CIB Session 9th
Intro to NoSQL Database

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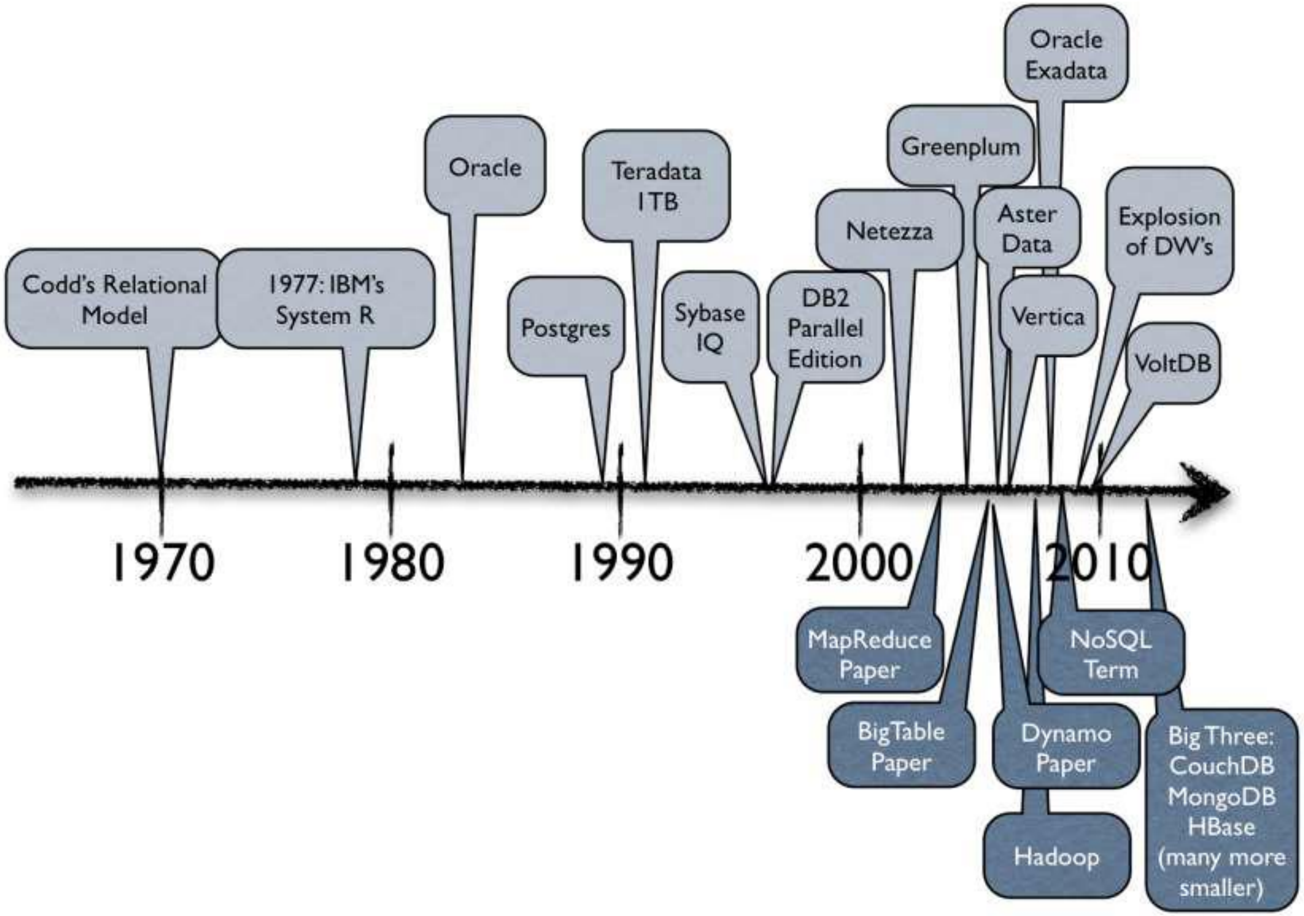
Agenda

