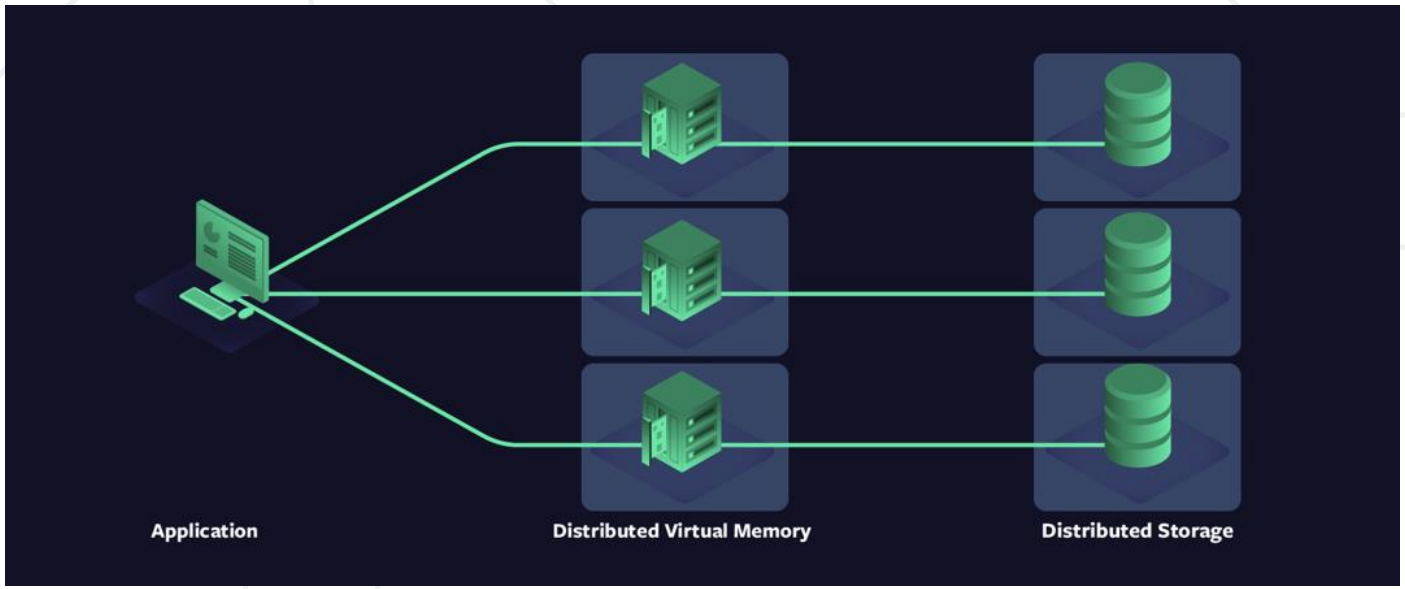
- Availability
  - Any client making a request for data gets a response, even if one or more nodes are down
- Partition tolerance
  - The cluster must continue to work despite any number of communication breakdowns between nodes in the system

# Distributed Systems

# Distributed Systems

- A network that stores data on more than one physical or virtual machines at the same time
- NoSQL databases are often distributed, and the data is stored on multiple computers



# 8 Fallacies of Distributed Systems

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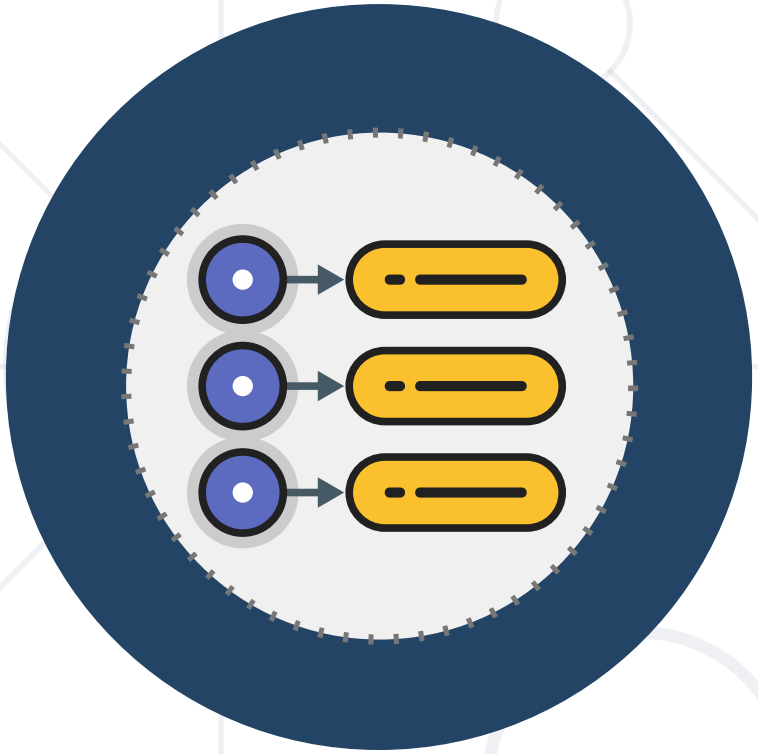
- The 8 fallacies are
  - The network is reliable
  - Latency is zero
  - Bandwidth is infinite
  - The network is secure
  - Topology doesn't change
  - There is one administrator
  - Transport cost is zero
  - The network is homogeneous

