Cloud Databases

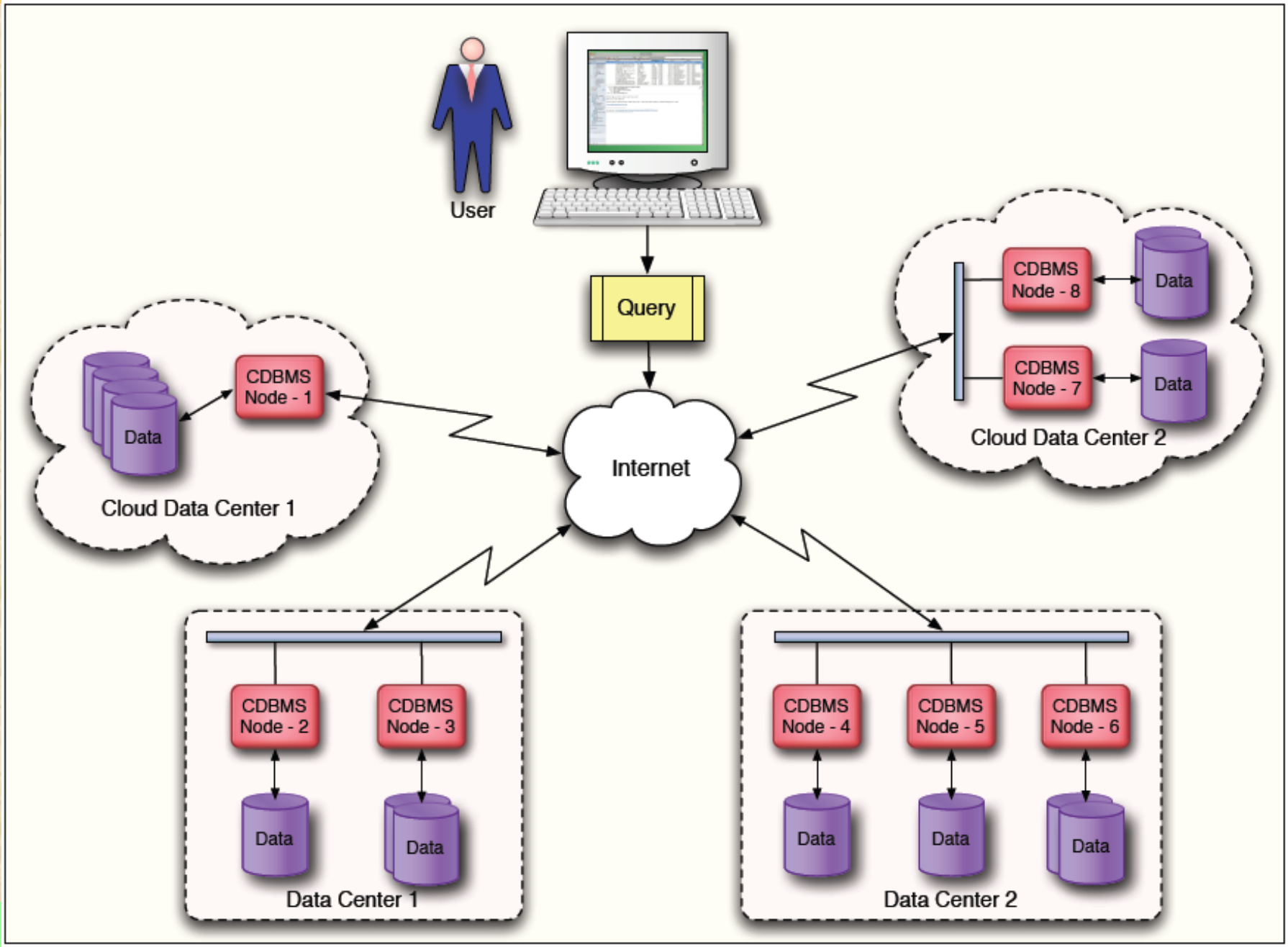
Introduction

- Std. Layered Architecture
- **Cloud Infrastructure**
- A **cloud database** is a database that typically runs on a *cloud computing* platform, such as *Amazon EC2, GoGrid*, *Salesforce*, *Rackspace*, and *Microsoft Azure*.
- Deployment models
  - users can run databases on the cloud independently, using a *virtual machine* image
  - they can purchase access to a database service, maintained by a cloud database provider. ***DBaaS***
- Data Models : **SQL , NoSQL**