- Some history
- Relational databases
- ACID Theorem
- Scaling Up
- Distributed Database Systems
- CAP Theorem
- What is NoSQL?
- BASE Transactions
- NoSQL Types
- Some Statistics
- NoSQL vs. SQL Summery

A brief history of databases



Relational databases

- Benefits of Relational databases:
  - Designed for all purposes
  - ACID
  - Strong consistency, concurrency, recovery
  - Mathematical background
  - Standard Query language (SQL)
  - Lots of tools to use with i.e: Reporting, services, entity frameworks, ...
  - Vertical scaling (up scaling)

ACID Theorem

- **A**tomic:
  - All of the work in a transaction completes (commit) or none of it completes
  - All operations in a transaction succeed or every operation is rolled back.
- **C**onsistent:
  - A transaction transforms the database from one consistent state to another consistent state. Consistency is defined in terms of constraints.
  - On the completion of a transaction, the database is structurally sound.
- **I**solated:
  - The results of any changes made during a transaction are not visible until the transaction has committed.
  - Transactions do not contend with one another. Contentious access to data is moderated by the database so that transactions appear to run sequentially.
- **D**urable:
  - The results of a committed transaction survive failures
  - The results of applying a transaction are permanent, even in the presence of failures.

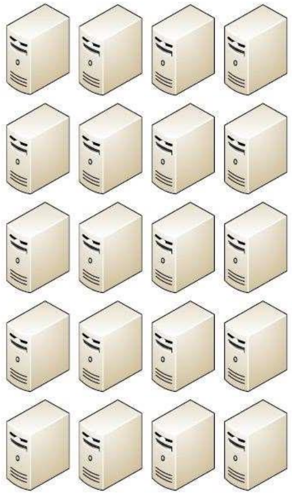
Era of Distributed Computing

But…

- Relational databases were not built for **distributed applications.**

Because…

- Joins are expensive
- Hard to scale horizontally
- Impedance mismatch occurs
- Expensive (product cost, hardware , Maintenance)

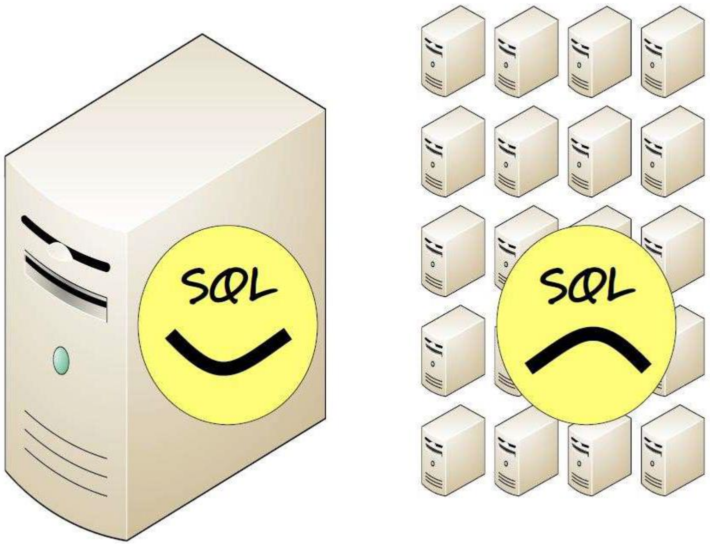


Era of Distributed Computing

But…
- Relational databases were not built for **distributed applications.**

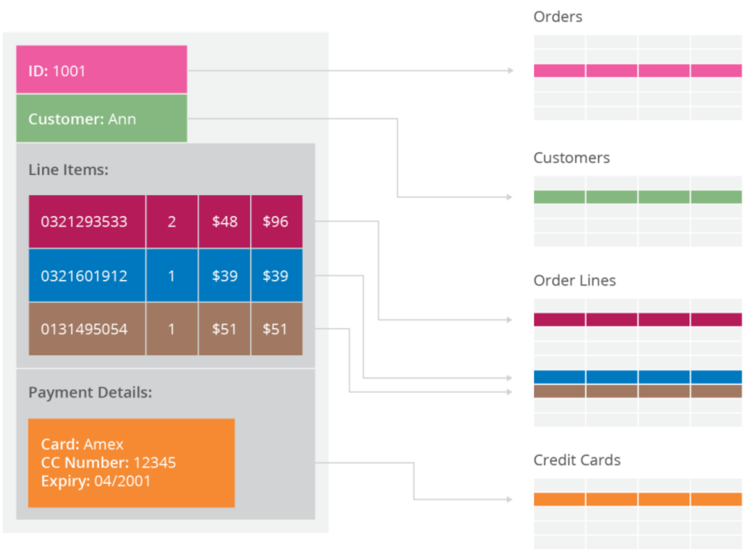
Because…
- Joins are expensive
- Hard to scale horizontally
- Impedance mismatch occurs
- Expensive (product cost, hardware , Maintenance)

