# NoSQL


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# Outline

- Motivation
- CAP Theorem
- Characteristics
- Database Landscape
- Example: MongoDB

Take home message:

*RDBMS do not scale well -> NoSQL which play around with the Consistency/Availability dilemma*

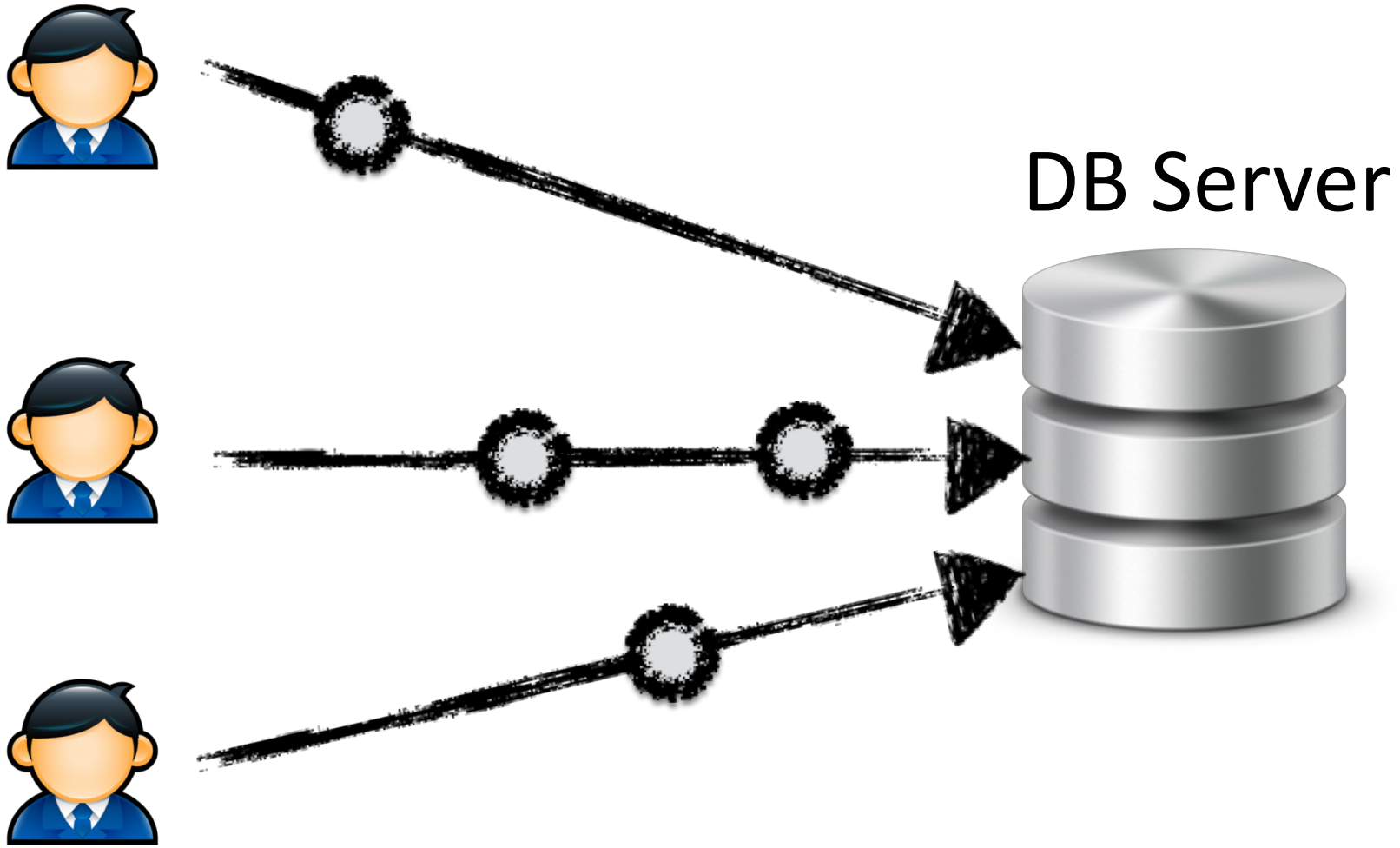
# MOTIVATIONS

# A Long Time ago…

- Everybody was happy with RDBMS
  - Centralised
  - Easy maintenance
  - Available anytime
  - Stable performance
  - Reliable (ACID)




# Traditional RDBMS



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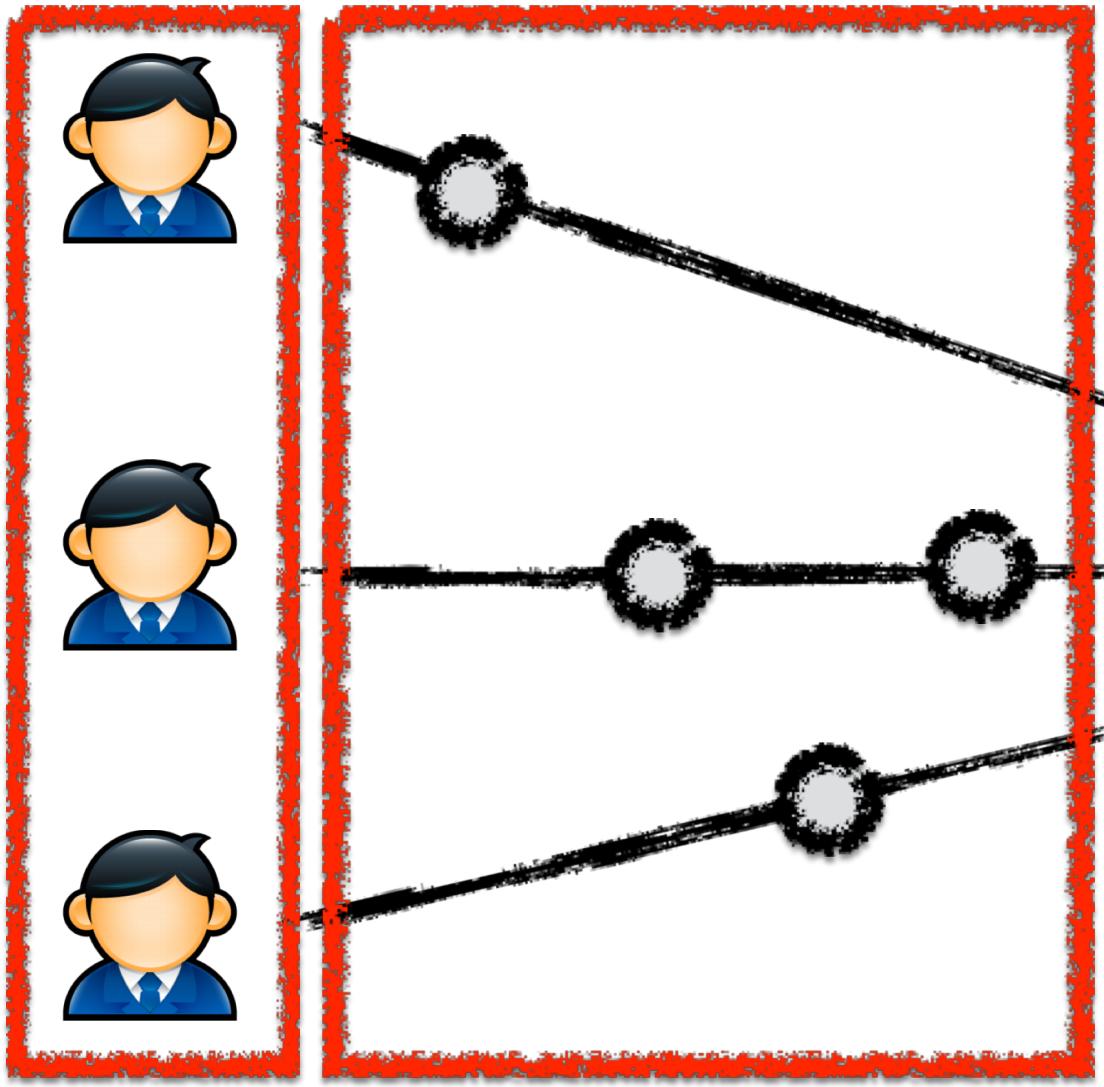


