NoSQL Databases and JSON

NoSQL Databases

Data Model	Example Databases
Key-Value ("Key-Value Databases," p. 81)	BerkeleyDB
	LevelDB
	Memcached
	Project Voldemort
	Redis
	Riak
Document ("Document Databases," p. 89)	CouchDB
	MongoDB
	OrientDB
	RavenDB
	Terrastore
Column-Family ("Column-Family Stores," p. 99)	Amazon SimpleDB
	Cassandra
	HBase
	Hypertable
Graph ("Graph Databases," p. 111)	FlockDB
	HyperGraphDB
	Infinite Graph
	Neo4J
	OrientDB

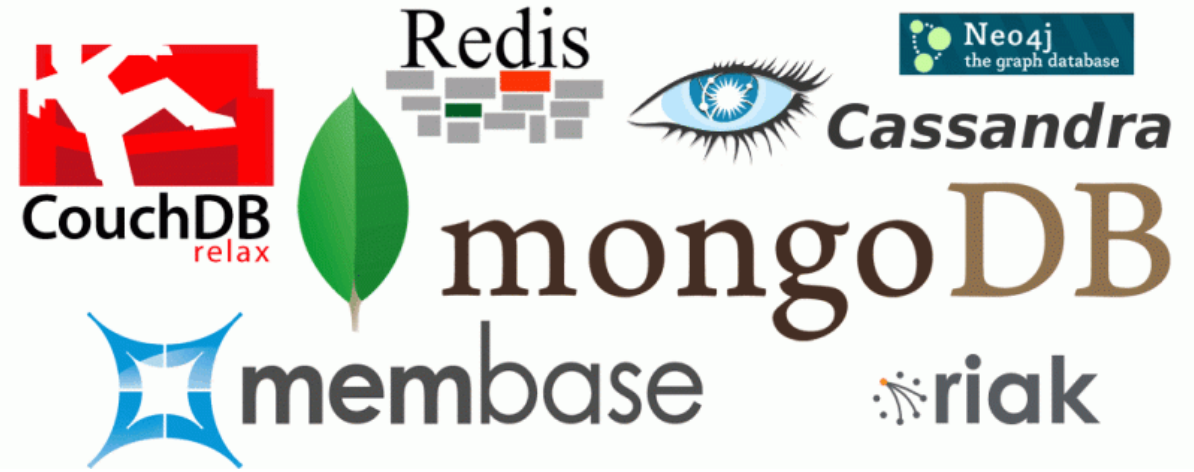
Source: NoSQL Distilled, by P. Sadalage and M. Fowler

NoSQL Databases

→ NoSQL means **N**ot **O**nly **SQL**

→ NoSQL covers multiple types of databases

Why NoSQL?



- → Fits well to many data types and application areas
- → Dynamic Schema! (Bad and Good)
- → Easy to scale
  - → Data Size increases (Big Data)
- → Often easy to replicate
- → High Performance
- → Less powerful query languages
- → Versioning

A comment on database sizes (Relational DBs)

		id	Symbol ▲ 1	Price	Timestamp
☐	Ret Kopi Slet	16777216	BTCUSDT	23494.4	1677554256
☐	Ret Kopi Slet	33554432	BTCUSDT	27888	1679411028
☐	Ret Kopi Slet	50331648	BTCUSDT	29282.3	1682851218
☐	Ret Kopi Slet	65536	BTCUSDT	20976.3	0
☐	Ret Kopi Slet	16842752	BTCUSDT	23407.1	1677560723
☐	Ret Kopi Slet	33619968	BTCUSDT	28347.6	1679418043
☐	Ret Kopi Slet	50397184	BTCUSDT	29203.9	1682858445
☐	Ret Kopi Slet	131072	BTCUSDT	21120.8	0
☐	Ret Kopi Slet	16908288	BTCUSDT	23393.2	1677567301
☐	Ret Kopi Slet	33685504	BTCUSDT	28070	1679424984
☐	Ret Kopi Slet	50462720	BTCUSDT	29255	1682865889

Viser rækkerne 0 - 24 (5977768 i alt, Forespørgsel tog 24.4428 sekunder.)

About 6.000.000 rows

A comment on database sizes (Relational DBs)

✔ MySQL returnerede ingen data (fx ingen rækker). (Forespørgsel tog 18.7534 sekunder.)

```
SELECT * from price_logs WHERE Symbol LIKE "BTCUSD*" LIMIT 20;
```

Takes 18,7 seconds to run

✔ MySQL returnerede ingen data (fx ingen rækker). (Forespørgsel tog 87.5783 sekunder.)

```
CREATE INDEX symbol_index on price_logs(Symbol);
```

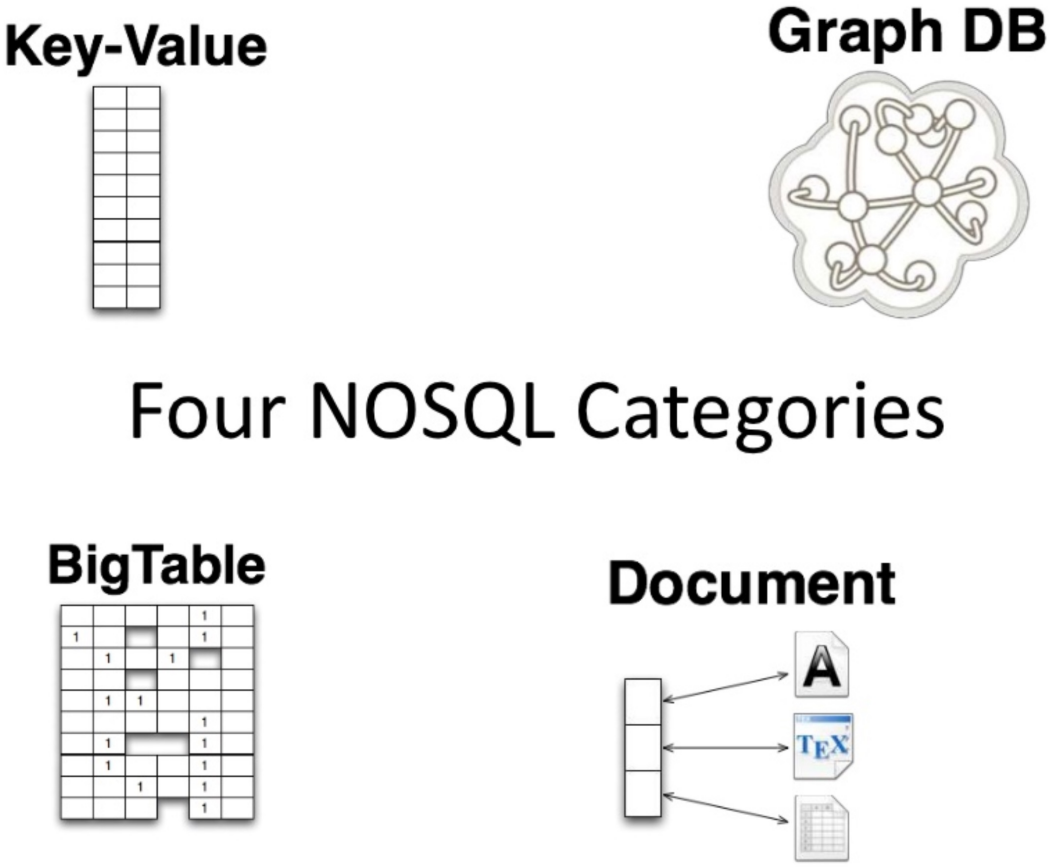
Create an index to optimize the 'like' clause, which takes 87,5783 seconds to create in memory.

✔ MySQL returnerede ingen data (fx ingen rækker). (Forespørgsel tog 0.0002 sekunder.)

```
SELECT * from price_logs WHERE Symbol LIKE "BTCUSD*" LIMIT 20;
```

After optimization, the query takes 0,0002 seconds to run (or 0.2 milliseconds)

What types exist?