And …
It's weak in:
- Speed (performance)
- High availability
- Partition tolerance



Scaling Up

- Issues with scaling up when the dataset is just too big
- RDBMS were not designed to be distributed
- Began to look at multi-node database solutions
- Known as ‘scaling out’ or ‘horizontal scaling’
- Different approaches include:
  - Master-slave
  - Sharding



Scaling RDBMS – Master/Slave

- Master-Slave
  - All writes are written to the master. All reads performed against the replicated slave databases
  - Critical reads may be incorrect as writes may not have been propagated down
  - Large data sets can pose problems as master needs to duplicate data to slaves

Scaling RDBMS - Sharding

- Partition or sharding
  - Scales well for both reads and writes
  - Not transparent, application needs to be partition-aware
  - Can no longer have relationships/joins across partitions
  - Loss of referential integrity across shards

Sharding Advantages

- Tables are divided and distributed into multiple servers
- Reduces index size, which generally improves search performance
- A database shard can be placed on separate hardware
- greatly improving performance
- if the database shard is based on some real-world segmentation of the data then it may be possible to infer the appropriate shard membership easily and automatically

Other ways to scale RDBMS

- Multi-Master replication
- INSERT only, not UPDATES/DELETES
- No JOINs, thereby reducing query time
  - This involves de-normalizing data
- In-memory databases

What we need?

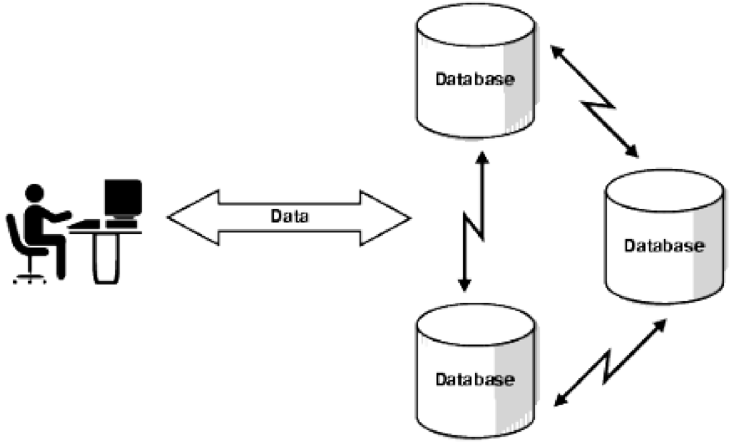
We need a distributed database system having such features:

- **High Concurrency**
- **High Availability**
- **Fault tolerance**
- **High Scalability**
- **Low latency**
- **Efficient Storage**
- **Reduce Manage and Operation Cost**

Which is impossible!!!
According to CAP theorem

Distributed Database Systems

- Data is stored across several sites that share no physical component.
- Systems that run on each site are independent of each other.
- Appears to user as a single system.



Distributed Data Storage

- **Partitioning :**
  - Data is partitioned into several fragments and stored in different sites.
  - Horizontal – by rows.
  - Vertical – by columns.

- **Replication :**
  - System maintains multiple copies of data, stored in different sites.

Replication and Partitioning can be combined !

Partitioning

key	value
x	5
y	7
z	10
w	12

A

key	value
x	5

B

key	value
y	7
z	10

C

key	value
w	12

Horizontal

A

key
x
y
z
w

B

value
5
7
10
12

Vertical

- Locality of reference – data is most likely to be updated and queried locally.