Few Clients

DB Server

Few tx/sec

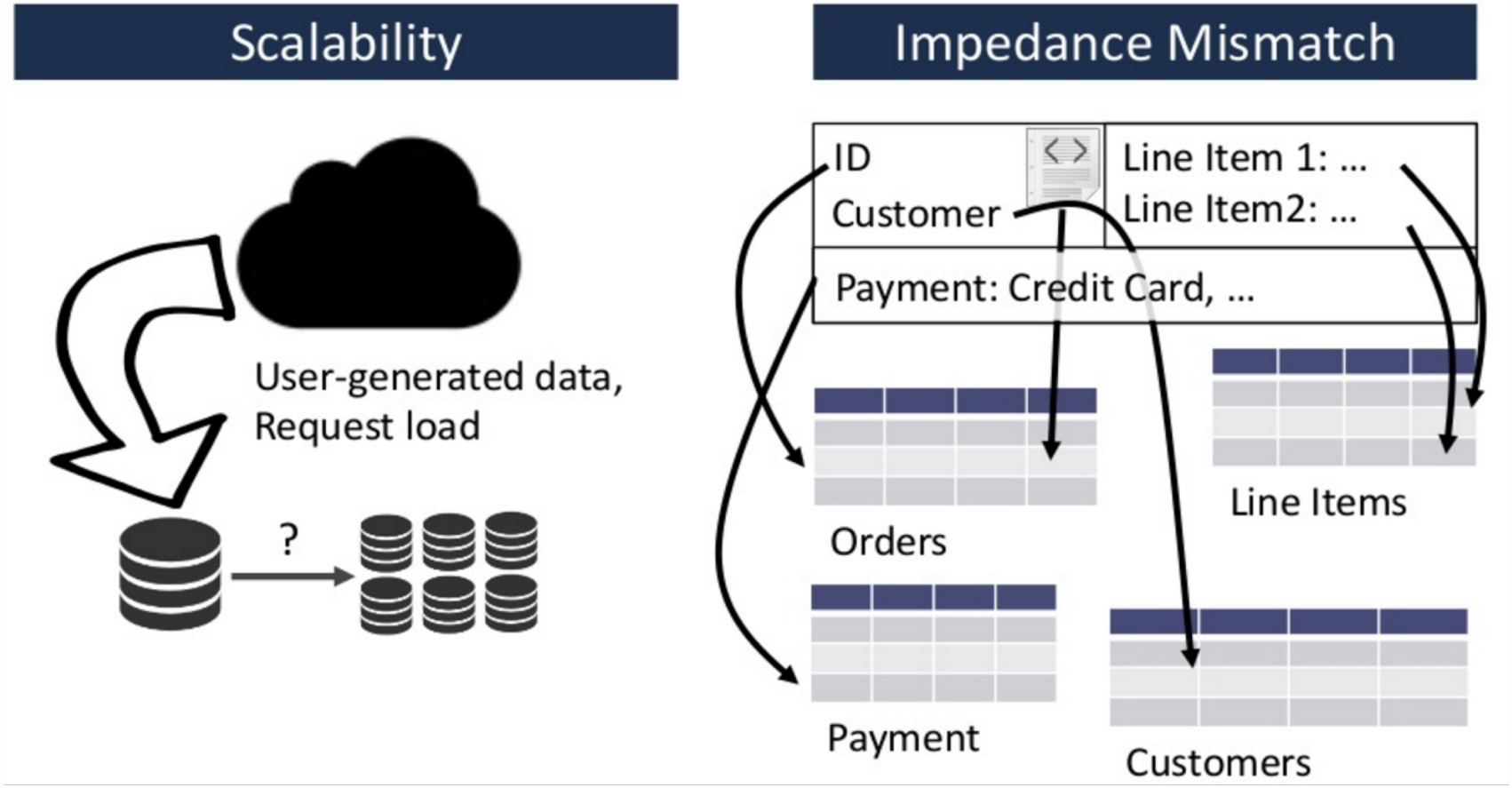
# RDBMS meet Big Data

- ***Large number of sources***: users, devices, sensors
- ***Swarm of transactions***: e.g. 1,000tx/sec/source
- ***Huge data size***: e.g. 10MB/sec stream

# RDBMS are not Agile

- Facebook added a new feature: replying with a photo
  (June 2013)

# Motivation for NoSQL



# CHARACTERISTICS

# Key Features of NoSQL

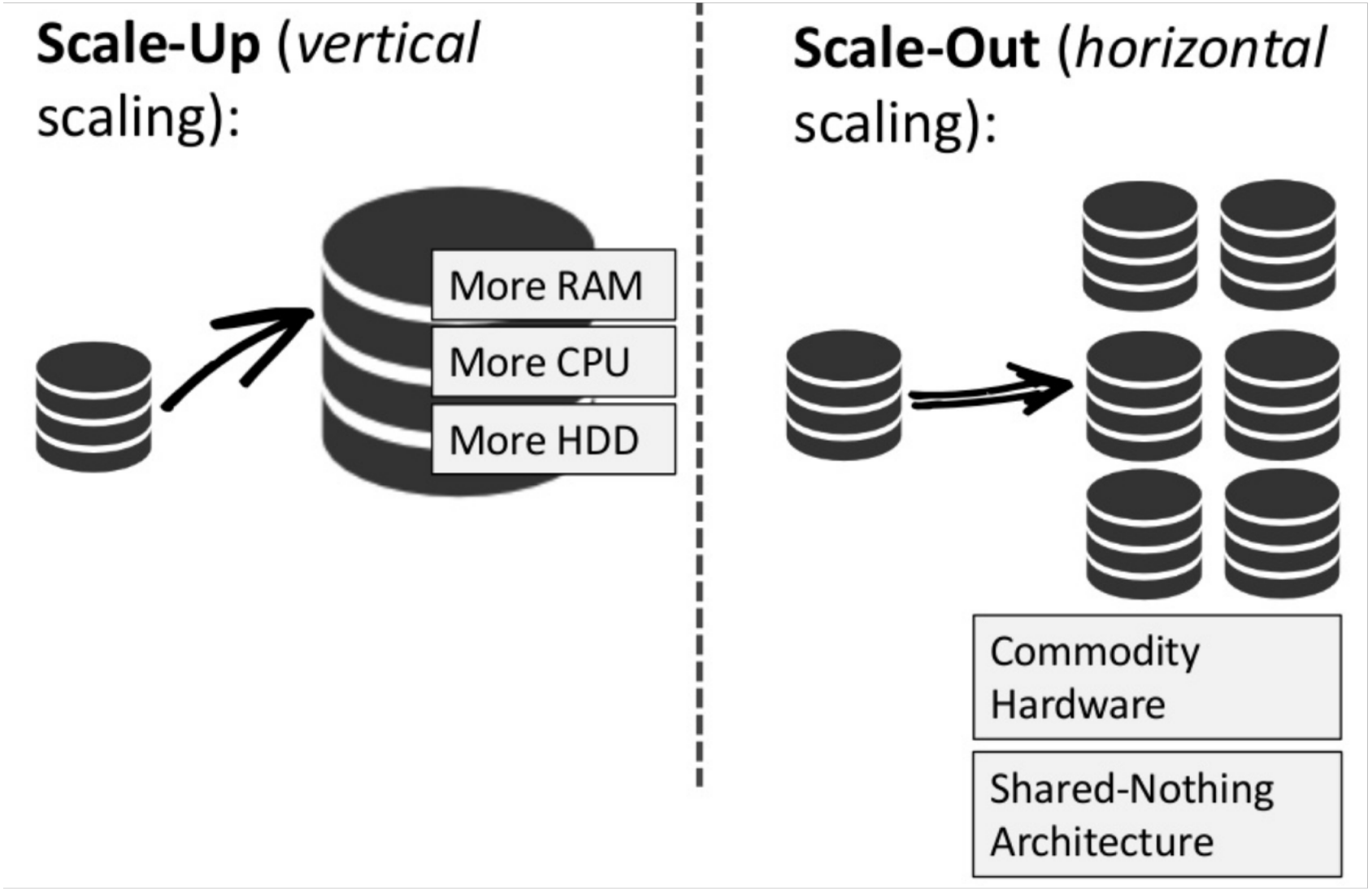
- Term coined in 2009 (Not Only SQL)


- Scalable (e.g. horizontal scaling)
- Easy replication through the network
- "Simple" API language (NO query language)
- Tunable consistency model (NO ACID properties)
- Ability to add new attributes to record (NO schema)