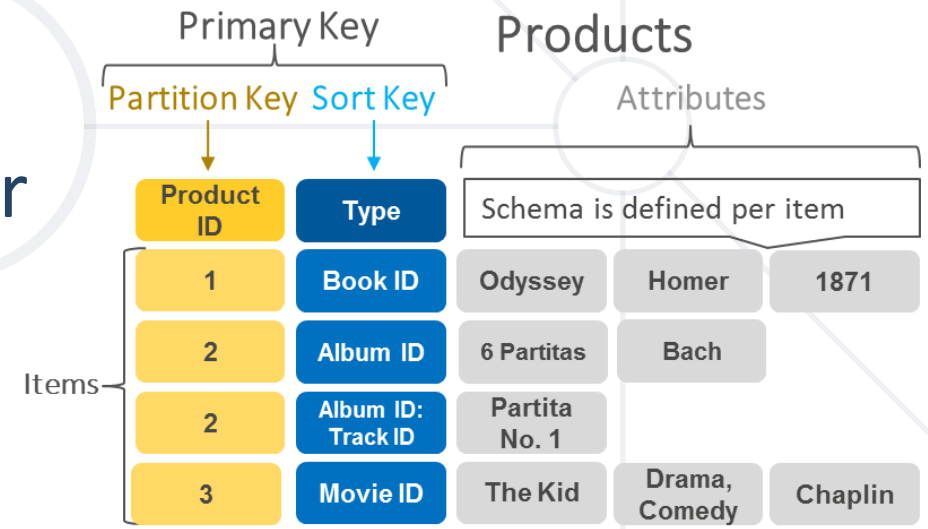
# Cats and Fallacies



# Key-Value Databases

# Key-Value Databases

- Key-value databases work by storing and managing associative arrays
  - Keys serve as a unique identifier to retrieve an associated value
  - Values can be anything from simple objects, like integers or strings, to more complex objects



# Document-Oriented Databases

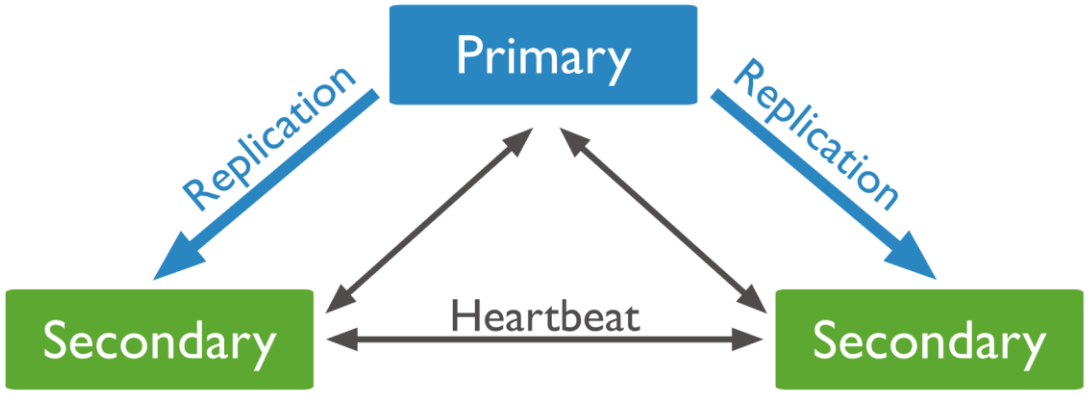
# Document-Oriented Databases

- Document-oriented databases, or document stores, are NoSQL databases that store data in the form of documents
  - Document stores are a type of key-value store
    - Each document has a unique identifier
    - Document itself serves as the value
  - Usually stored as JSON, XML, Proto-Buff, etc.

```
{
    "FirstName": "Bob",
    "Address": "5 Oak St.",
    "Hobby": "sailing"
}
```

# Replication

- A **replica** set is a group of mongod instances that maintain the same data set
- If the primary is unavailable, an eligible secondary will hold an election to elect itself the new primary
- All reads and writes happen from the primary (configurable)