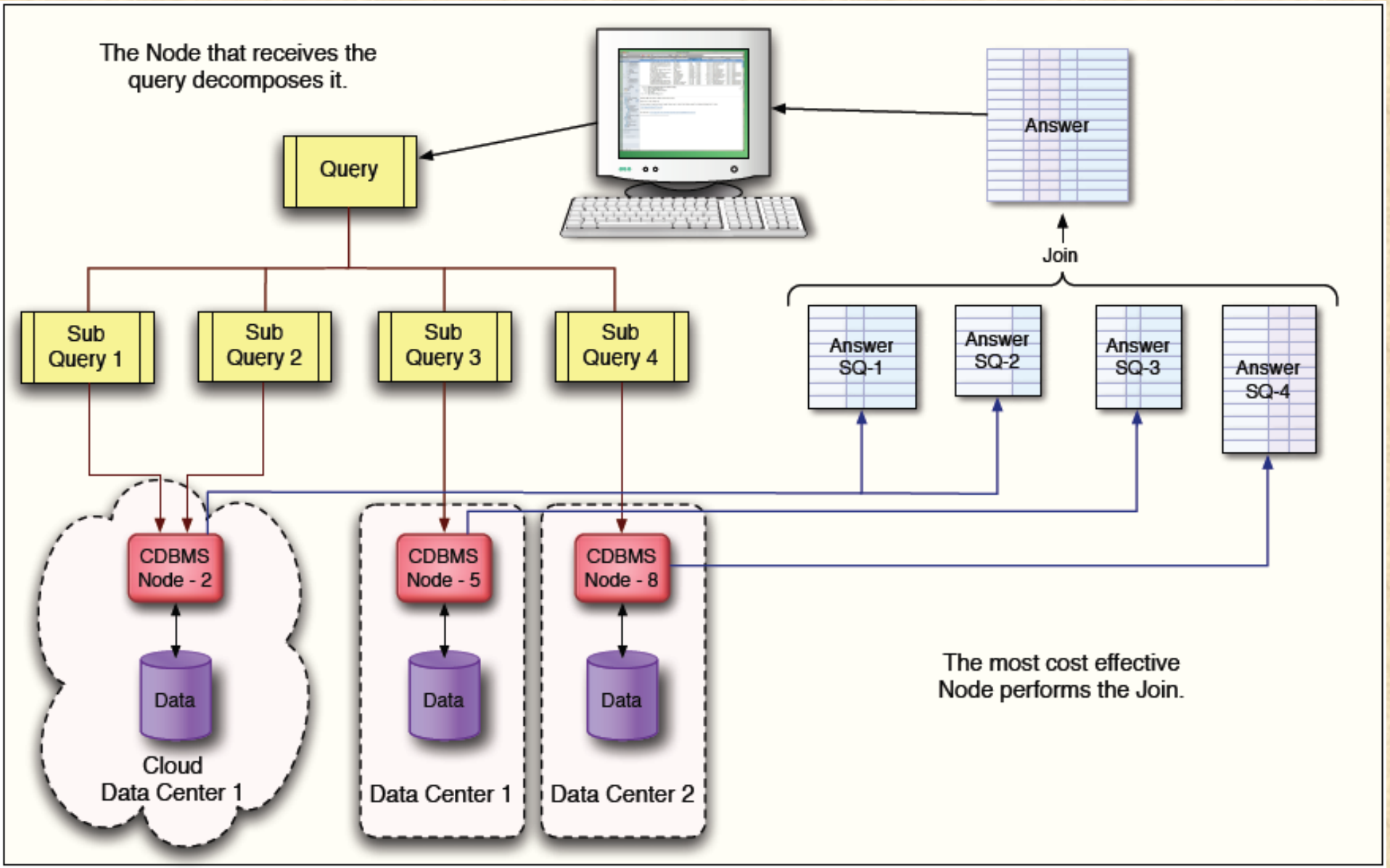
Definition

Cloud dbms (CDBMS) is a distributed database that delivers a query service across multiple distributed database nodes located in multiple geographically-distributed data centers, both corporate data centers and cloud data centers.