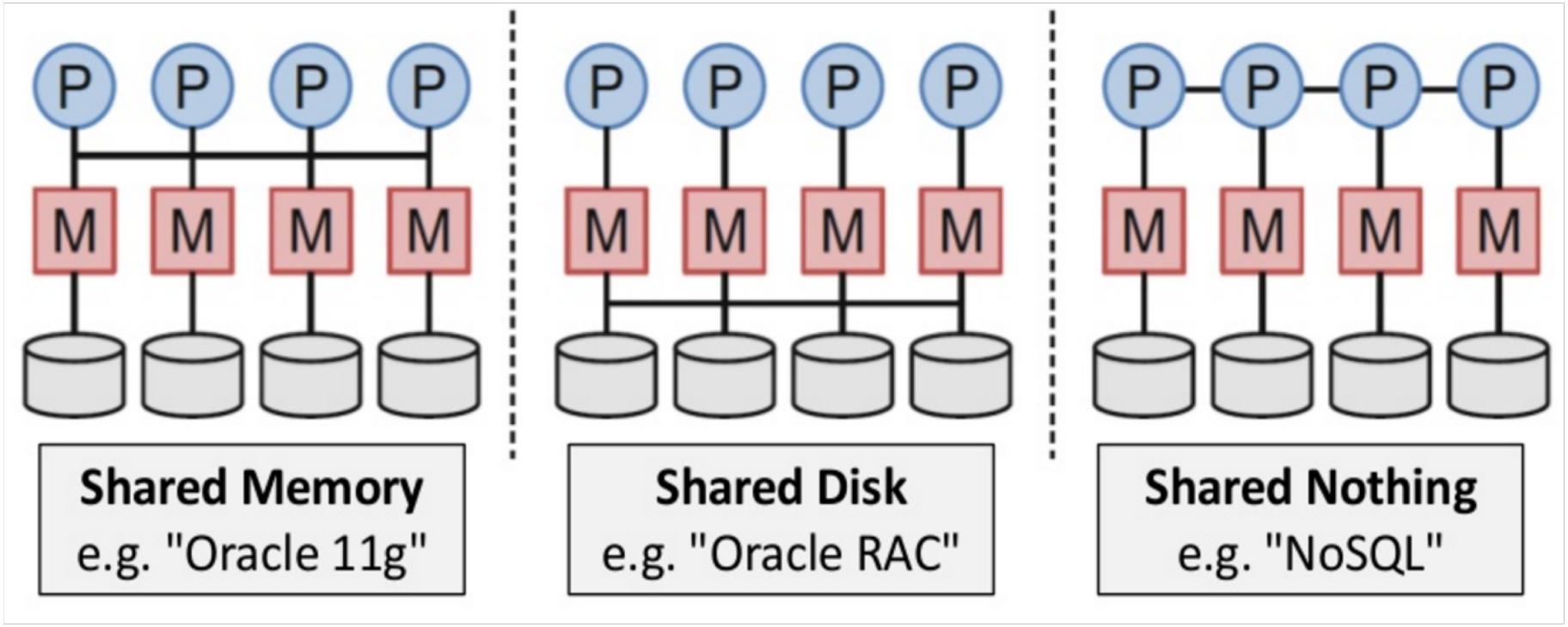
# (Old) SQL vs NewSQL vs NoSQL

| | OldSQL | NoSQL |
|---|---|---|
| ACID/Transaction | ✓ | ✗ |
| Language/Algebra | ✓ | ✗ |
| Schema/Constraints | ✓ | ✗ |
| Scalability | ✗ | ✓ ✓ ✓ |
| In-memory Tx | ✗ | ✓ |
| Easy replication | ✗ | ✓ |