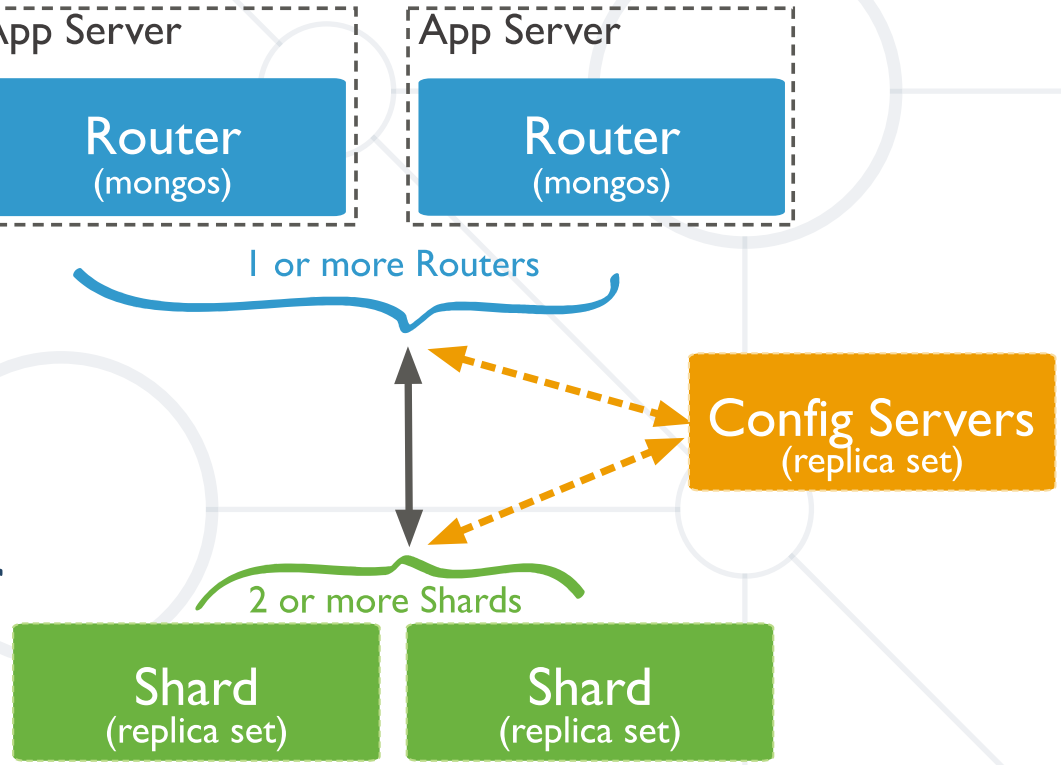


# Sharding

- **Sharding** is a method for distributing data across multiple machines
- MongoDB uses sharding to support deployments with very large data sets and high throughput operations
- Database systems with large data sets or high throughput applications can challenge the capacity of a single server

# Sharded Cluster

- A MongoDB **sharded cluster** consists of the following components