Architecture / Layout



Distributed Query Processing



Data Model : SQL

- **SQL database**, such as *NuoDB, Oracle Database, Microsoft SQL Server*, and *MySQL*, are one type of database which can be run on the cloud (either as a Virtual Machine Image or as a service, depending on the vendor).
- SQL databases are difficult to scale, not natively suited to a cloud environment
- Cloud database services based on SQL are attempting to address this challenge

Data Model : NoSQL *www.nosql-database.org*

- NoSQL means '**N**ot **O**nly **SQL**' , 'Not Relational'.
- **NoSQL databases**, such as *Apache Cassandra, CouchDB and MongoDB*, are another type of database which can run on the cloud.
- NoSQL databases are built to service heavy read/write loads and are able scale up and down easily
- More natively suited to running on the cloud.
- working with NoSQL databases often requires a complete rewrite of application code
- Set of APIs to access data. ***no SQL like query***

NoSQL : Advantages

- non-relational
- don’t require schema
- data are replicated to multiple nodes (so, identical & fault-tolerant) and can be partitioned:
  - down nodes easily replaced
  - no single point of failure
- horizontal scalable
- cheap, easy to implement (open-source)
- massive write performance
- fast key-value access

NoSQL : Disadvantages

- Don’t fully support relational features
  - no join, group by, order by operations (except within partitions)
  - no referential integrity constraints across partitions
- No declarative query language (e.g., SQL) → more programming
- Relaxed ACID (see CAP theorem) → fewer guarantees
- No easy integration with other applications that support SQL

NOSQL Modeling Types

1. Key-value
   - Example: DynamoDB, Voldermort, Scalaris
2. **Document-based**
   - Example: MongoDB, CouchDB
3. **Column-based**
   - Example: BigTable, Cassandra, Hbased
4. ***Graph-based***
   - Example: Neo4J, InfoGrid

- "No-schema" is a common characteristics of most NOSQL storage systems
- Provide "flexible" data types

NoSQL Transactions

Types of consistency:

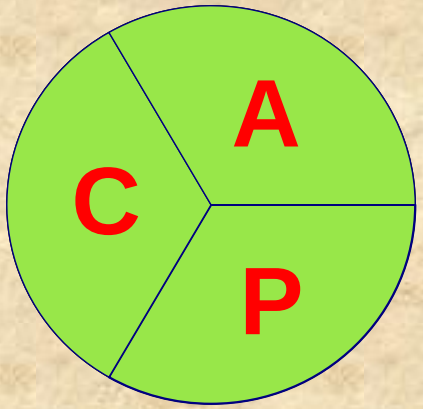
1. Strong consistency – ACID
   (**A**tomicity, **C**onsistency, **I**solation, **D**urability)
   do not supported by NoSQL