→ Document-based NoSQL systems

→ NoSQL key-value stores

→ Column based or wide column-based NoSQL systems

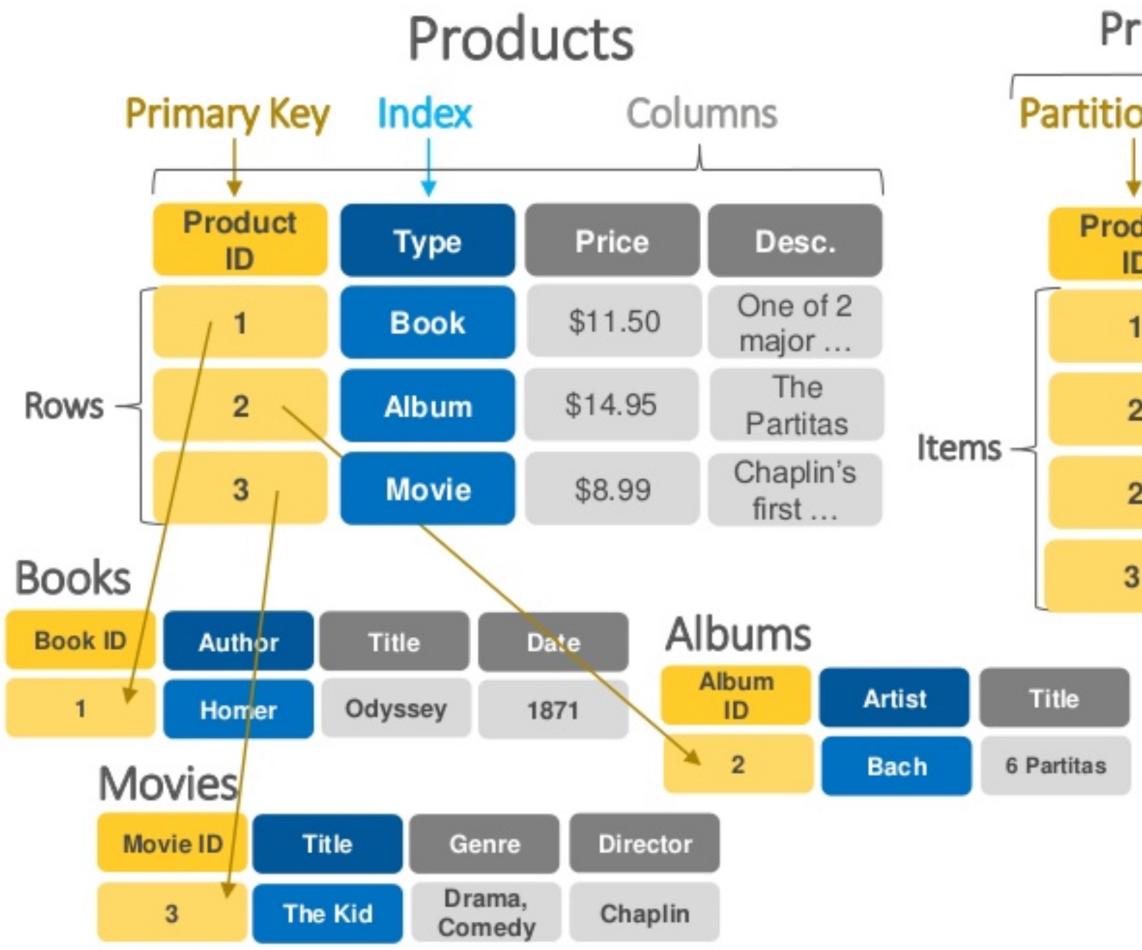
→ Graph based NoSQL systems

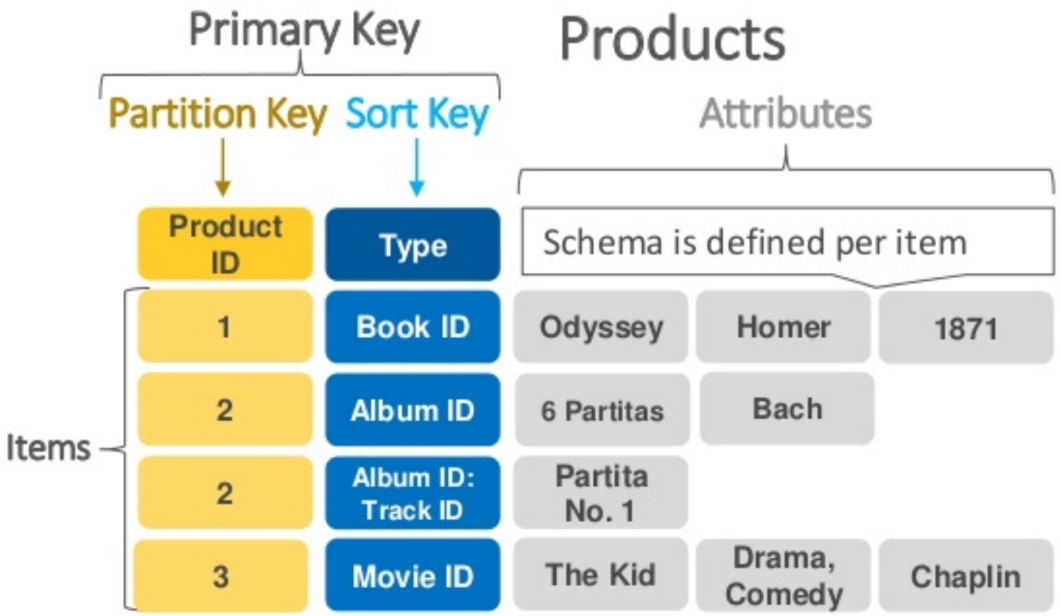
→ Hybrid NoSQL systems

  → Object databases

  → XML databases

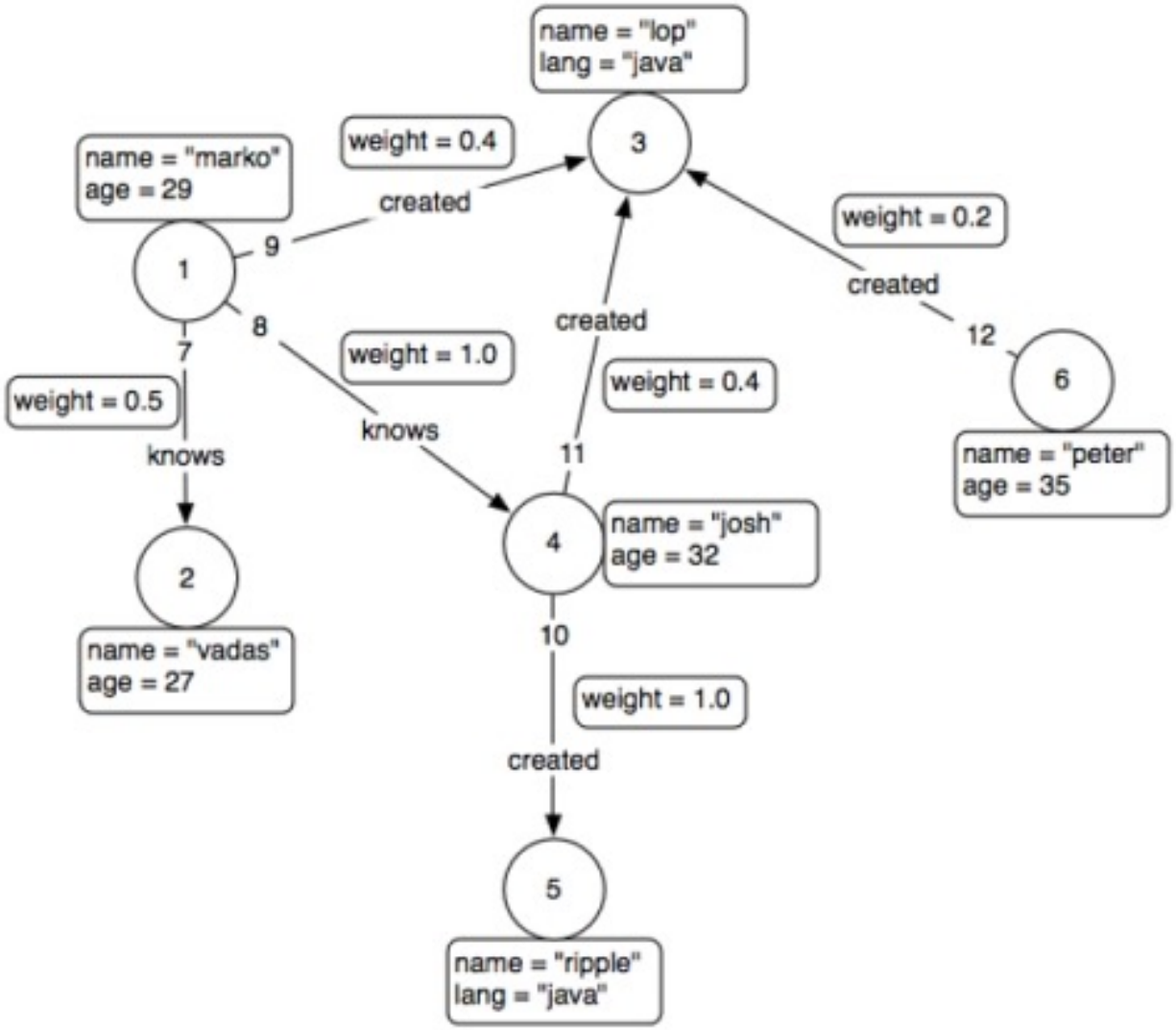
Relational vs. Key Value



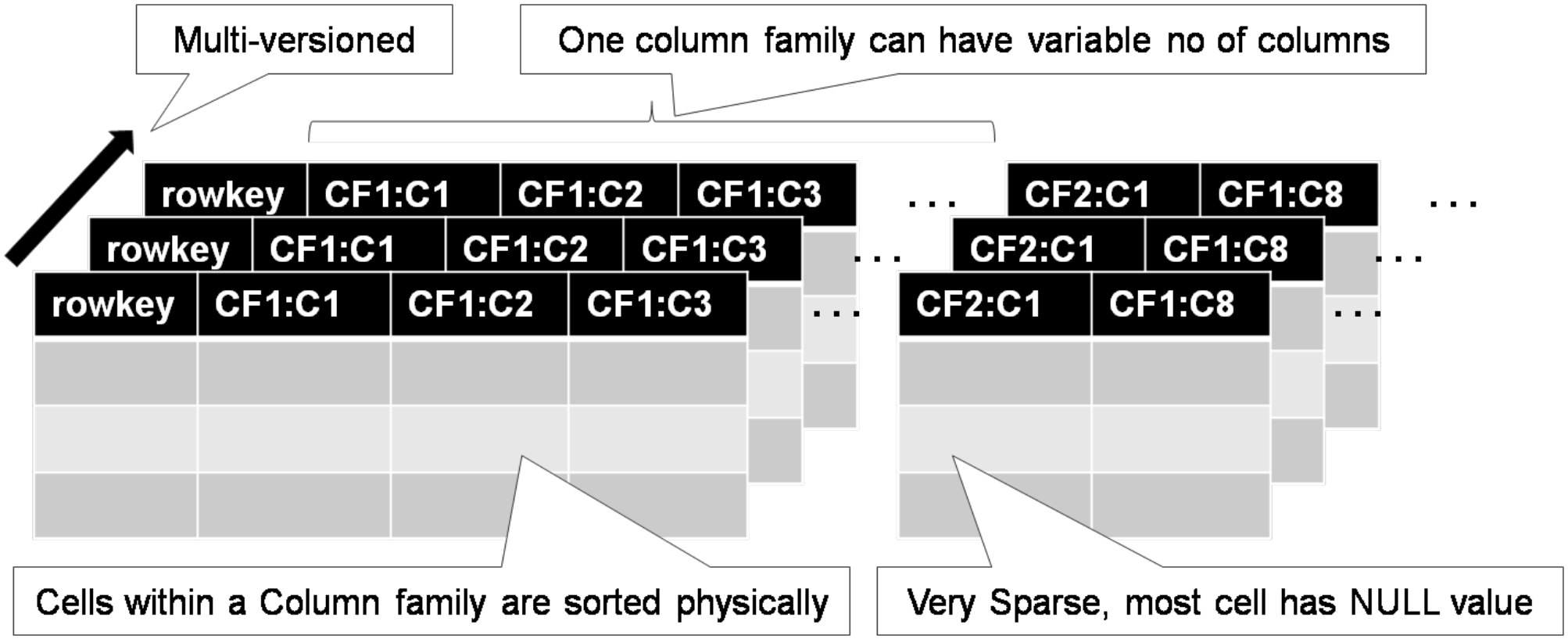


- Implemented in different ways, but all key/value based