  - **Shard** – each contains a subset of the sharded data
  - **Mongos** - a query router, providing an interface between client applications and the sharded cluster
  - **Config Servers** - store metadata and configuration settings for the cluster



# Sharding

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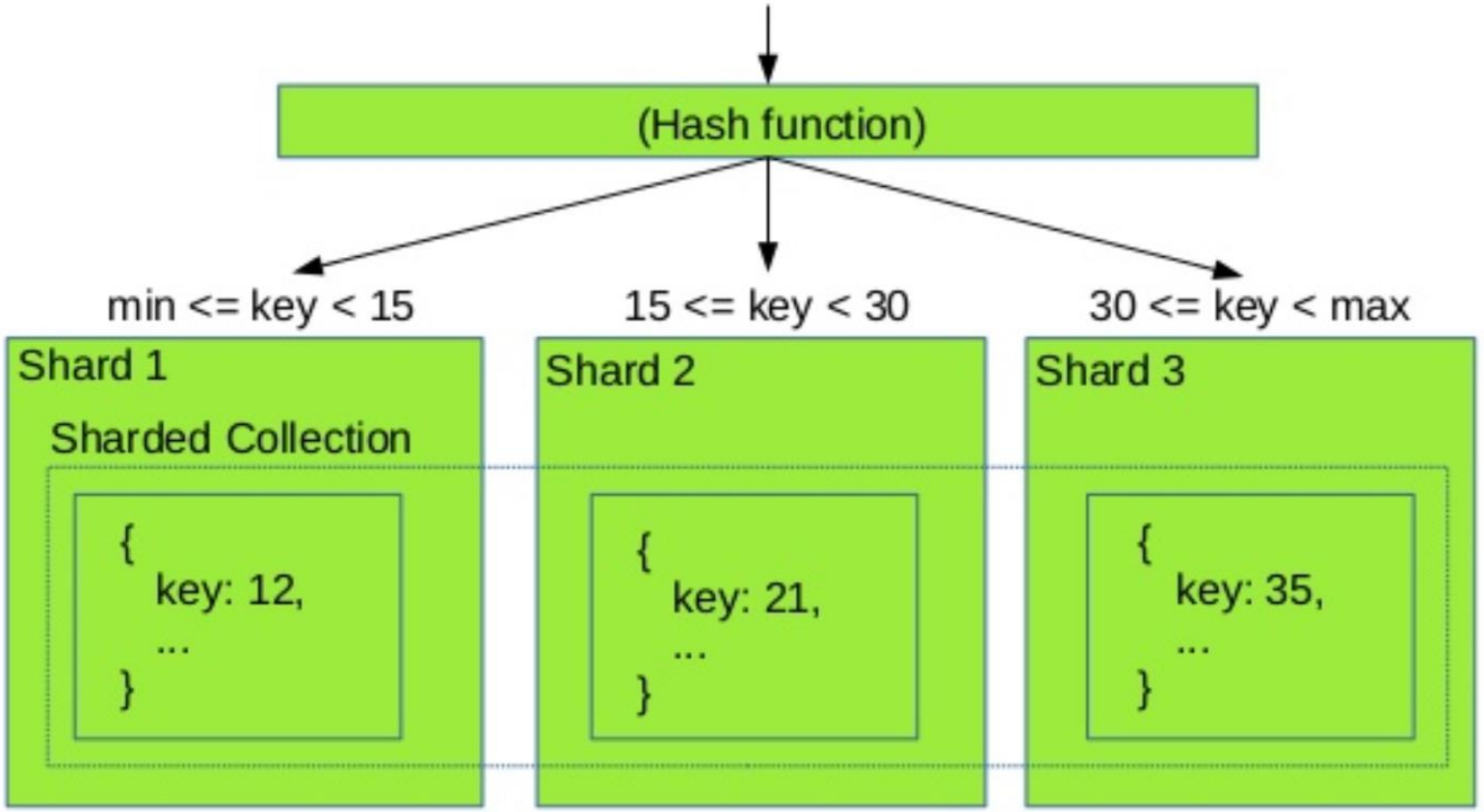
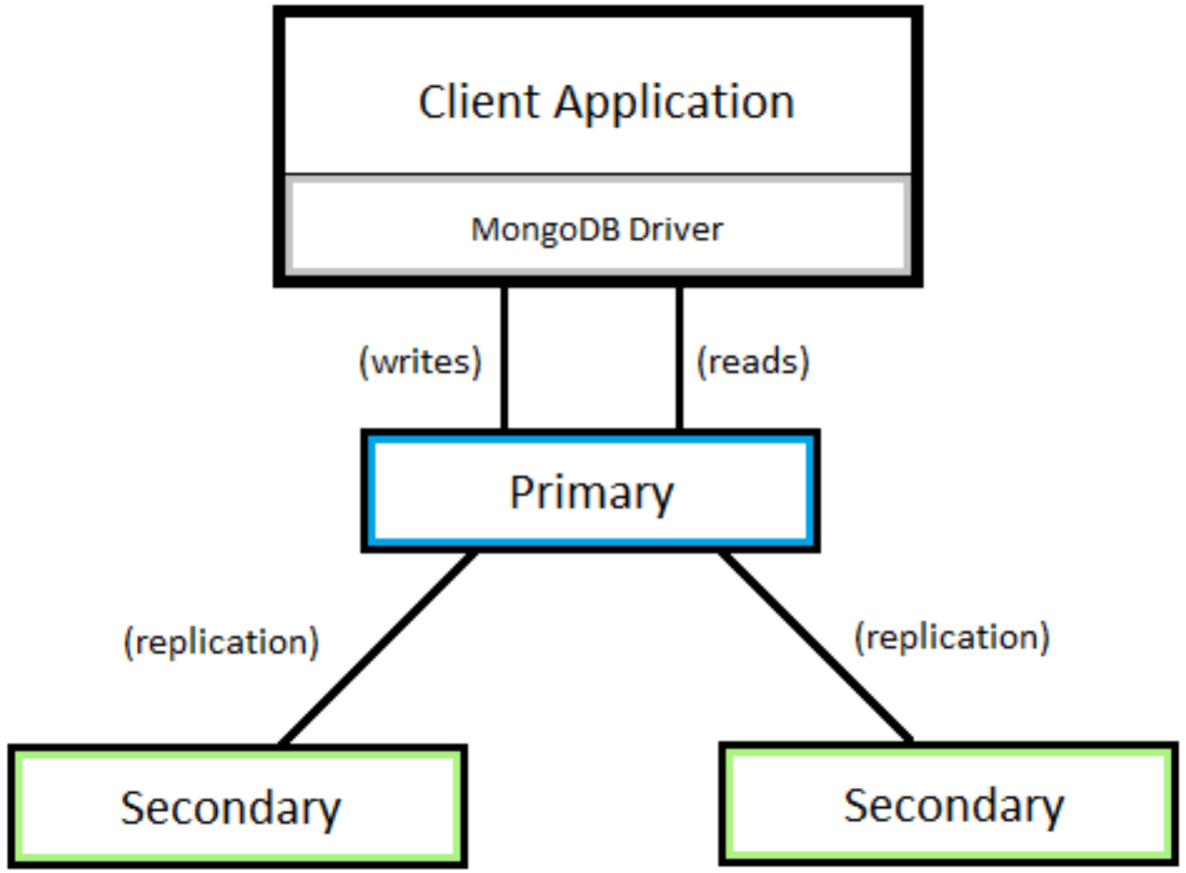
## MongoDB