Replication

key	value
x	5
y	7
z	10
w	12

A

key	value
x	5
y	7

B

key	value
x	5
z	10

C

key	value
y	7
w	12

D

key	value
z	10
w	12

- **Pros** – Increased availability of data and faster query evaluation.
- **Cons** – Increased cost of updates and complexity of concurrency control.

CAP Theorem

- In 2000, Berkeley, CA, researcher Eric Brewer published his now foundational CAP Theorem
  - (consistency, availability and partition tolerance)
- which states that it is impossible for a distributed computer system to simultaneously provide all three CAP guarantees.
- In May 2012, Brewer clarified some of his positions on the oft-used "two out of three" concept.

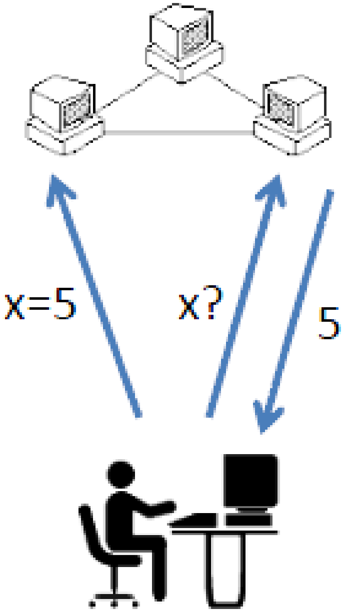
CAP Theorem

- **Consistency:**
  - all nodes see the same data at the same time
- **Availability:**
  - a guarantee that every request receives a response about whether it was successful or failed
- **Partition tolerance:**
  - the system continues to operate despite arbitrary message loss or failure of part of the system

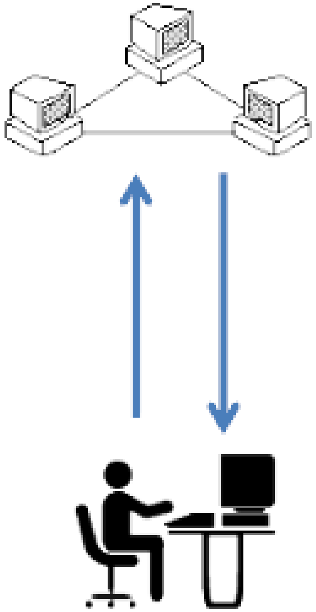
Theorem – You can have at most two of these properties for any shared-data system.