- DynamoDB Example (in diagram above)
  - No sequences
  - Data found based on partition key and sort key

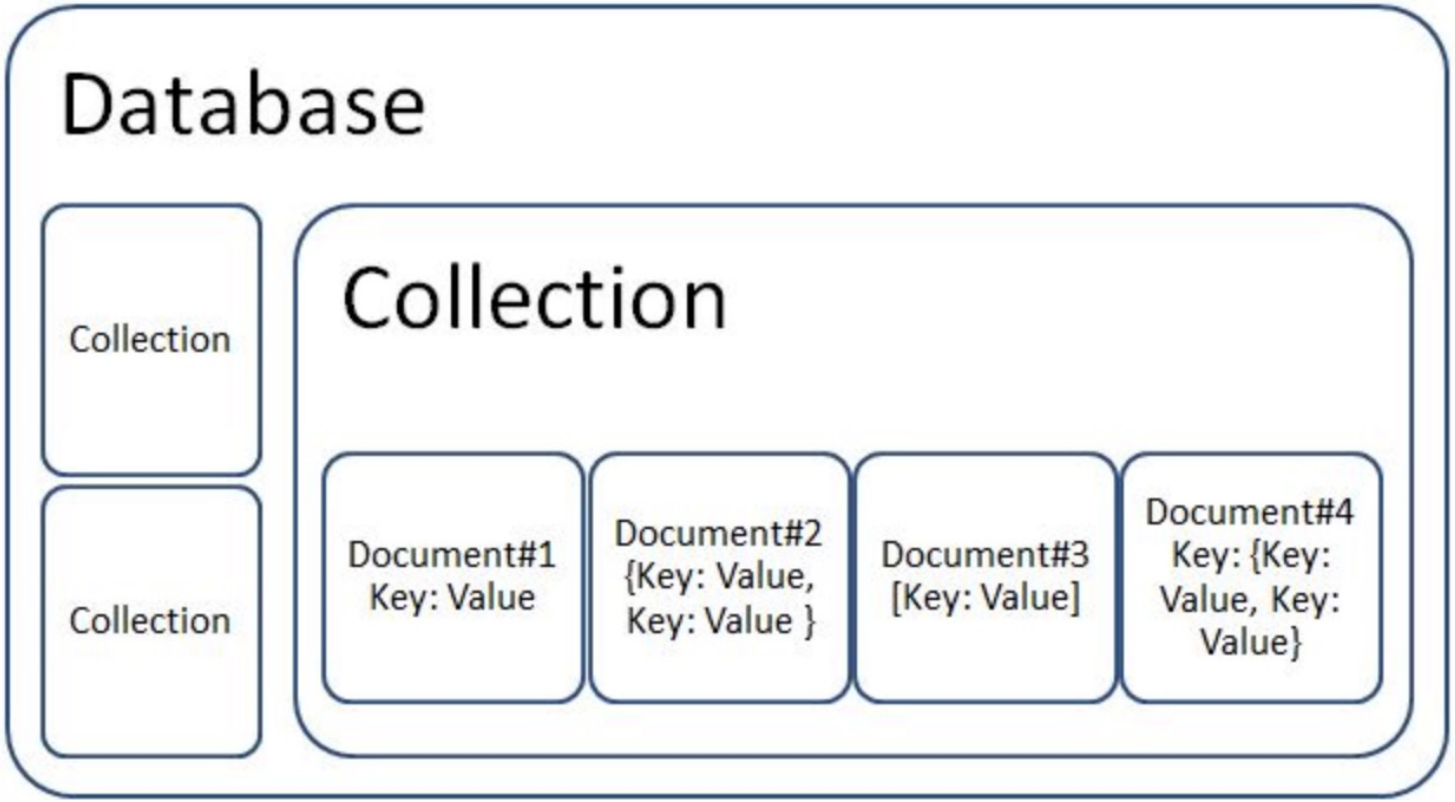
Graph Based


name = "lop"
lang = "java"
3
weight = 0.4
name = "marko"
age = 29
created
weight = 0.2
9
created
1
created
12
8
6
7
weight = 1.0
weight = 0.4
weight = 0.5
knows
knows
11
name = "peter"
age = 35
4
name = "josh"
age = 32
2
10
name = "vadas"
age = 27
weight = 1.0
created
5
name = "ripple"
lang = "java"