### Shard key selection



# Replication



# Columnar Databases

# Columnar Databases (1)

- Columnar databases, are database systems that store data in columns
  - Each column is stored in a separate file or region in the system's storage
  - Examples of columnar databases are Cassandra, Hbase, Redshift, etc.

Row-oriented (1)

| name | age | sex | zipcode |
|---|---|---|---|
| thomas | 18 | male | 1416 |
| martin | 33 | male | 1645 |
| bob | 25 | male | 1613 |

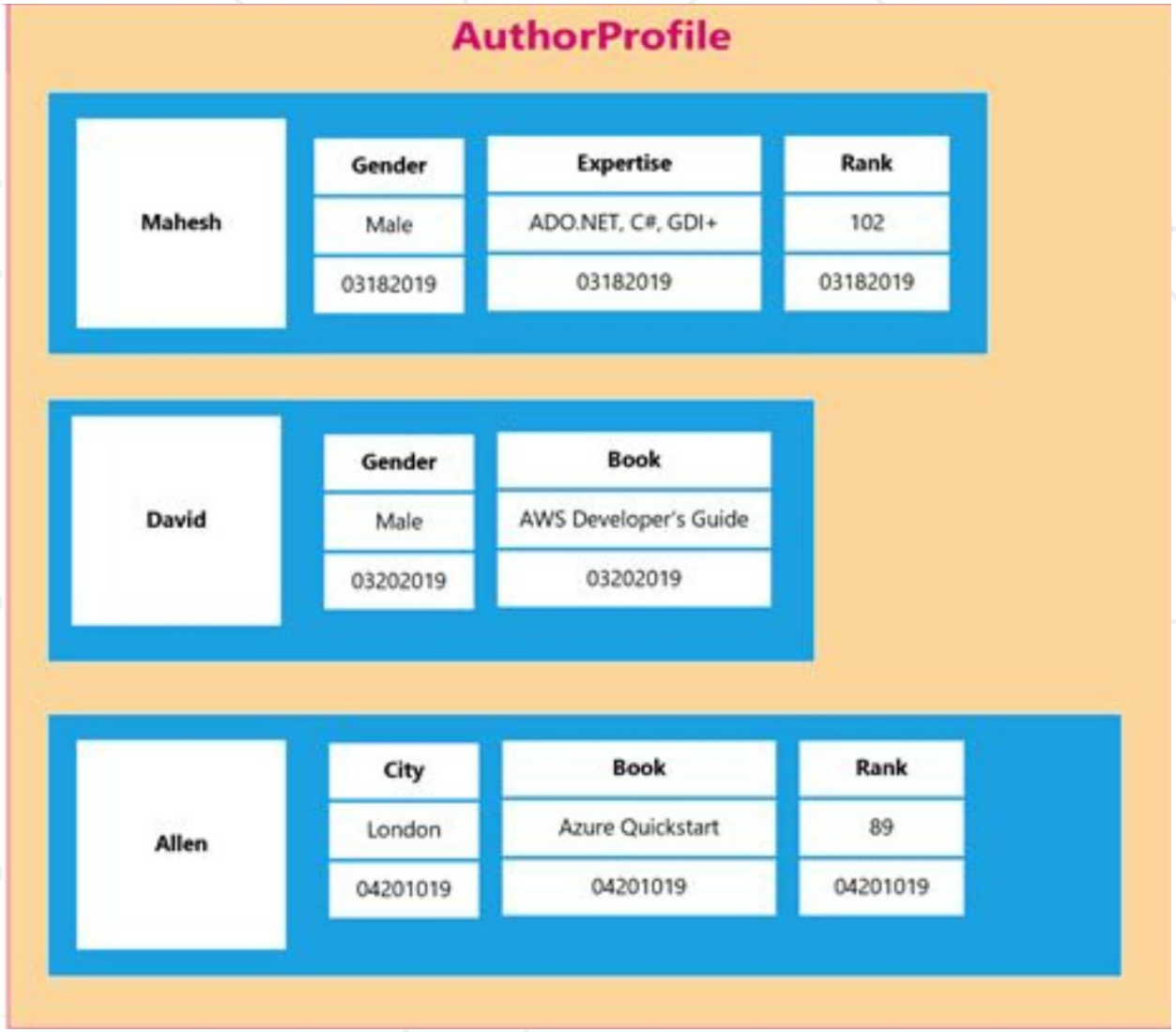
Column-oriented (2)

| name | age | sex | zipcode |
|---|---|---|---|
| thomas | 18 | male | 1416 |
| martin | 33 | male | 1645 |
| bob | 25 | male | 1613 |

# Columnar Databases (2)

- Key benefits of column store databases include faster performance in load, search, and aggregate functions
- Column-oriented organizations are more efficient when an aggregate needs to be computed over many rows but only for a notably smaller subset of all columns of data
- Not efficient when many columns of a row are required at the same time

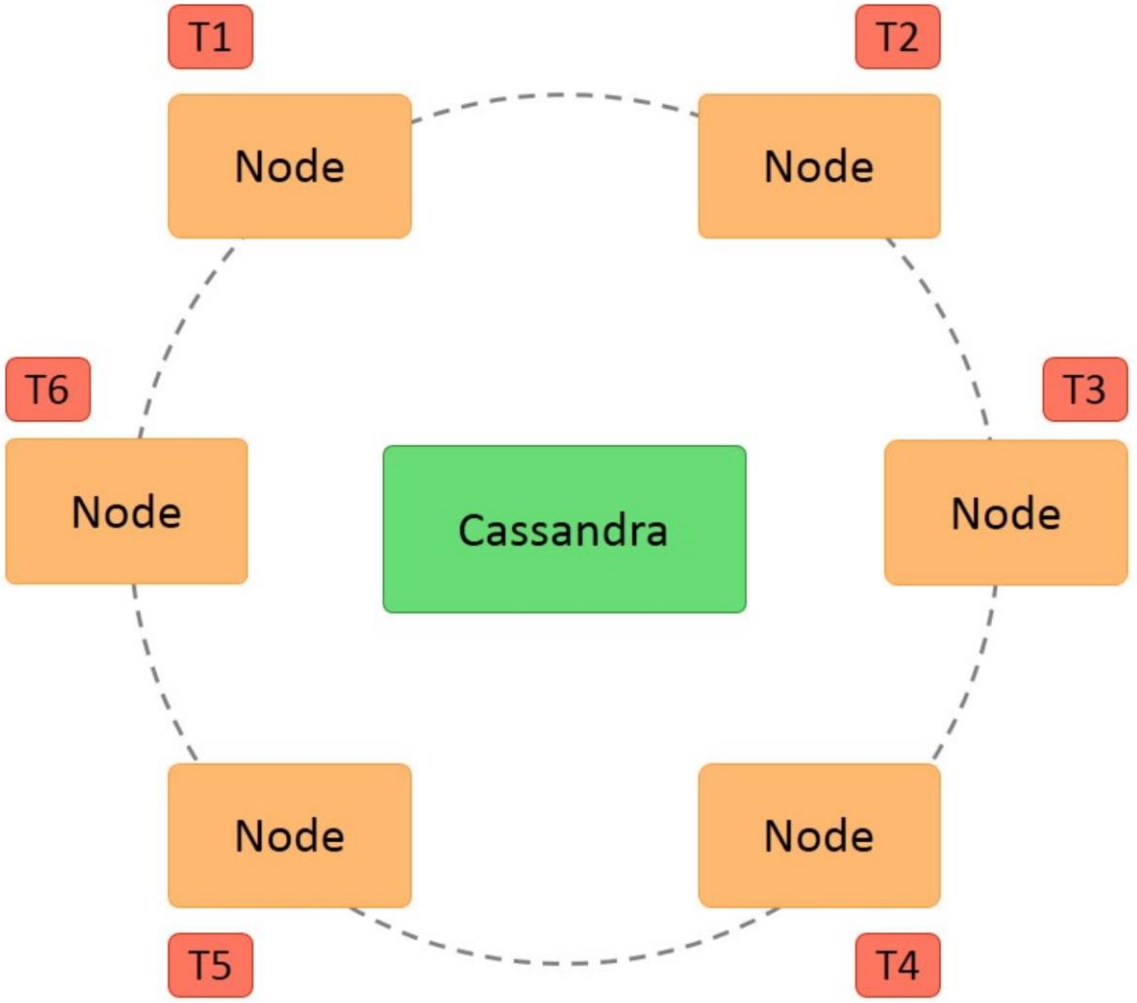
# Columnar Databases (3)