# Vertical vs Horizontal Scaling

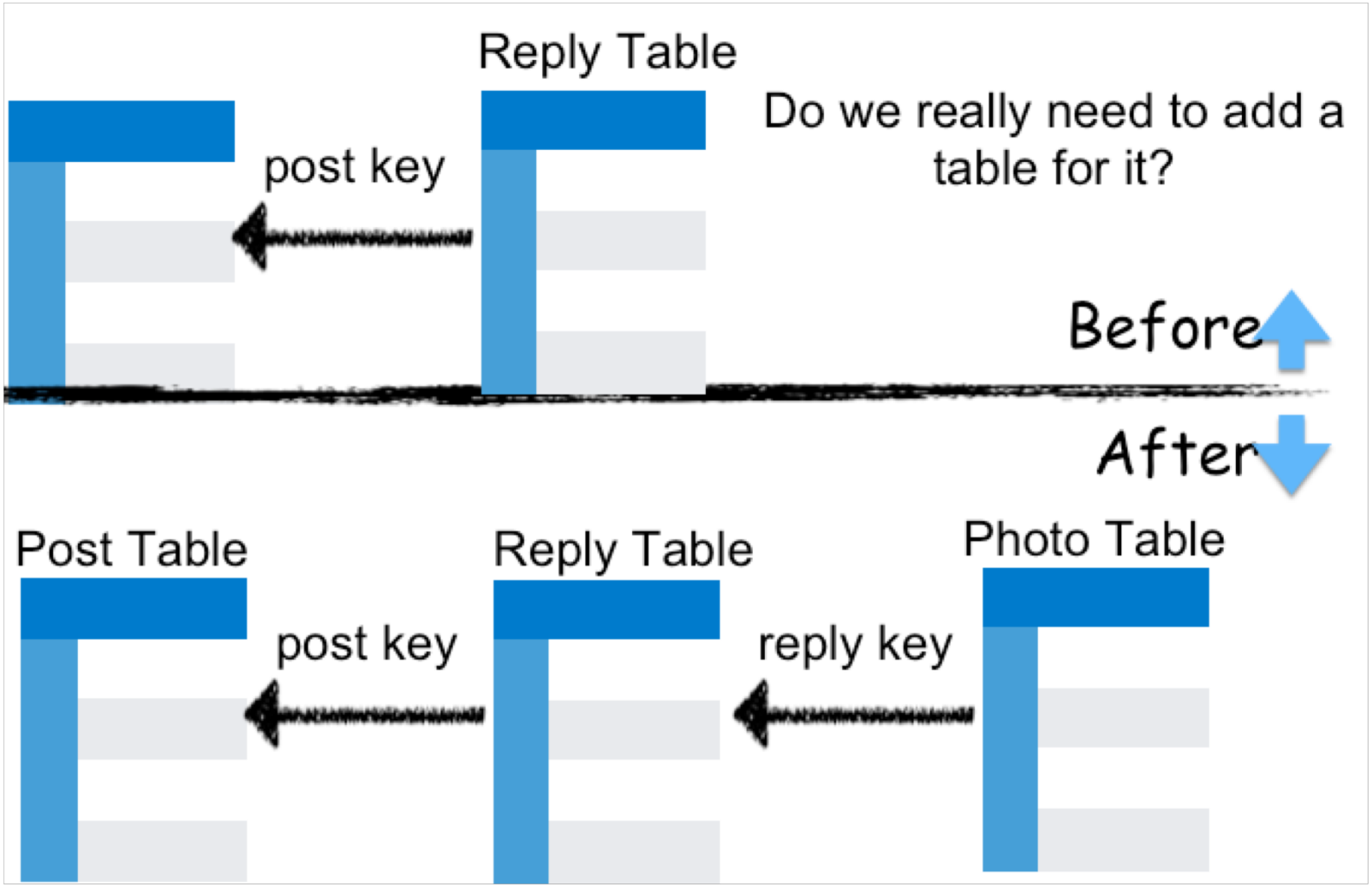


# Shift Towards "Shared Nothing"

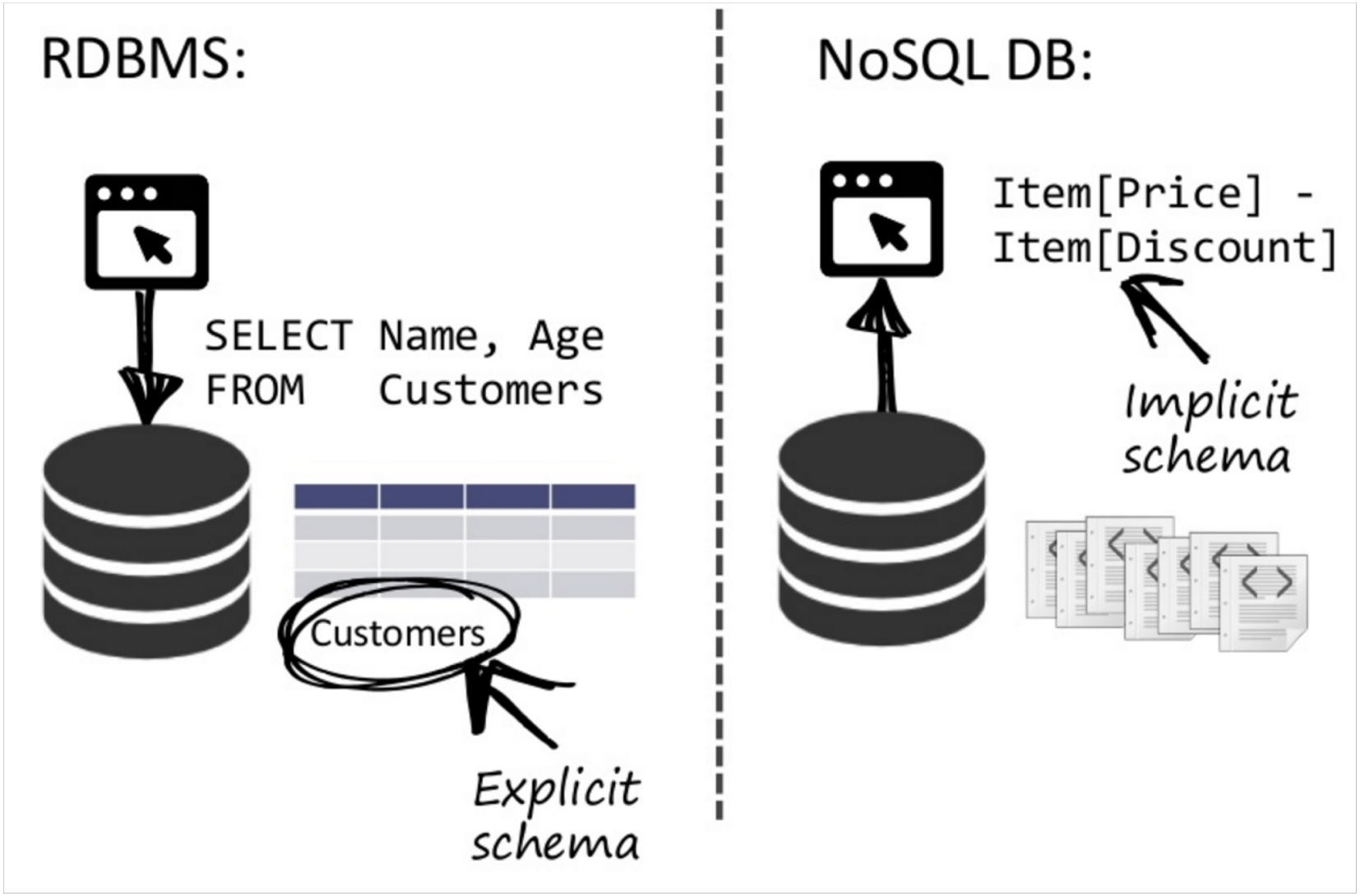



- When each node is independent and self-sufficient, there is no single point of contention across the system
- the potential for scaling is huge !

# Schema-dependent



# Schema-free

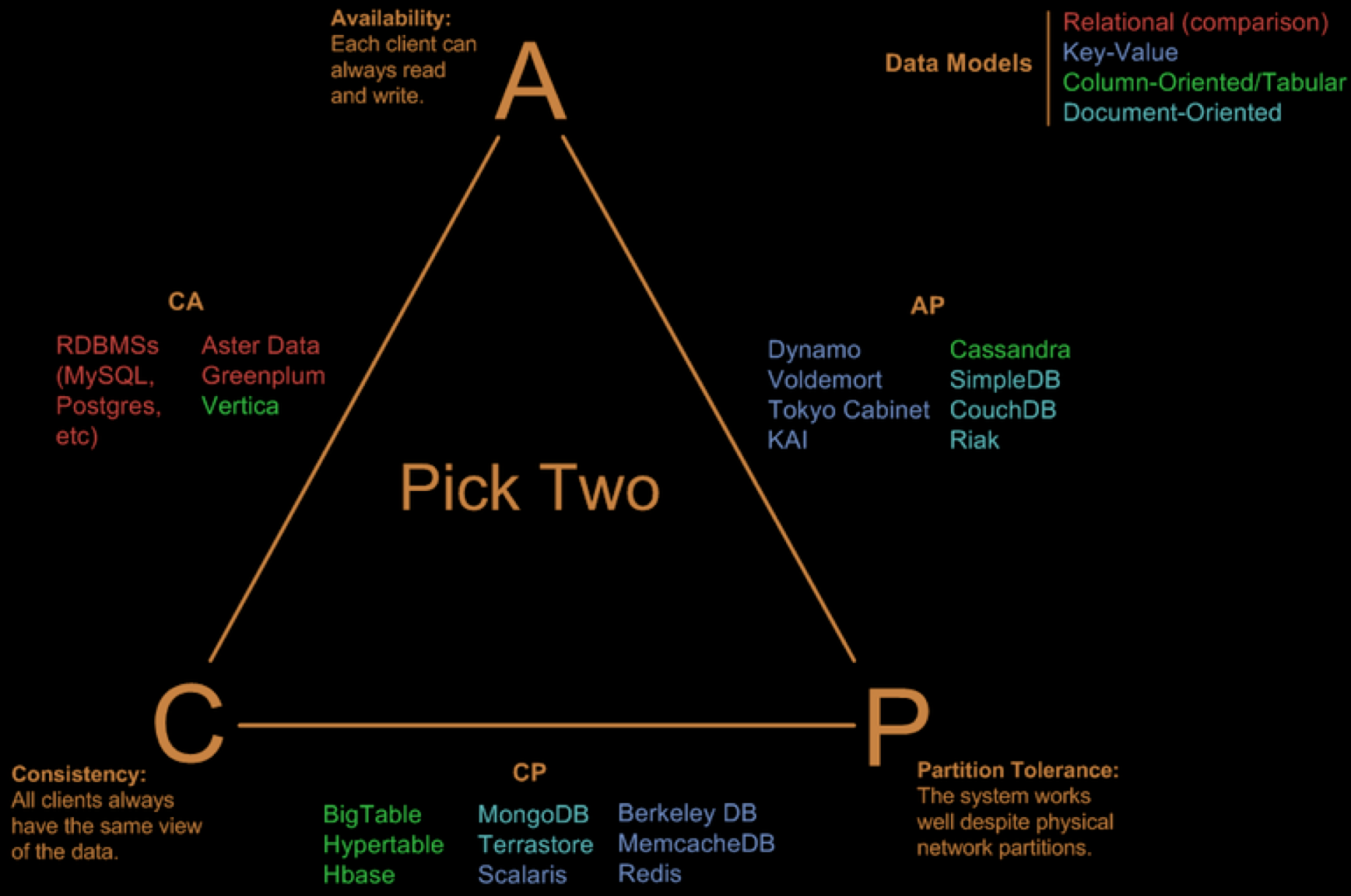

RDBMS:
SELECT Name, Age
FROM Customers
Customers
Explicit schema
NoSQL DB:
Item[Price] -
Item[Discount]
Implicit schema