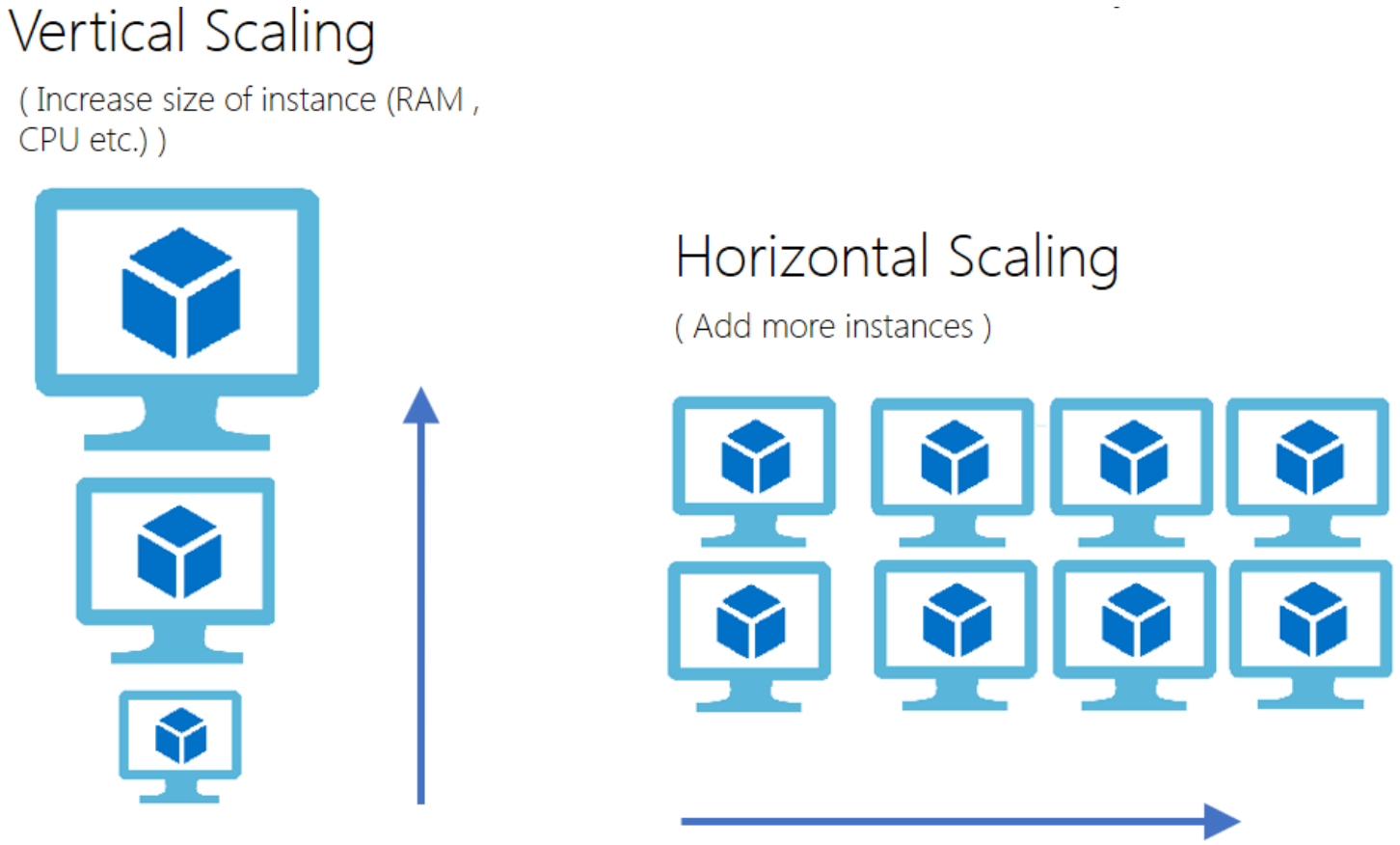
Big Table


Multi-versioned
One column family can have variable no of columns
rowkey
CF1:C1
CF1:C2
CF1:C3
CF2:C1
CF1:C8
Cells within a Column family are sorted physically
Very Sparse, most cell has NULL value

Document based



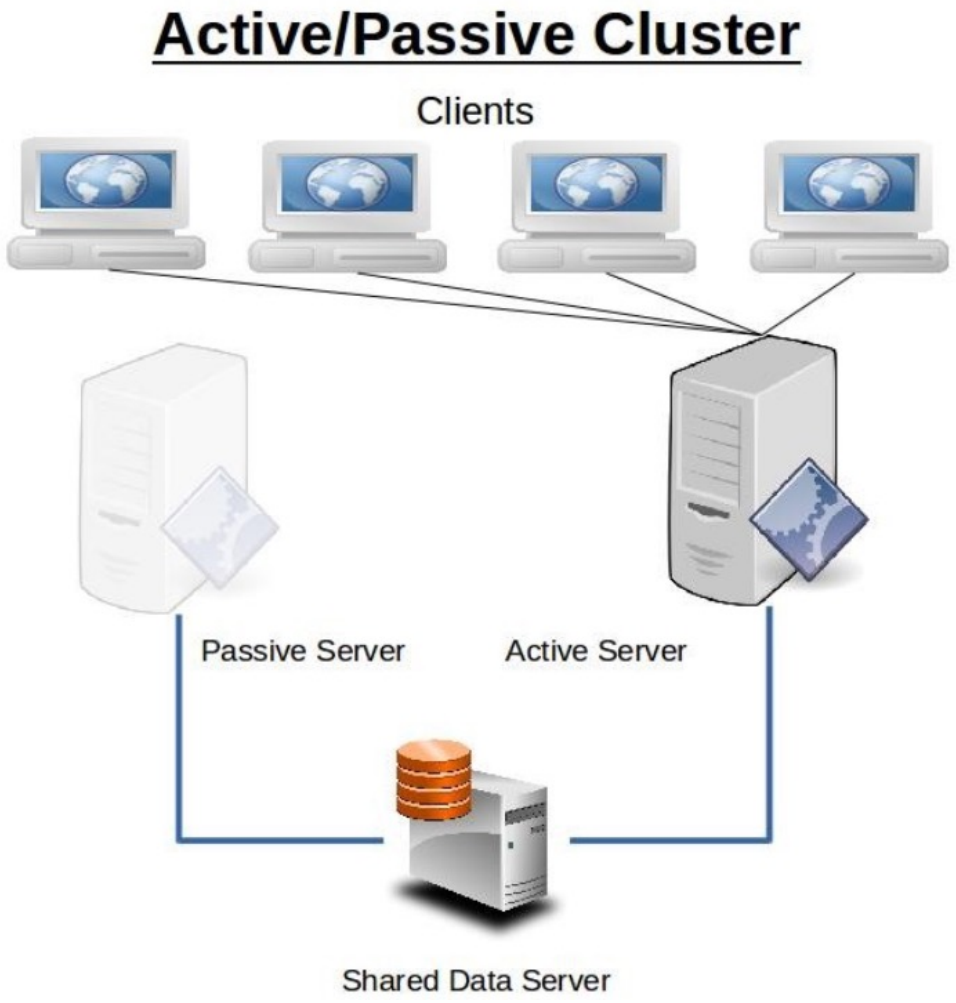
Horizontal vs Vertical Scaling

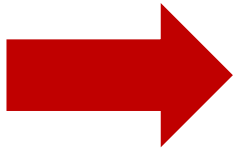


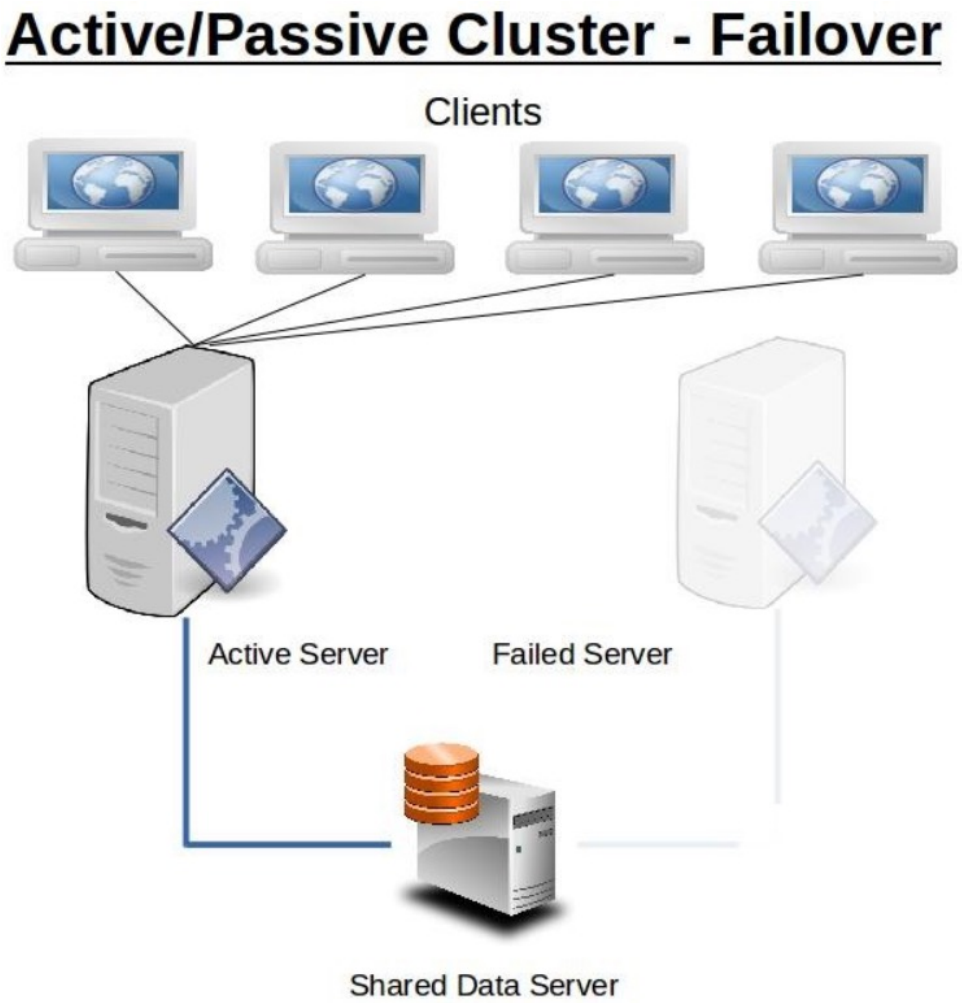
- → Vertical
  - → Increasingly Expensive to get larger hardware
  - → Requires no code changes
- → Horizontal
  - → Less expensive hardware
  - → Allows for large-scale systems
  - → Need to change software for a distributed architecture
    - → Leads to more complex code
  - → Need for Load Balancing

→ Do you know examples of these?