# Cassandra

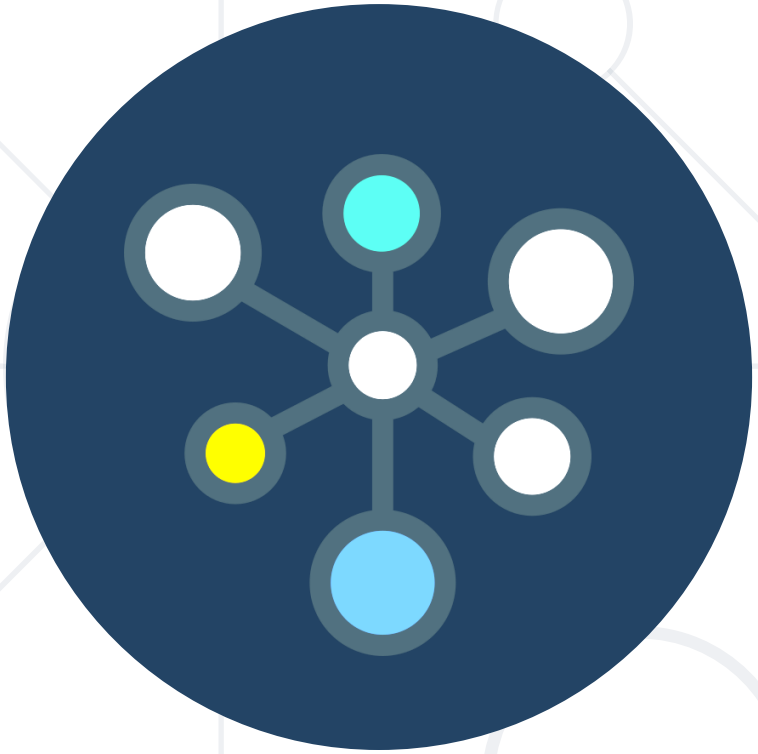
- Generally considered AP (in CAP)
- Every node in the cluster has the same role. There is no single point of failure.
- Data is distributed across the cluster (so each node contains different data)
- Failed nodes can be replaced with no downtime.
- Eventually consistent (configurable)
- Uses CQL for queries

# Cassandra (2)



# Cassandra Usage

- **Discord** switched to Cassandra to store billions of messages from MongoDB in November, 2015
- **Netflix** uses Cassandra as their back-end database for their streaming services
- **Apple** uses 100,000 Cassandra nodes
- **Uber** uses Cassandra to store around 10,000 features
- Many more applications