# Benefits of Schema-free

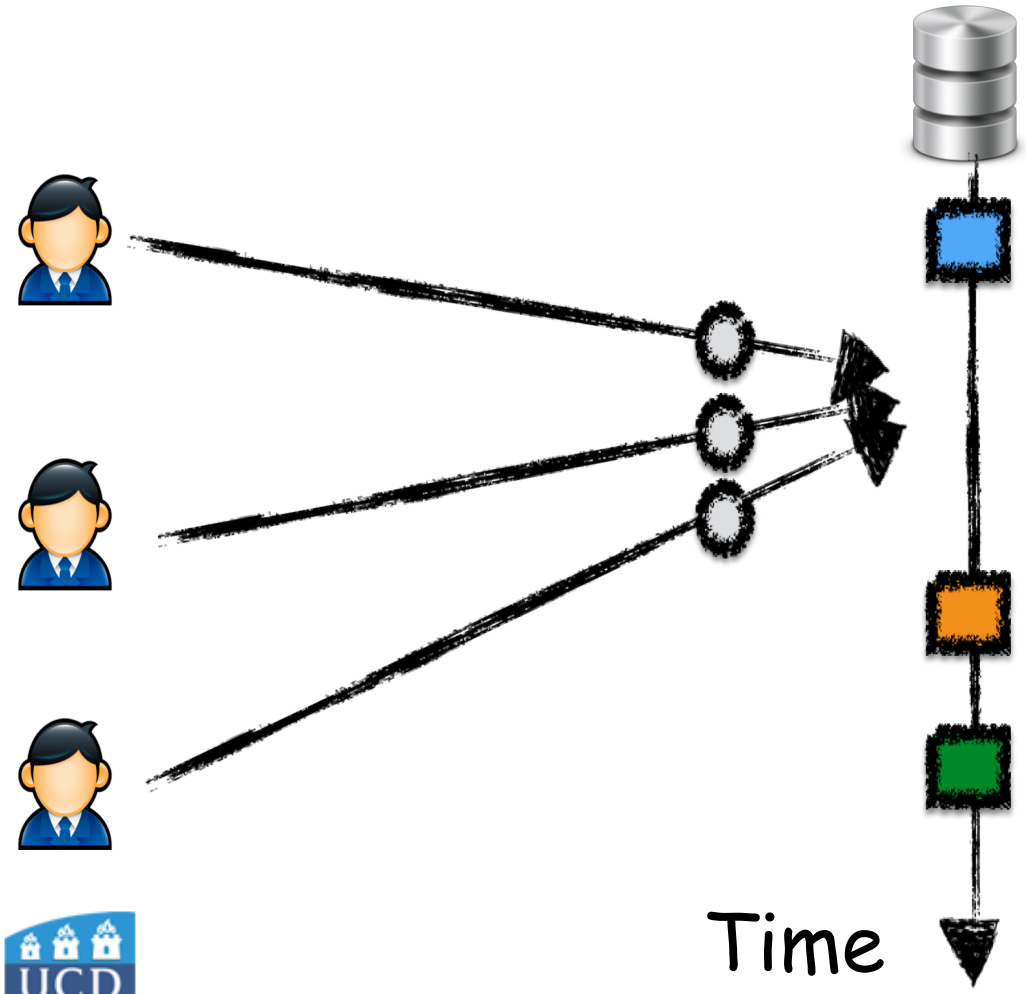
- Flexibility
- Easy to replicate
- Easy to partition
- Join-free