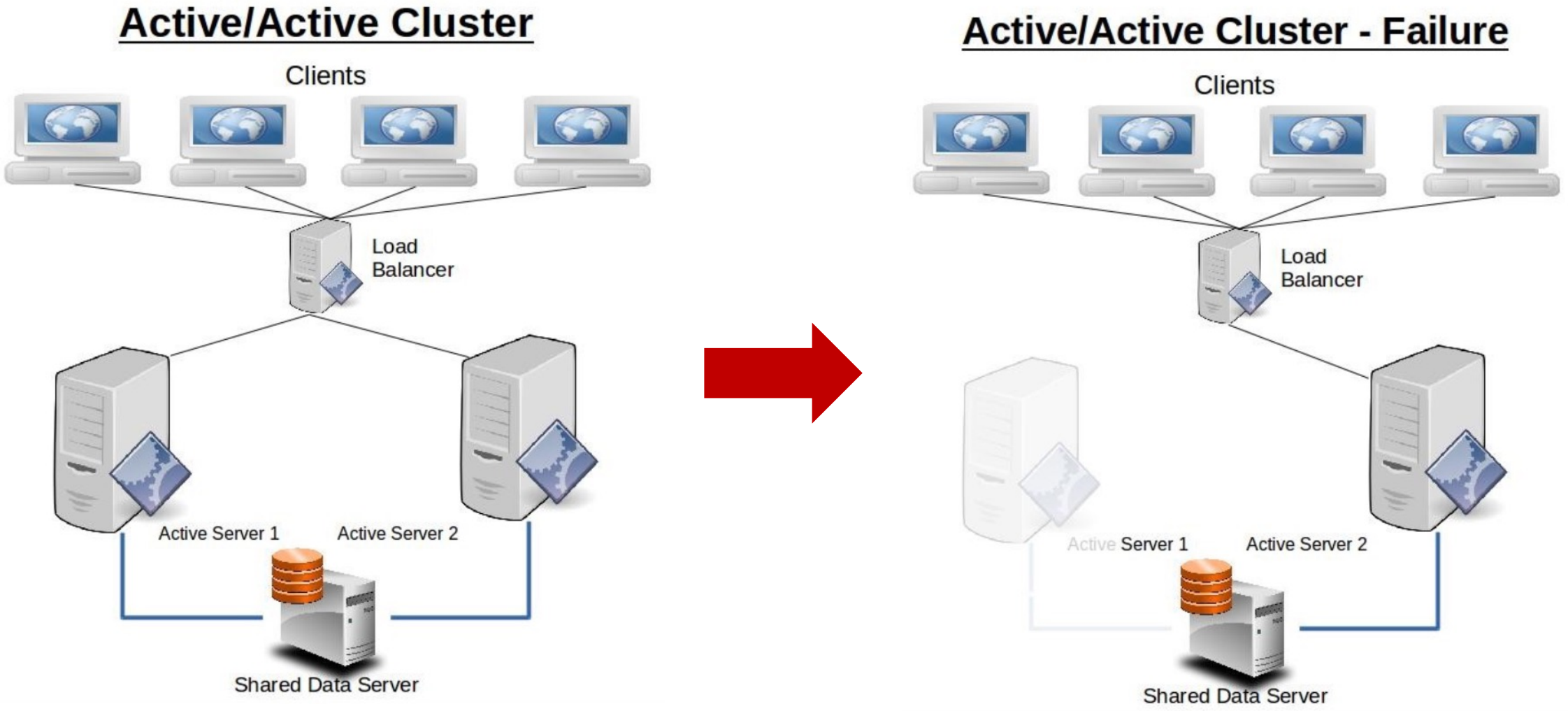
High Availability 1/3



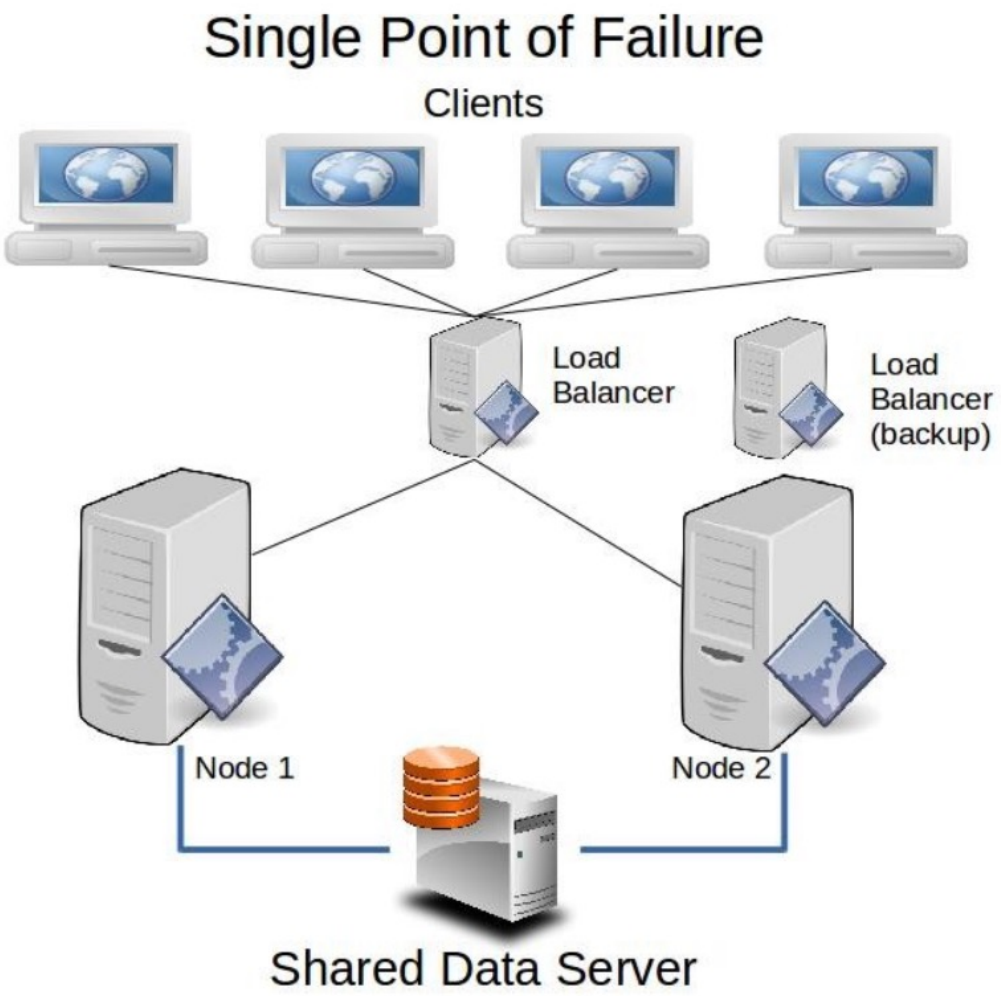


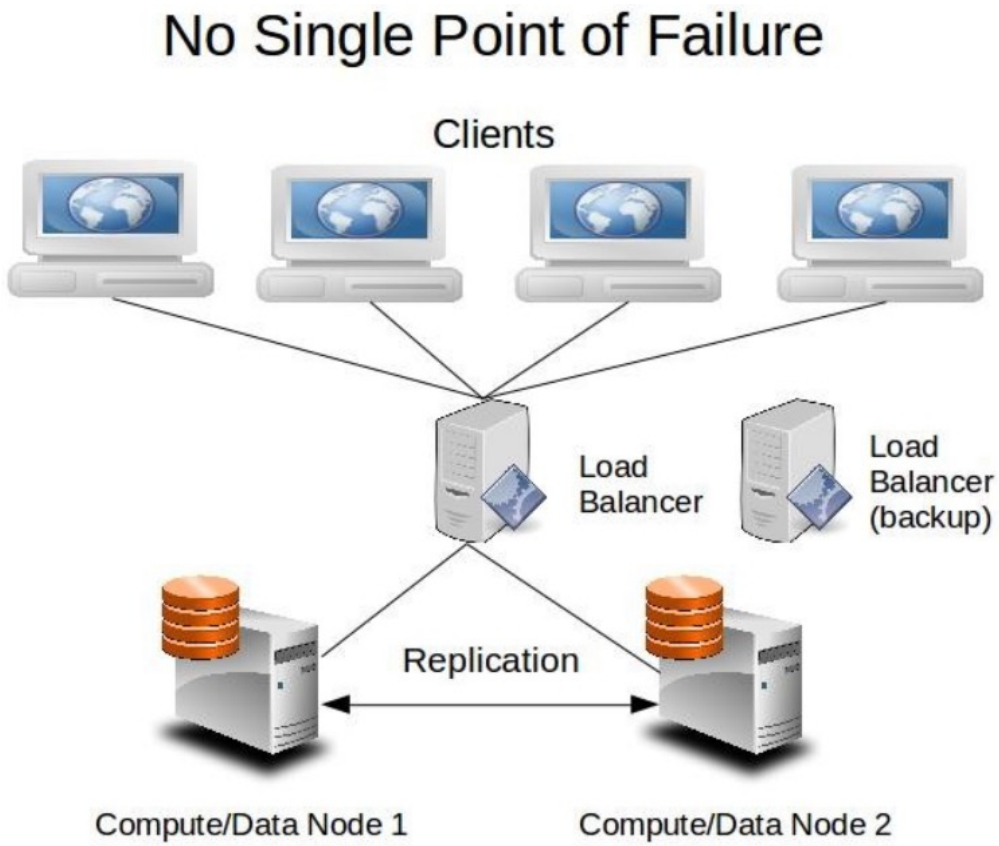