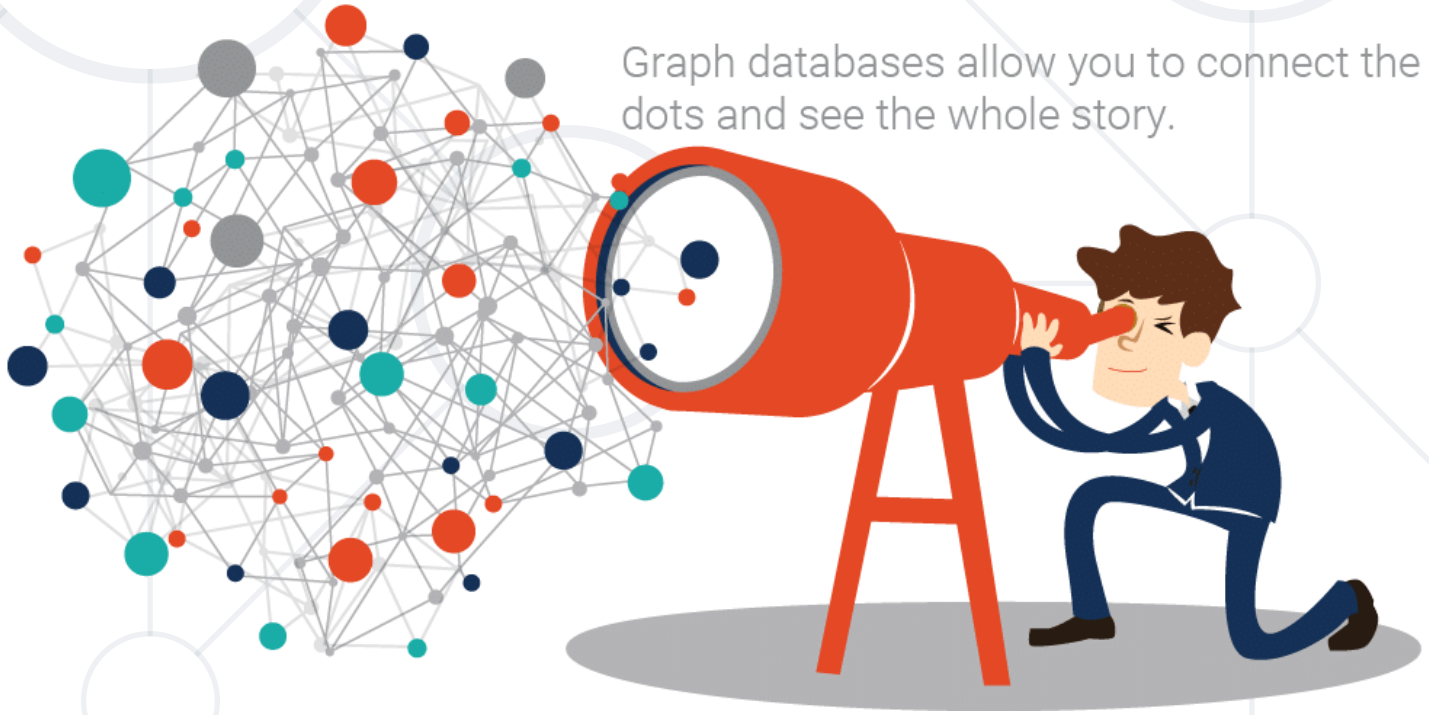
# Graph Database

# What is a Graph Database? (1)

- Allow simple and fast retrieval of complex hierarchical structures that are difficult to model in relational systems
- No universal query language is present for graph databases (like SQL). Each database has own implementation of queries

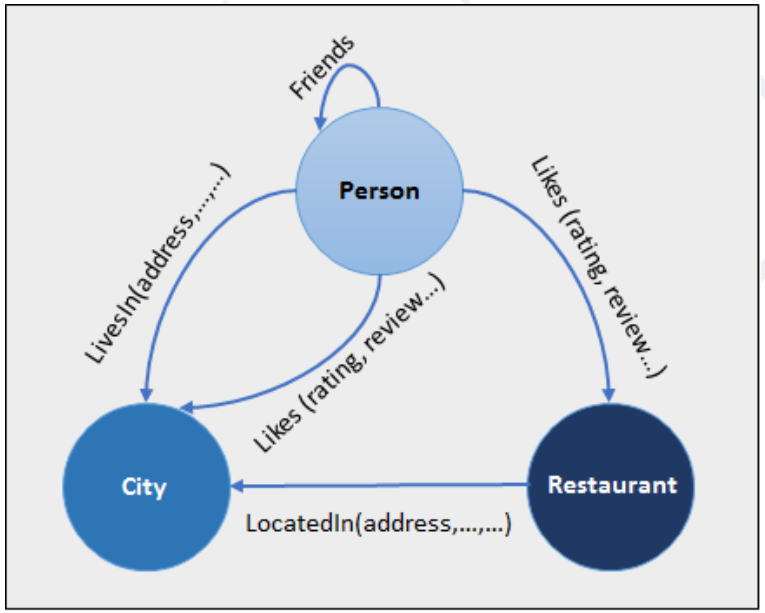
# What is a Graph Database? (2)

- A graph database contains a collection of nodes and edges
  - A node represents an object
  - An edge represents the connection or relationship between two objects



# What is a Graph Database? (3)

- Each node is identified by a unique identifier that expresses key-value pairs
- Each edge is defined by a unique identifier that details a starting or ending node, along with a set of properties



# MongoDB Overview

## Installation, Configuration, Startup

# What is MongoDB?

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- MongoDB is a **document database**
- It stores data in flexible, **BSON** documents
- The document model maps to the objects in the application code, making data easy to work with
- MongoDB is a **distributed database** at its core

# Install MongoDB

- Download from: https://www.mongodb.com/download-center
- When **installed**, MongoDB needs a **driver**
  - One to use with Node.js, .NET, Java, etc..
  - MongoDB C#/.NET driver: https://docs.mongodb.com/drivers/csharp

# Working with MongoDB GUI

- Choose one of the many
- For example
  - Robo 3T → https://robomongo.org/download
  - NoSQLBooster → https://nosqlbooster.com
  - Compass → https://www.mongodb.com/products/compass

# Working with MongoDB Shell Client

- Start the shell from a **CLI**
  - Type the command **mongo**

```
show dbs
```

Shows all databases in the data folder

```
use mytestdb
```

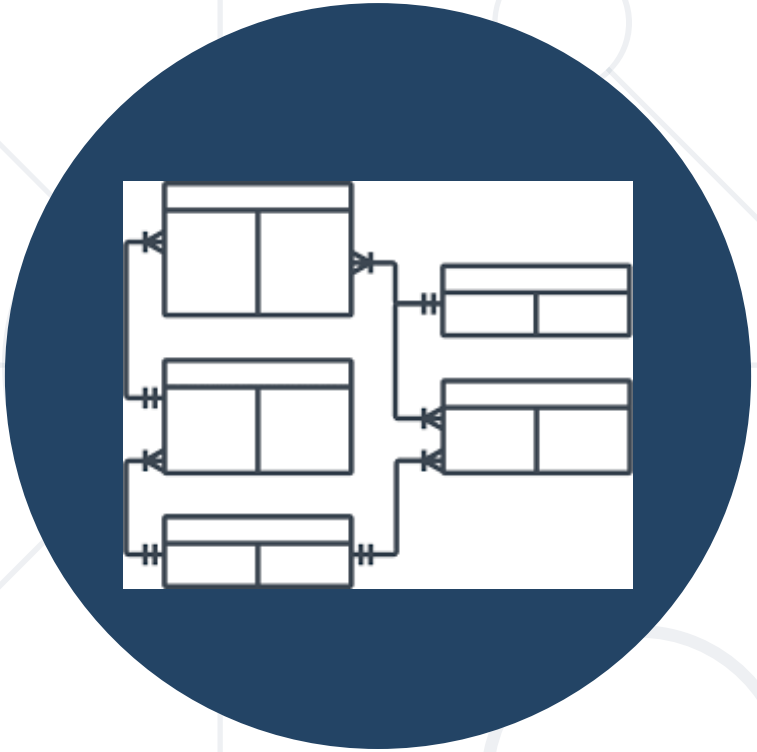
```
db.mycollection.insert({"name":"George"})
```

```
db.mycollection.find({"name":" George"})
```

```
db.mycollection.find({})
```