# CAP THEOREM

# Visual Guide to NoSQL Systems

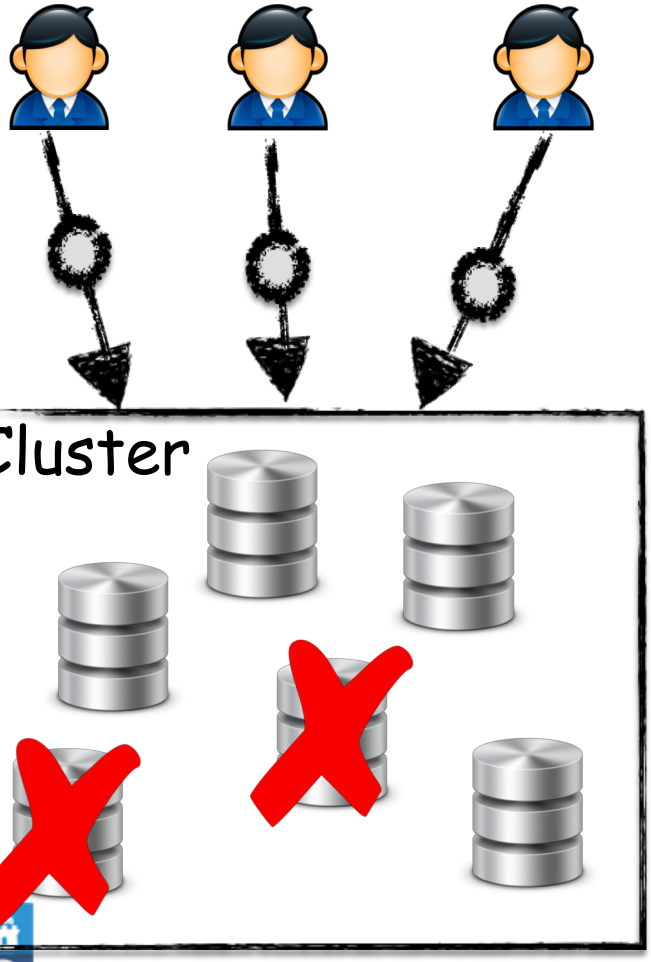


# Consistency



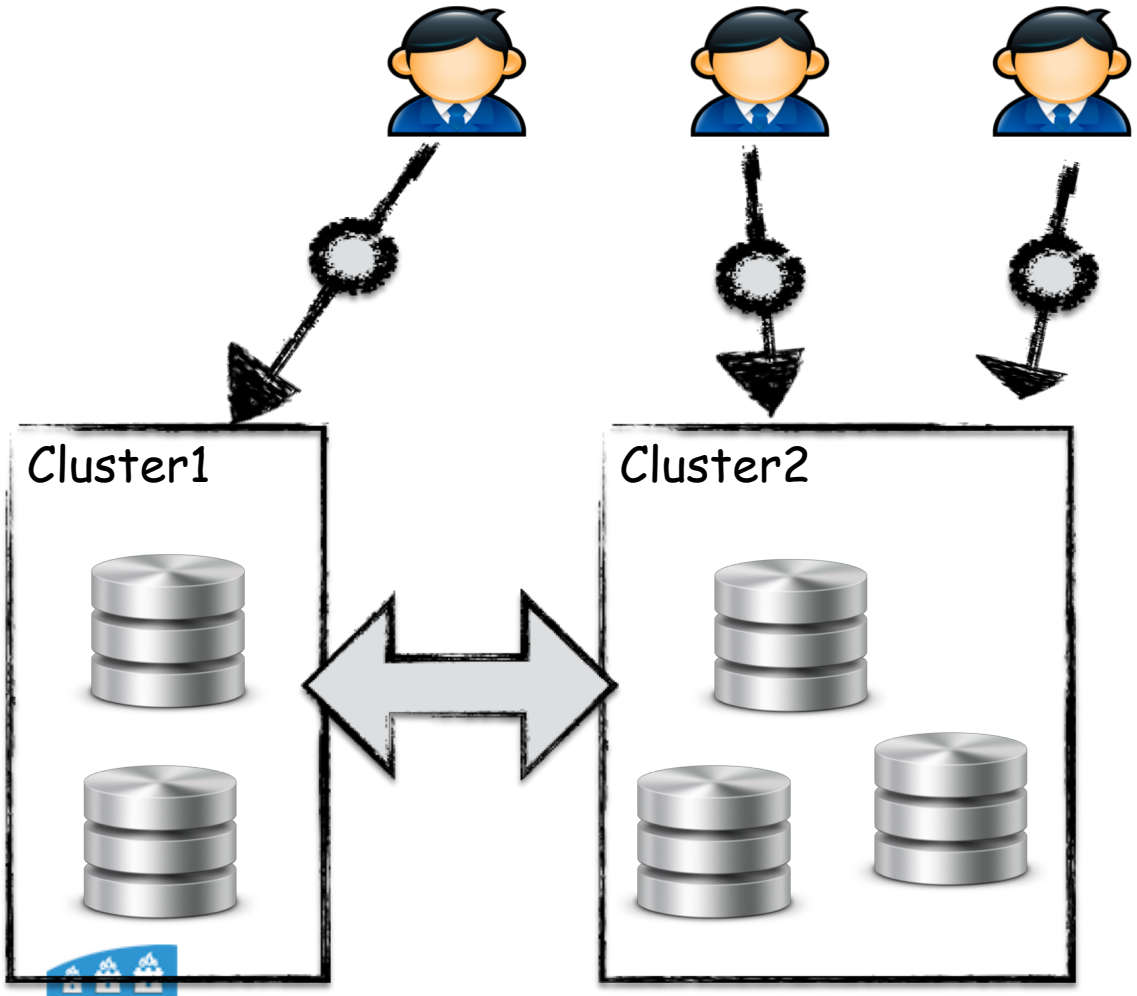

All clients have the same view on the data

# Availability




Every request to a non-failed node must result in a correct response

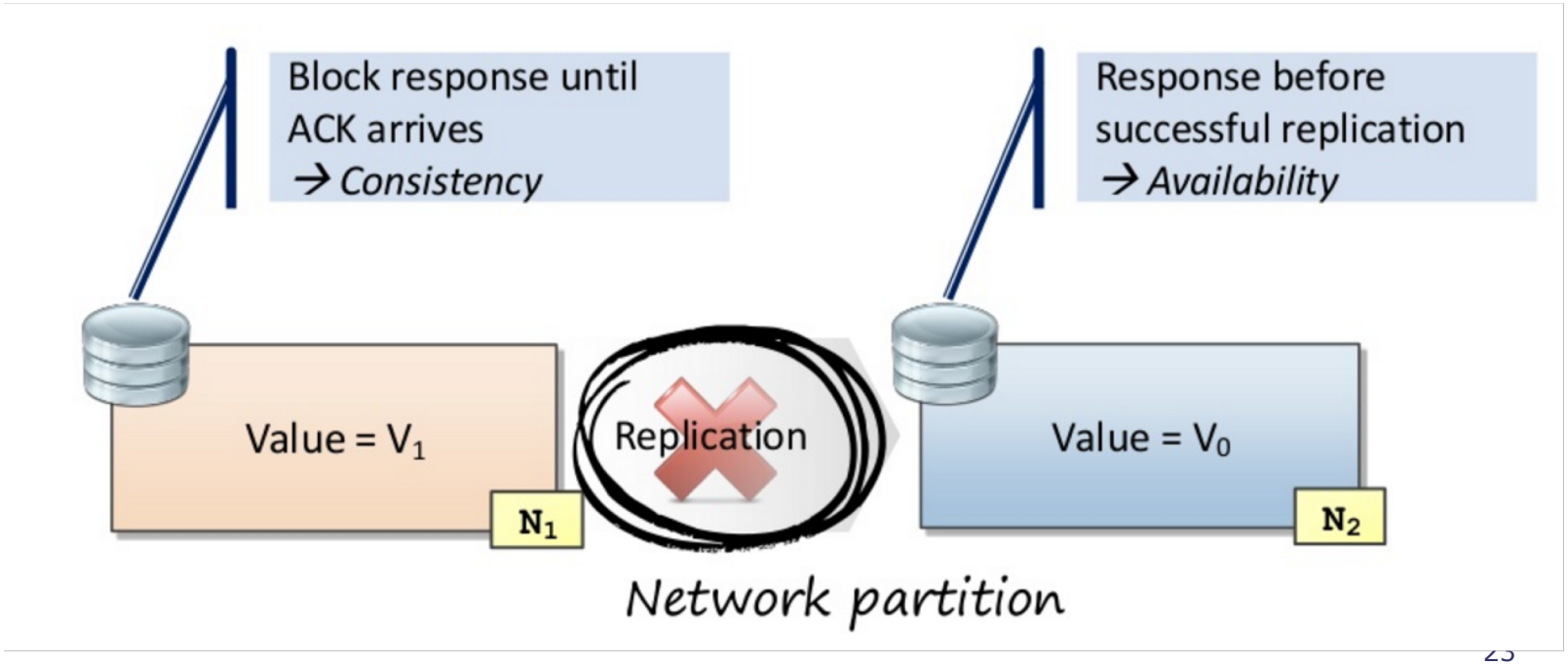
# Partition Tolerance




The system has to continue working, even under arbitrary network partitions

# Ideas

- When a network partition occurs, either consistency or availability is not ensured

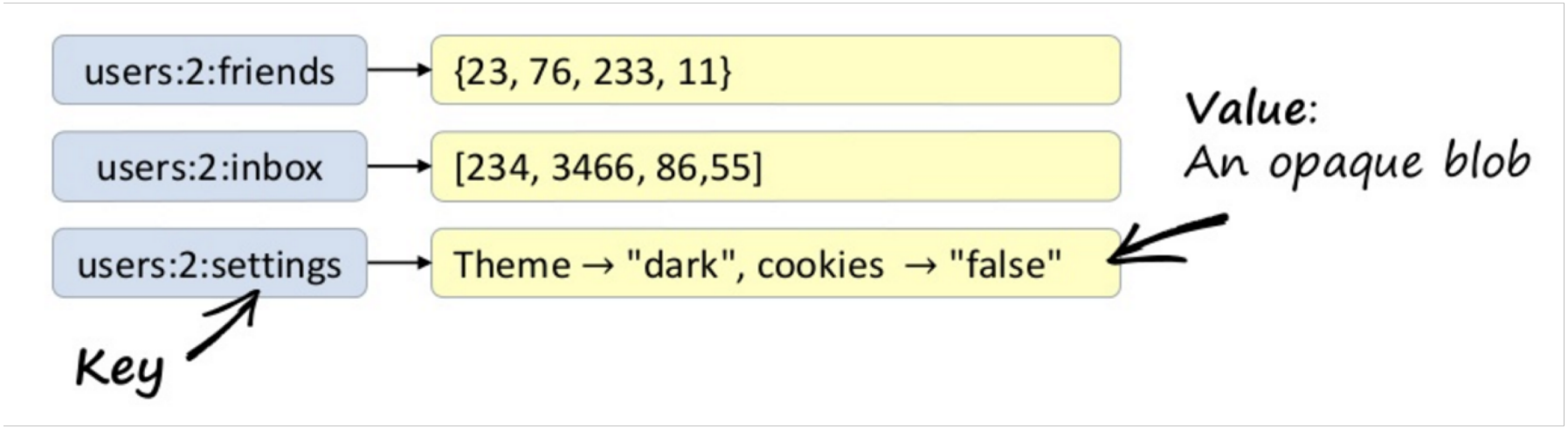


# DATABASE LANDSCAPE

# NoSQL Landscape

# Key-Value

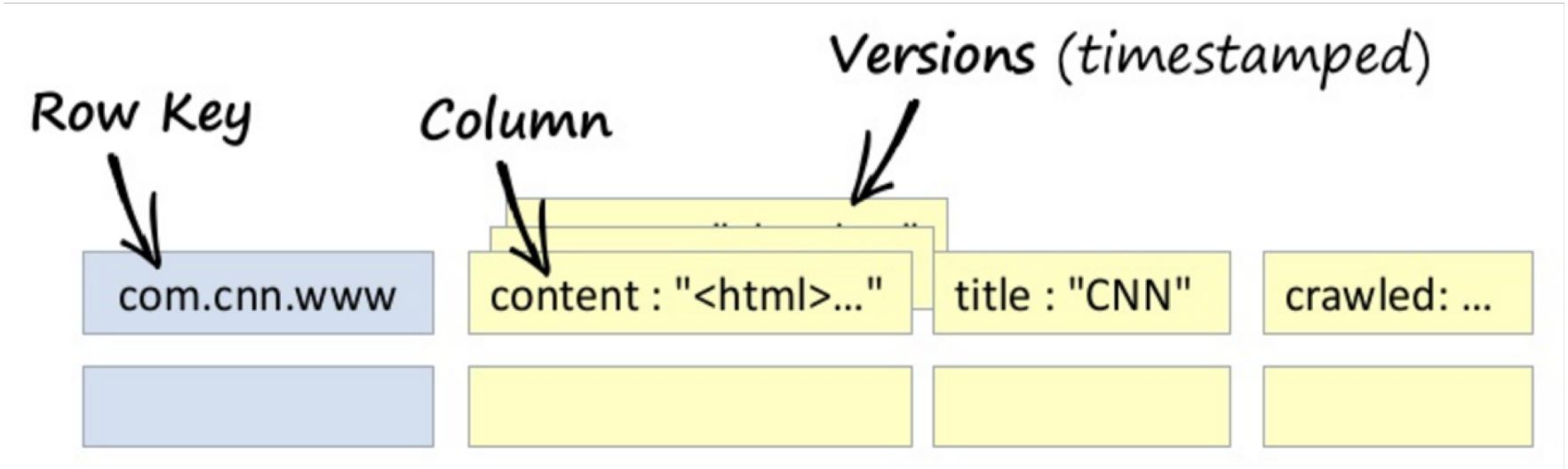
- ***single (key) -> value, no foreign key/value indices*** appropriate for instant access to data (shop basket)




- Example: Dynamo (AP), Riak (AP), Redis (CP)

# Wide-column

- ***data indexed by a 3D map: (row, col, time) -> val*** appropriate for aggregation and analytics (reports)