High Availability 2/3

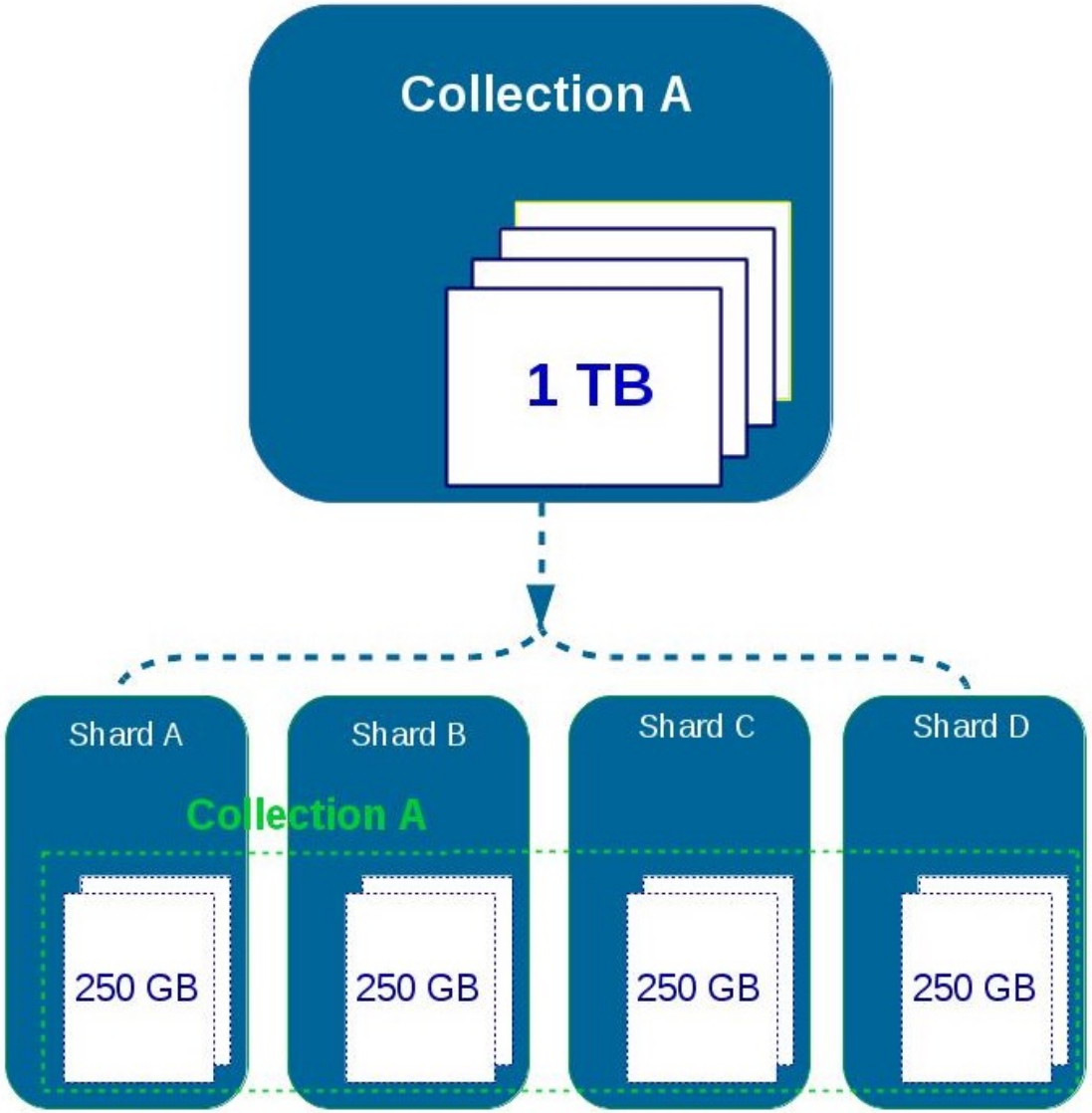


High Availability 3/3



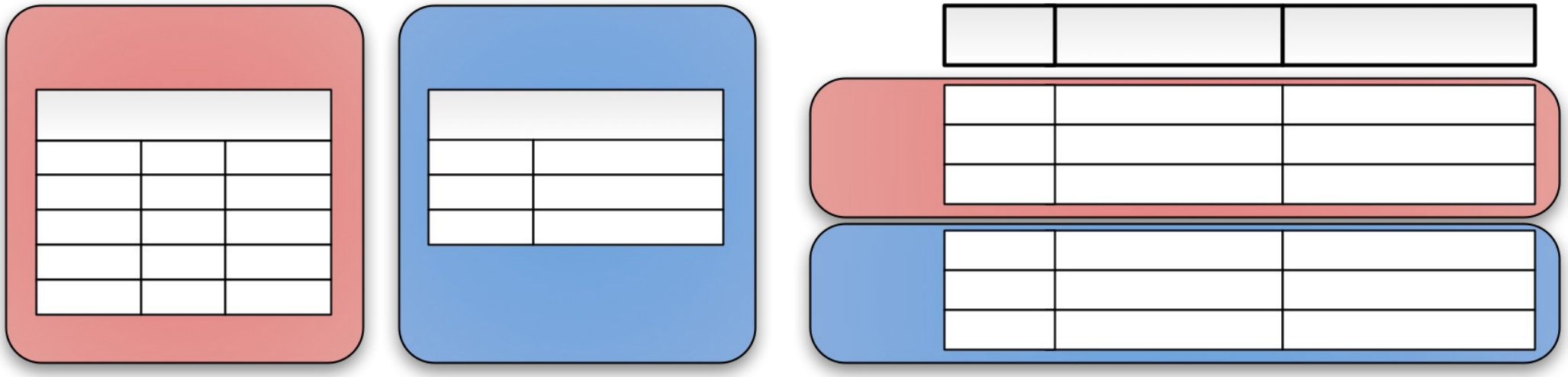


Partitioning (Sharding)