2. Weak consistency – BASE
   (**B**asically **A**vailable **S**oft- state **E**ventual consistency)

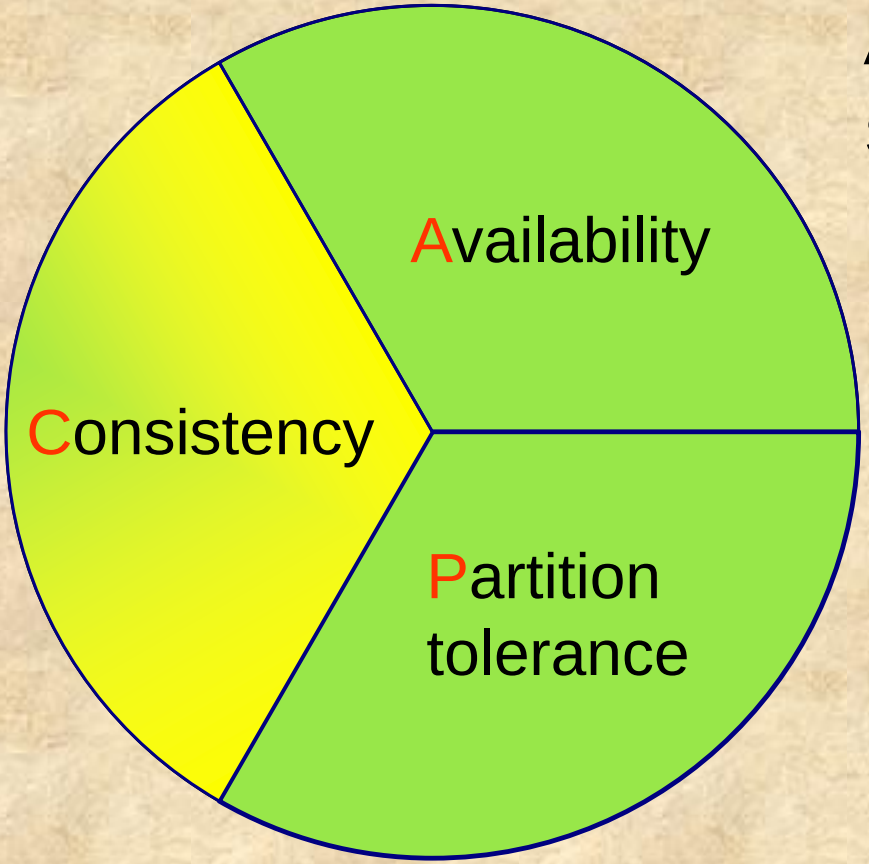
Based on CAP Theorem

CAP Theorem

- Three properties of a distributed system (sharing data)
  - **Consistency:**
    - all copies have same value
  - **Availability:**
    - reads and writes always succeed
  - **Partition-tolerance:**
    - system properties (consistency and/or availability) hold even when network failures prevent some machines from communicating with others