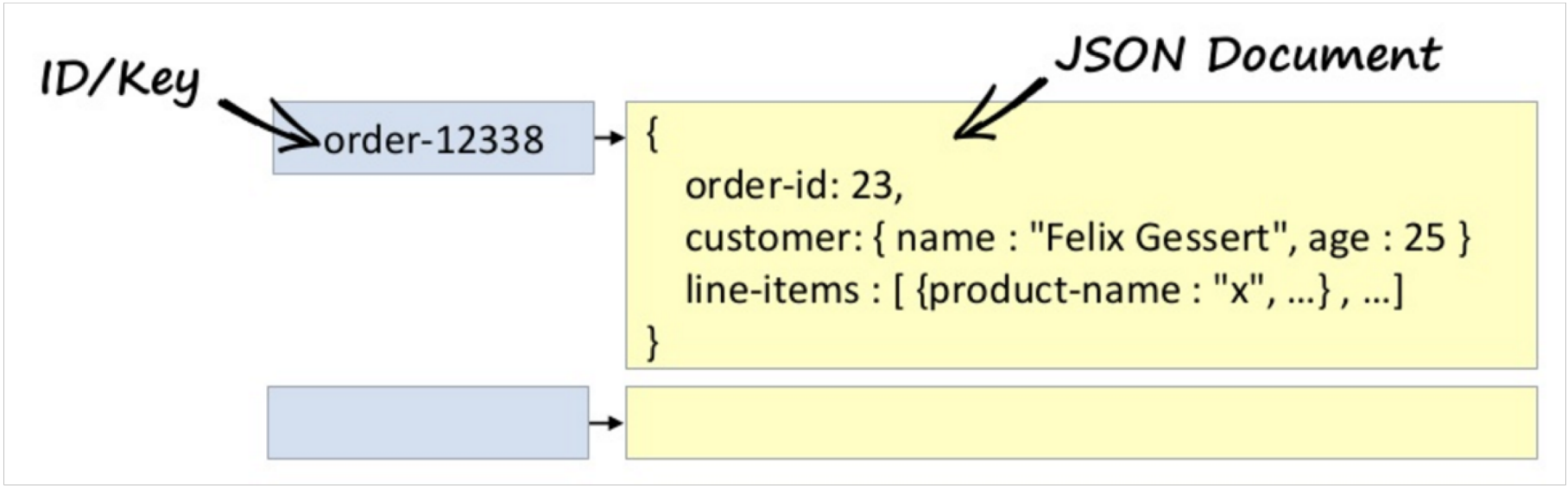



- Example: Cassandra (AP), BigTable (CP), HBase (CP)

# Document

- ***similar to JSON/XML: (coll, key) -> doc***

appropriate for data not frequently changing (logs)

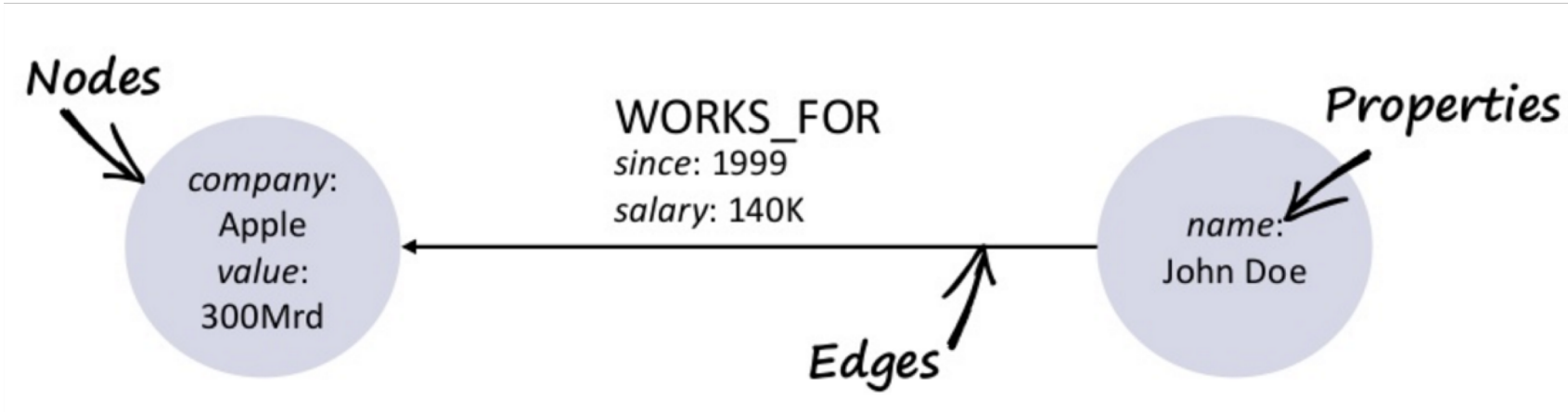




- Example: CouchDB (AP), SimpleDB (AP), MongoDB (CP)

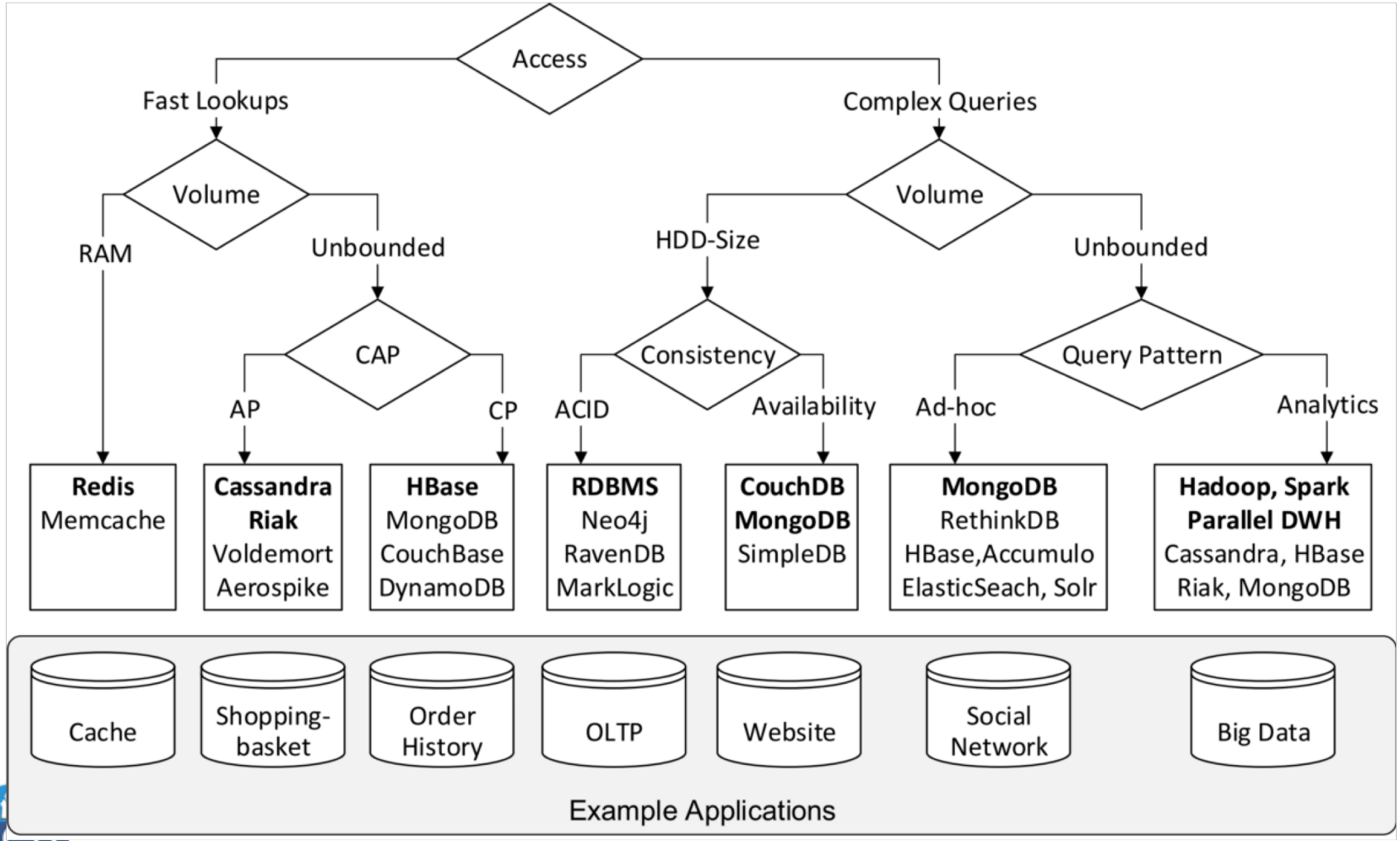
# Graph

- ***data represented by vertices/edges: G = (V, E)*** appropriate for complex structures (social network)