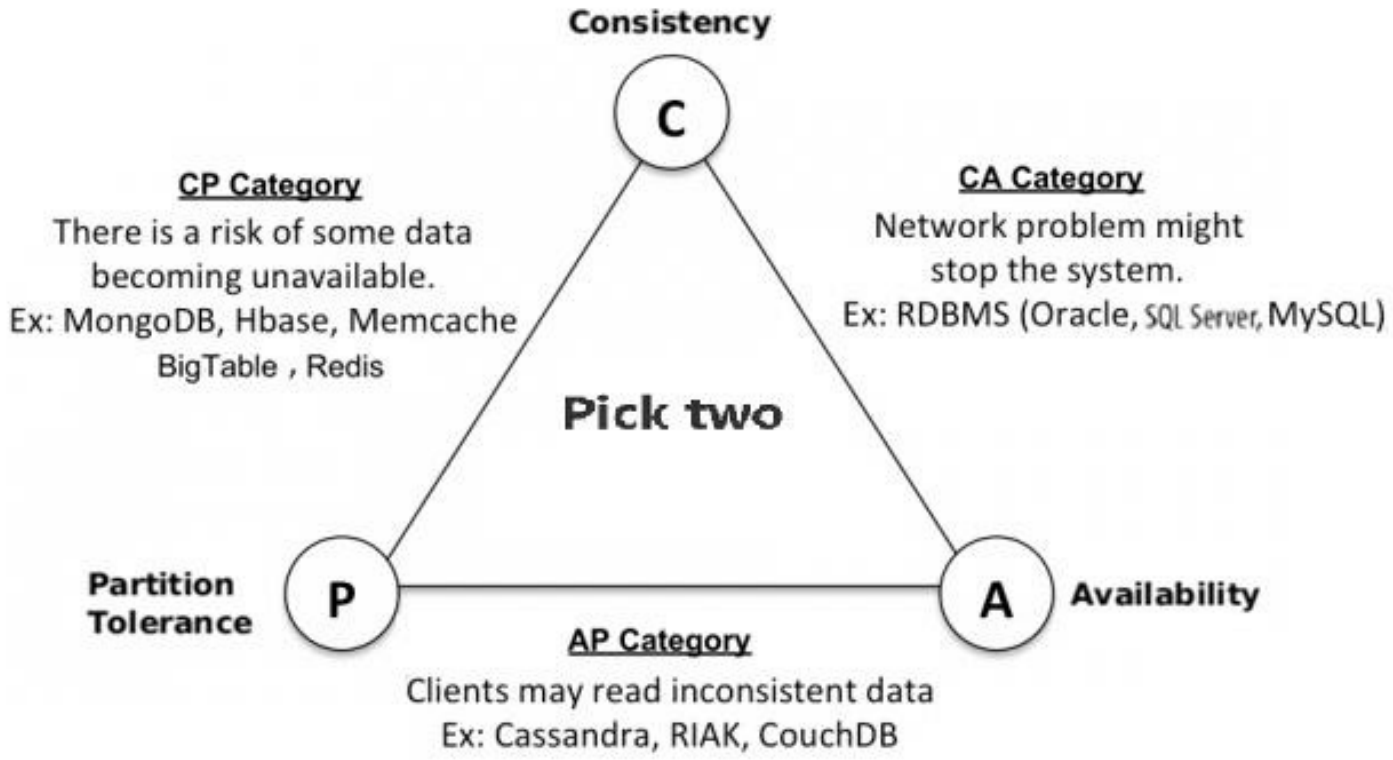


- → Splitting up the data between multiple servers
- → Together they represent the entire collection
- → Allows for better throughput as calculations and search are shared
- → Makes sense for Big Data Applications

Partitioning (Sharding)



The CAP Theorem – Distributed Databases

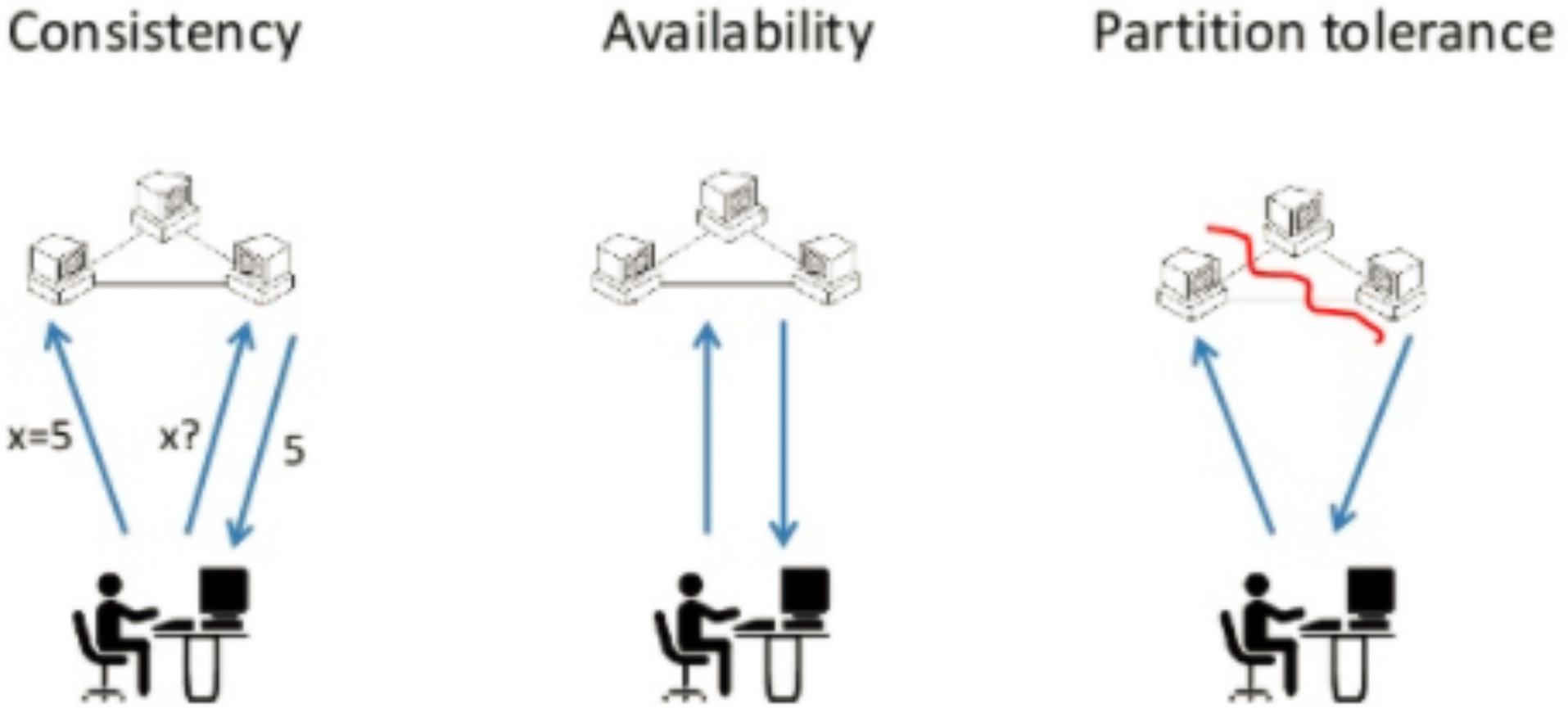


Consistency: Every read recieves the most recent write or an error. All nodes see the same data at all times.

Availability: System is always operational dispite invividual server status. Every Request recives a (non-error) repsonse, without the gurantee that it contains the most recent write

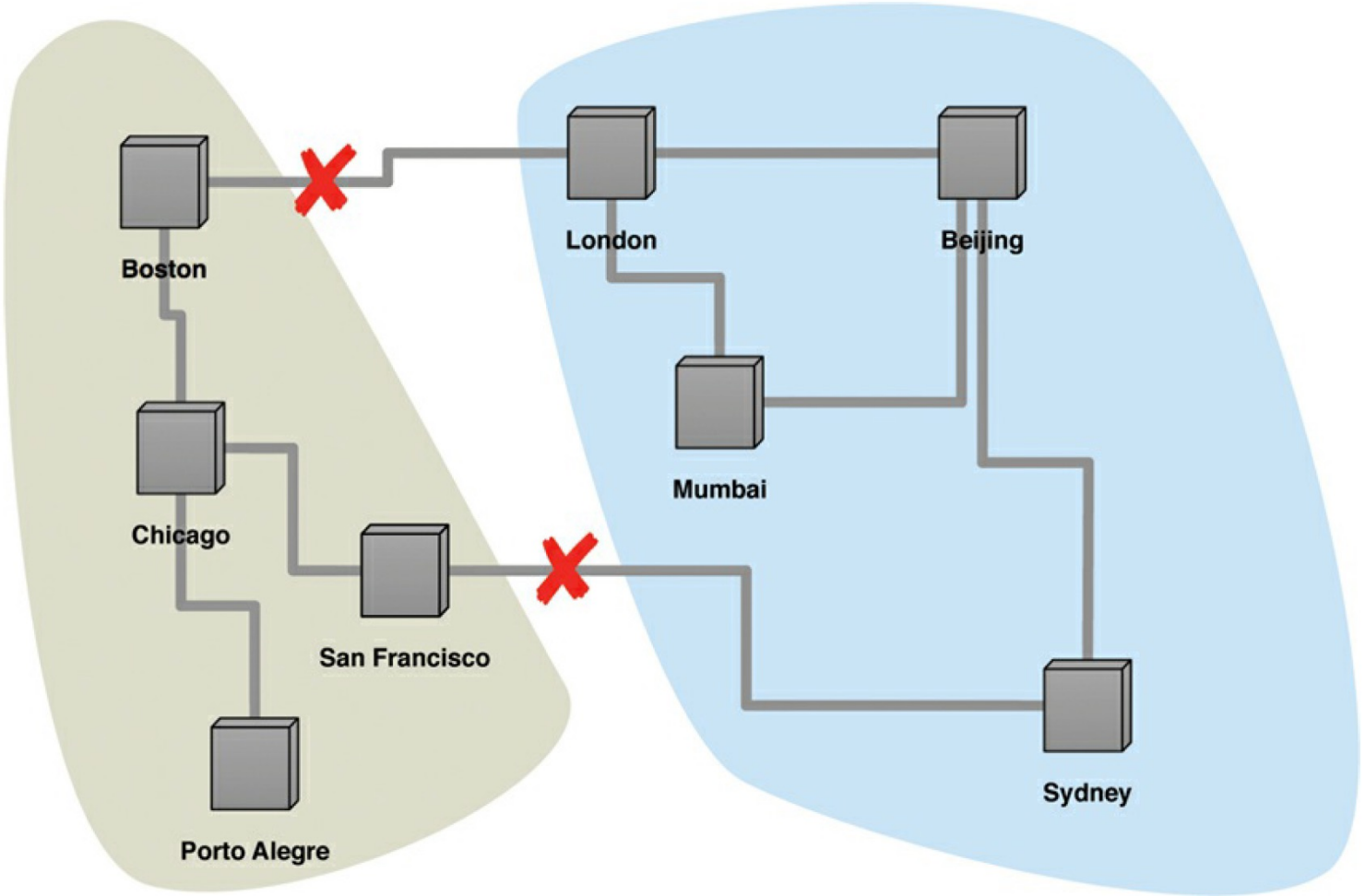
Partition Tolerance: The system continues to operate dispte of partition failure (a node dies with part of the data)