CAP Theorem

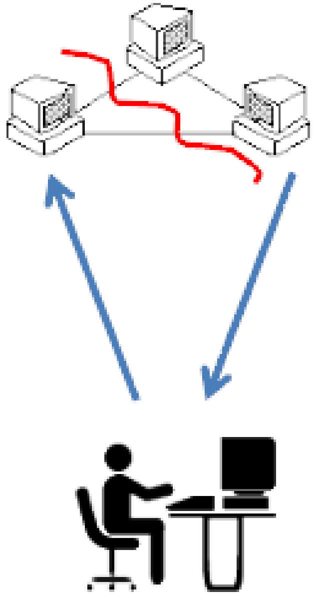
Consistency



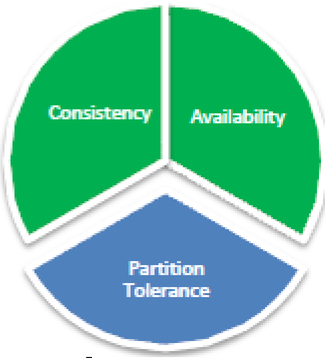
Availability



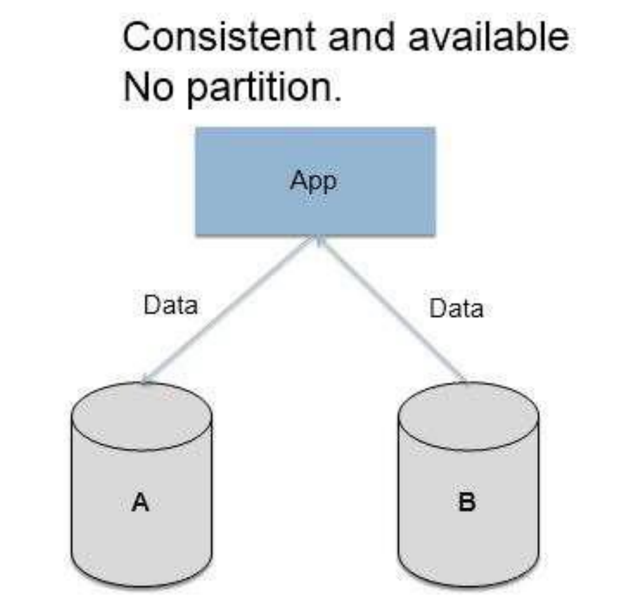
Partition tolerance



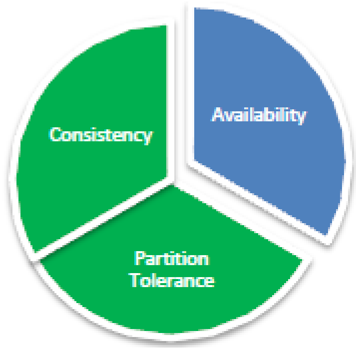
CAP - 2 of 3



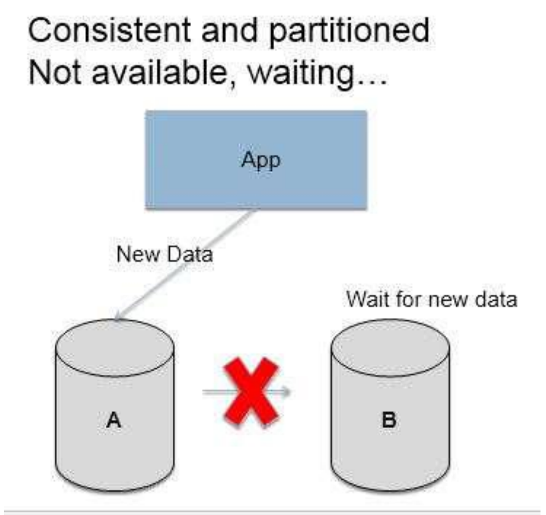
- If there are no partitions, it is clearly possible consistent, available data (e.g. read-any write-all).Best-effort availability:
- Examples:
  - RDBMs



CAP - 2 of 3

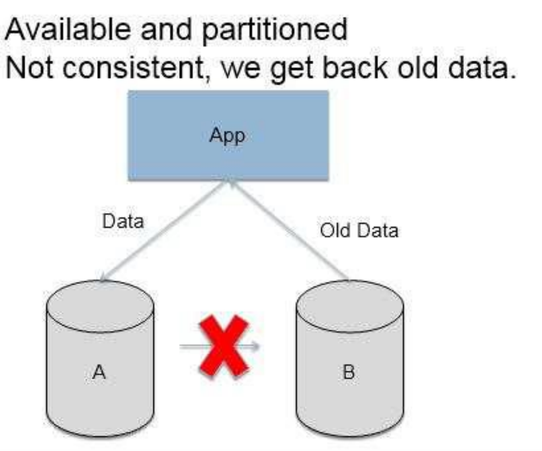


- Trivial:
  - The trivial system that ignores all requests meets these requirements.
- Best-effort availability:
  - Read-any write-all systems will become unavailable only when messages are lost.
- Examples:
  - Distributed database systems, BigTable



CAP - 2 of 3

- Trivial:
  - The service can trivially return the initial value in response to every request.
- Best-effort consistency:
  - Quorum-based system, modified to time-out lost messages, will only return inconsistent(and, in particular, stale) data when messages are lost.
- Examples:
  - Web cashes, Dynamo



Reference

- http://nosql-database.org/
- http://wikibon.org/wiki/v/21_NoSQL_Innovators_to_Look_for_in_2020#Introduction
- https://db-engines.com
- http://basho.com/posts/technical/why-vector-clocks-are-easy/
- …


Thank
You
Merci
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Arigatô
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TerimaKasih
Mèsi
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