Gets all entries in the database

  - Additional information at https://docs.mongodb.com/manual/reference/mongo-shell/



# CRUD Operations

# Connect to MongoDB

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- To **connect** to a MongoDB cluster, use the connection string for your cluster

```
using MongoDB.Bson;
using MongoDB.Driver;
…
var client = new MongoClient(
"mongodb+srv://<username>:<password>@<cluster-address>/test?w=majority"
);
var database = client.GetDatabase("Example");
var collection = database.GetCollection<Interactions>("Interactions");
```

# Select

- To **select** a document use Linq

```
var result = IMongoCollectionExtensions
             .AsQueryable(collection)
             .FirstOrDefault(s => s.SiteName == "Example");
```

# Update

- FindOneAndUpdate()

```
var update = MongoDB.Driver.Builders.Update.Set(s => s.SiteName,
        "New Example");

collection.FindOneAndUpdate(s => s.SiteName == "Example",
update);
```

# Delete and Insert

- `DeleteOne()`
  - Deletes the first document that meets the filter

```
collection.DeleteOne(e => e.Name =="Example");
```

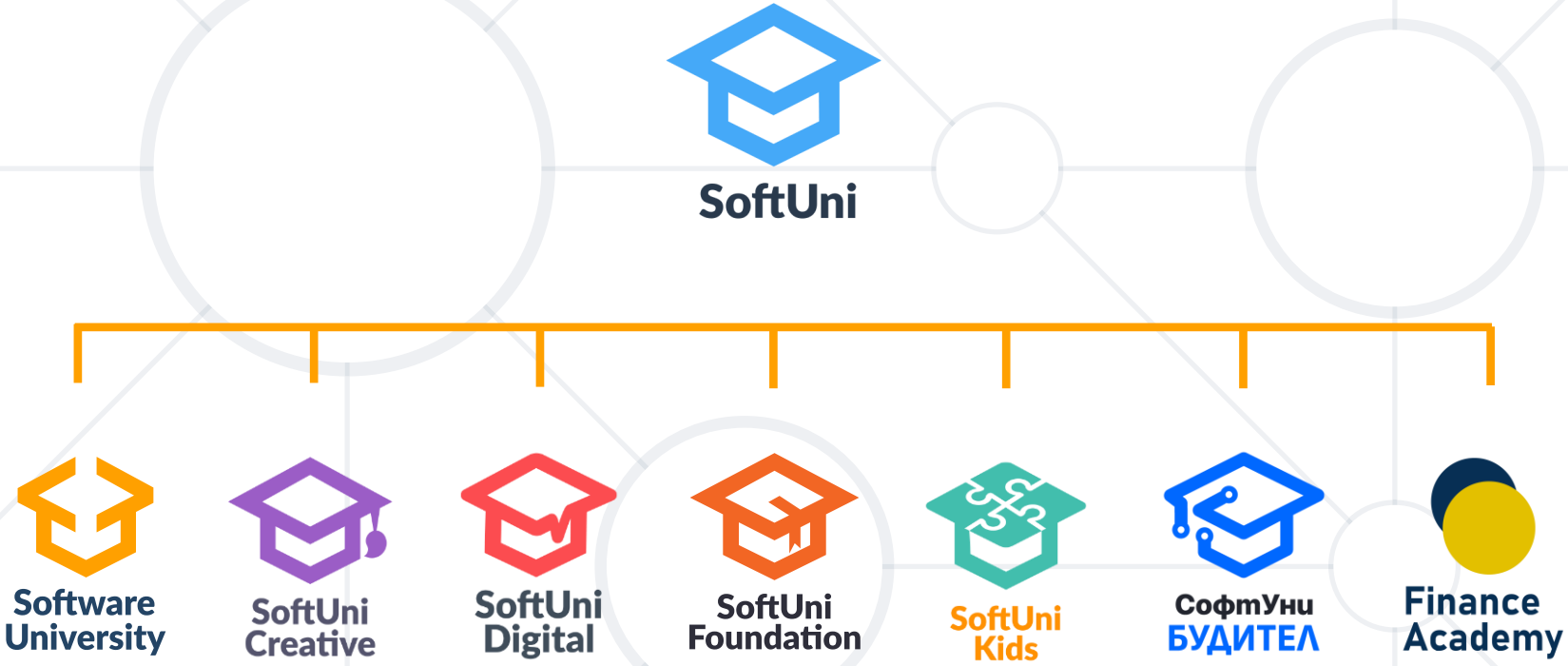
- `InsertOne()`
  - Inserts a new document

```
collection.InsertOne(newItem);
```

# Summary

- **NoSQL**
- Ability of a system's DB to **scale up** or **down**
- **CAP** Theorem
- **Distributed** Systems
- **Key-value**, **Document-oriented**, **Columnar** and **Graph** DBs
- **MongoDB** Overview
- **CRUD** Operations

# Questions?



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