Confusing? Indeed - Read the FAQ: https://github.com/henryr/cap-faq



Source: https://toppertips-bx67a.ondigitalocean.app/cap-theorem/

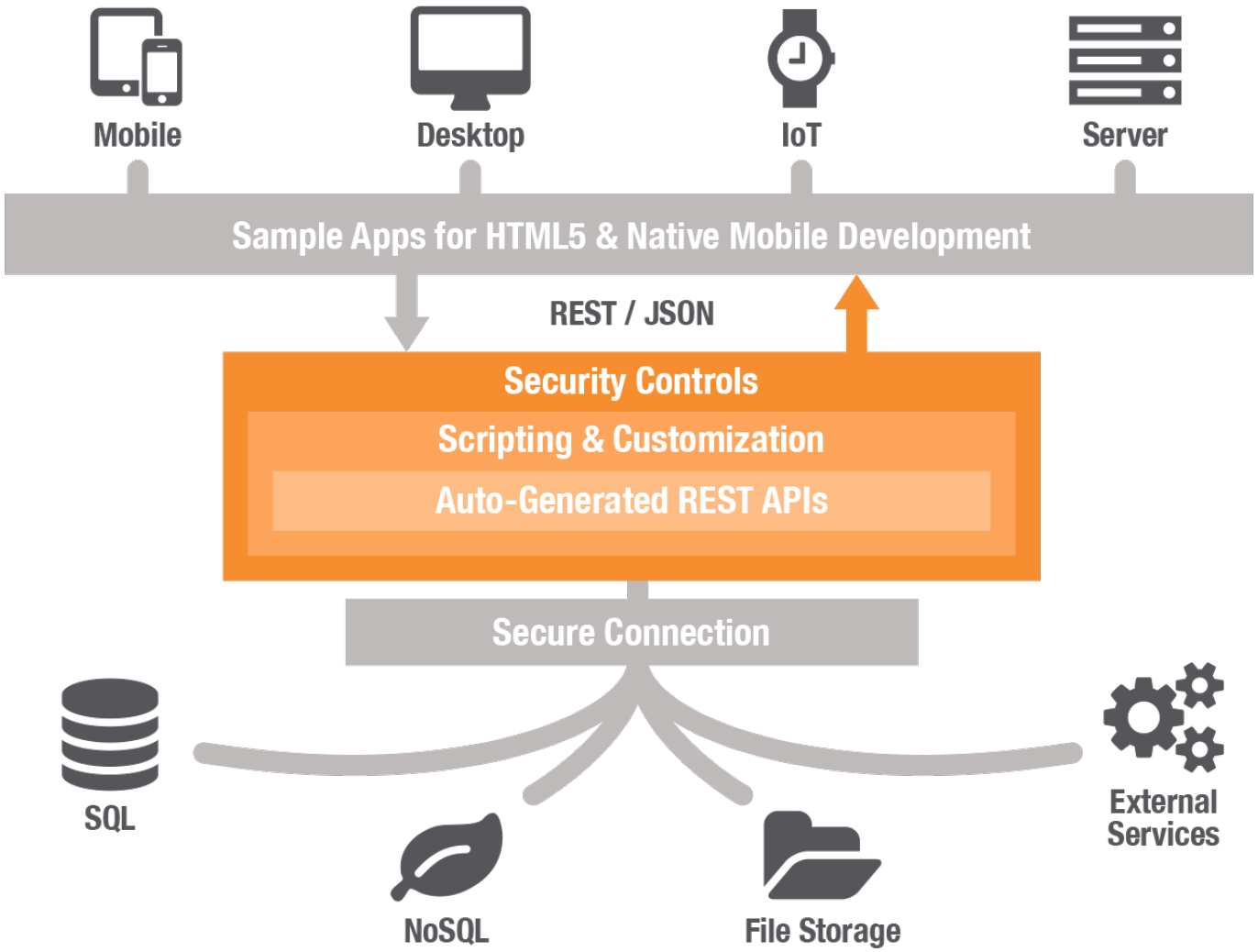
A CAP Theorem example



JSON

What is JSON?

- JSON is stands for “JavaScript Object Notation”,
- It’s used to store and exchange data as an alternative solution for XML.
- Easy to parse, and easy to read and write for a human.
- Based on JavaScript Object Literals, but it’s a text format.
- JSON is language independent; means you can use parse and generate JSON data in other programming languages.



How is JSON used?

- → Websites communicating with the backend
- → Mobile applications communicating with the backend
- → Temporary storage format of objects
- → …

Object Declaration

```
{
    "id": 2456,
    "name": "John Doe",
    "cpr": "111111-1111",
    "married": true
}
```

- → An object starts with { and ends with }.
- → Inside is a collection of Key/Values separated by comma
  - → Be aware it is a syntax error to have a comma after the last key/value
- → Each key is a string, so it uses the double quotes - “key”
- → A : mark separates a key and a value
- → Each value can be of several types. In the example we have number, string, and boolean.

Array Declaration

```
[
    "Odense",
    "Aarhus",
    "San Francisco"
]
```

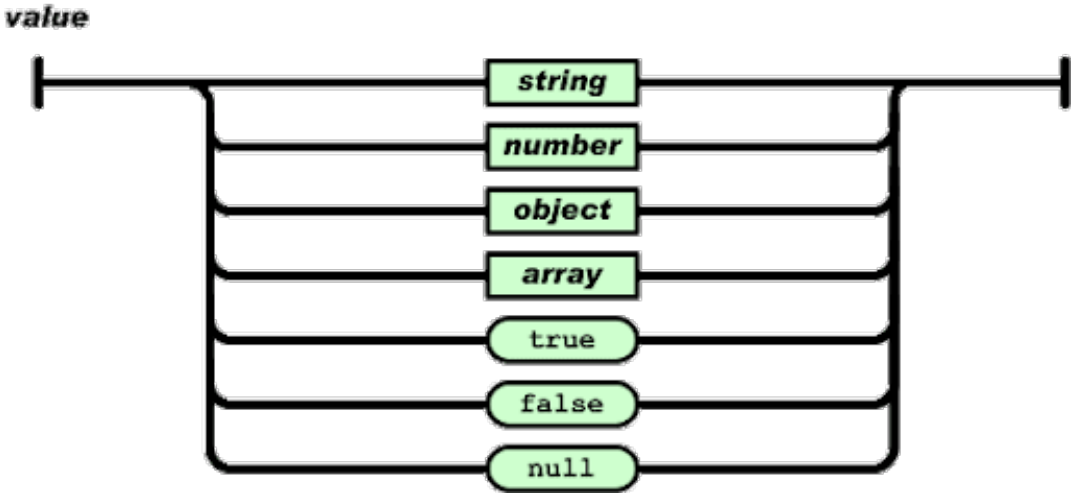
→ Arrays are ordered lists, and starts from 0

→ Initiated with [and ends with]

→ Values are separated by comma

→ An array can also hold objects

JSON Values



→ string; “string”
→ number; 1
→ boolean; true or false
→ null; null/left out
→ an object; {“key”: “value”}
→ an array; [1, “2”, null, true]

Putting it together

```
{
    "id": 2456,
    "name": "John Doe",
    "cpr": "111111-1111",
    "married": true,
    "relationships": [
        {
            "name": "Jane Doe",
            "relationshipType": "Wife"
        },
        {
            "name": "Danny Doe",
            "relationshipType": "Son"
        }
    ],
    "livedIn": ["Odense", "Aarhus"]
}
```

Live Demo

Pay attention, and don't try to replicate what I do right now!

You will have time to do that afterwards.

Exercises

→ Install MongoDB
→ Create JSON objects that reflect the Java objects
  → Download the assignment files from itslearning (Thanks to Oliver Marco van Komen for creating the files)
  → Unzip the file
  → Open the java files
  → Navigate to the Main.java file
  → Go to the jsonExercise() method
  → Implement the three ArrayLists found here into **one** JSON file