- Example: Neo4j (CA), InfiniteGraph (CA), OrientDB (CA)

# Decision Tree




Source: https://medium.baqend.com/nosql-databases-a-survey-and-decision-guidance-ea7823a822d

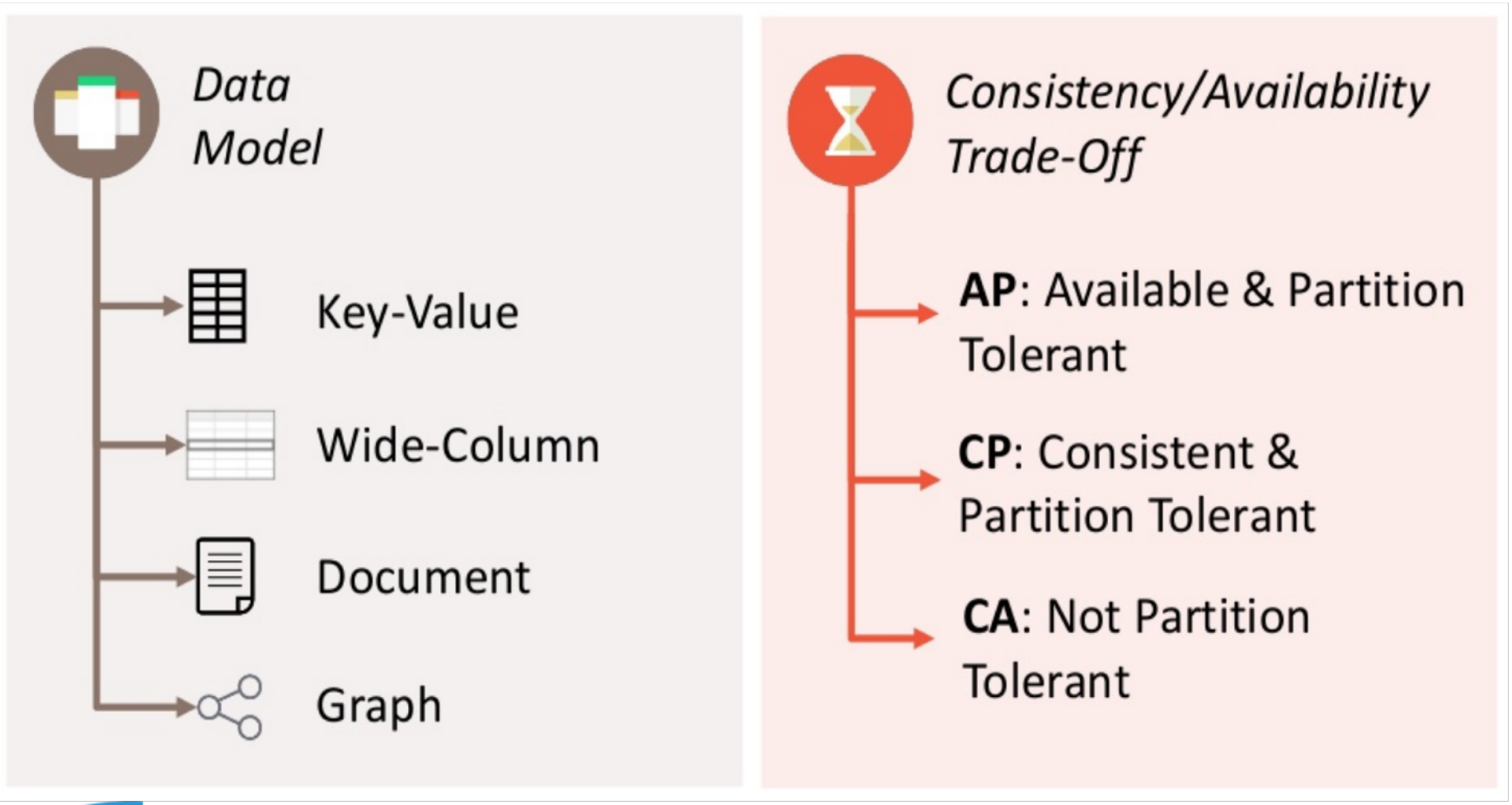
# Database Ranking

341 systems in ranking, January 2018

| Rank Jan 2018 | Rank Dec 2017 | Rank Jan 2017 | DBMS | Database Model | Score Jan 2018 | Score Dec 2017 | Score Jan 2017 |
|---|---|---|---|---|---|---|---|
| 1. | 1. | 1. | Oracle | Relational DBMS | 1341.94 | +0.40 | -74.78 |
| 2. | 2. | 2. | MySQL | Relational DBMS | 1299.71 | -18.36 | -66.58 |
| 3. | 3. | 3. | Microsoft SQL Server | Relational DBMS | 1148.07 | -24.42 | -72.89 |
| 4. | 4. | ↑ 5. | PostgreSQL | Relational DBMS | 386.18 | +0.75 | +55.81 |
| 5. | 5. | ↓ 4. | MongoDB | Document store | 330.95 | +0.18 | -0.96 |
| 6. | 6. | 6. | DB2 | Relational DBMS | 190.28 | +0.70 | +7.78 |
| 7. | 7. | ↑ 8. | Microsoft Access | Relational DBMS | 126.70 | +0.82 | -0.75 |
| 8. | ↑ 9. | ↓ 7. | Cassandra | Wide column store | 123.88 | +0.67 | -12.57 |
| 9. | ↓ 8. | 9. | Redis | Key-value store | 123.14 | -0.10 | +4.44 |
| 10. | 10. | ↑ 11. | Elasticsearch | Search engine | 122.55 | +2.77 | +16.38 |
| 11. | 11. | ↓ 10. | SQLite | Relational DBMS | 114.25 | -0.94 | +1.88 |
| 12. | 12. | 12. | Teradata | Relational DBMS | 72.63 | -2.11 | -1.54 |
| 13. | ↑ 14. | 13. | SAP Adaptive Server | Relational DBMS | 65.46 | -0.22 | -3.64 |
| 14. | ↓ 13. | 14. | Solr | Search engine | 64.37 | -1.93 | -3.71 |
| 15. | 15. | ↑ 16. | Splunk | Search engine | 64.00 | +0.21 | +8.51 |
| 16. | 16. | ↓ 15. | HBase | Wide column store | 61.64 | -1.78 | +2.50 |
| 17. | 17. | ↑ 20. | MariaDB | Relational DBMS | 58.30 | +1.56 | +13.26 |
| 18. | ↑ 19. | ↑ 19. | Hive | Relational DBMS | 55.49 | +0.81 | +4.35 |
| 19. | ↓ 18. | ↓ 17. | FileMaker | Relational DBMS | 55.20 | +0.00 | +1.72 |
| 20. | 20. | ↓ 18. | SAP HANA | Relational DBMS | 46.16 | -0.33 | -5.77 |
| 21. | 21. | 21. | Neo4j | Graph DBMS | 39.96 | +1.24 | +3.70 |

https://db-engines.com/en/ranking

# Summary




The era of one-size-fits-all DBMS is over

# EXAMPLE: MONGODB

# MongoDB in a Nutshell

- Created by MongoDB Inc. in Oct. 2007
  - MongoDB <= huMONGOus DB
- Document-oriented data model
  - BSON (similar to JSON)
- Supports:
  - indexing
  - replication
  - load balancing
  - server-side JavaScript execution.


# Insert/Update/Delete

- Insert: db.<collection>.insert(<document>)
  - db.users.insert({name:”Aoife”,city:”Dublin”})
  - no need to create a table upfront!

- Update: db.<collection>.update(<query>, <values>)
  - db.users.update({name:”Niamh”}, {$set: {city:”Cork”}})


- Delete: db.<collection>.remove(<query>)
  - db.users.remove({name:”Deirdre”})

# Select/Queries

- Simple Select: db.<collection>.find(<query>)
  - db.users.find({name:”Fionna”})
- Nested Select: use dot-notation
  - db.users.find({"score.math":30})
- Show specific columns only
  - db.users.find({},{“score.math”:1, “score.lang”:1})
- Query if
  - db.users.find({"score.math":{$exists:true}}, {name:1})

# Other Useful Operations

- count(): counting the number of documents
  - db.users.find().count()
  - db.users.count({name:”john”})
- sort(): sorting documents
  - db.users.find().sort({name:-1})
- List collections (tables) and databases
  - show collections/tables ; show databases
- limit(): Show a specified number of documents
  - db.users.find().limit(5)