CAP Theorem

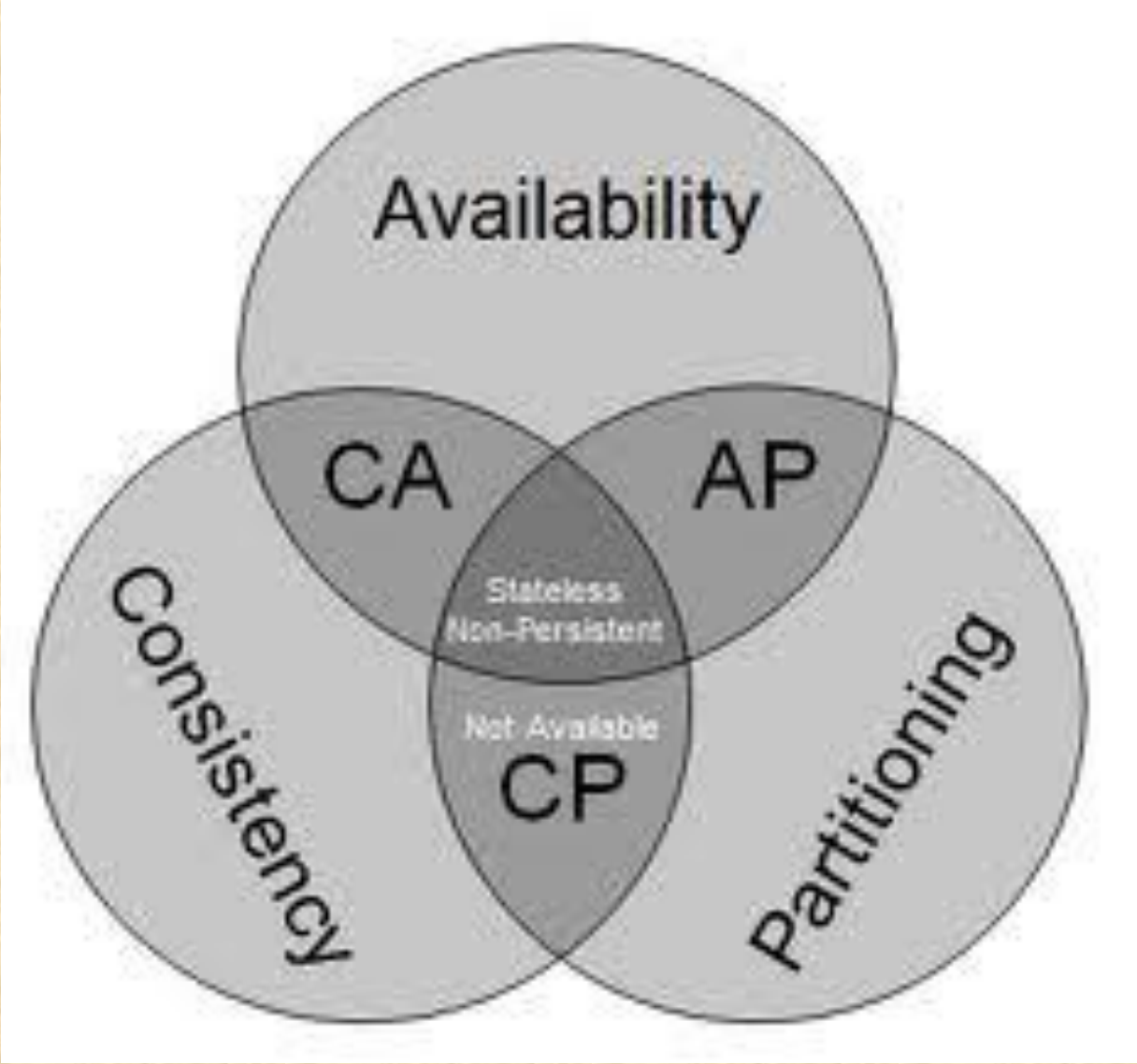


All client always have the same view of the data

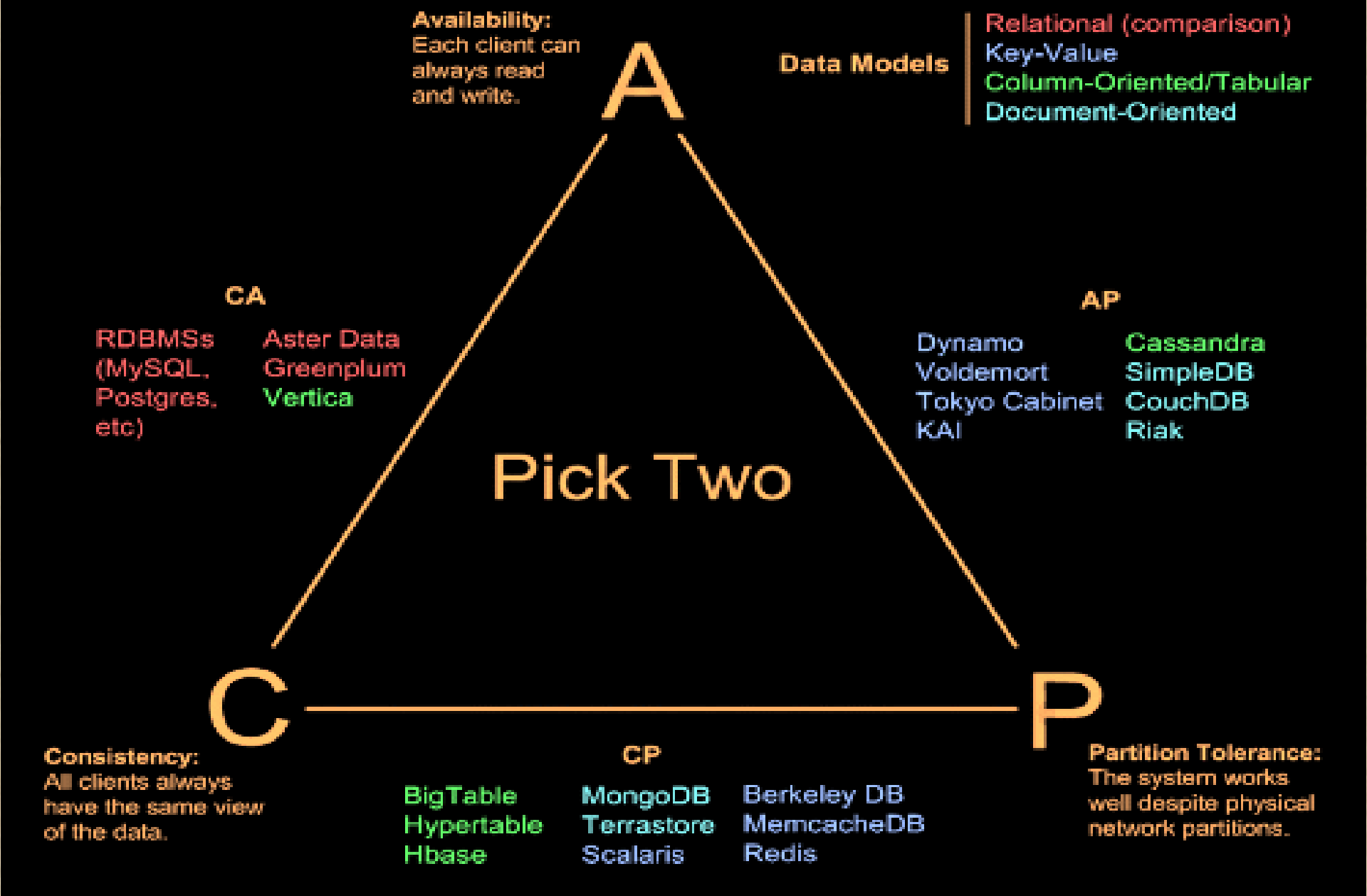
Brewer's CAP Theorem:

- *For any system sharing data, it is "impossible" to guarantee simultaneously all of these three properties*
- You can have at most two of these three properties for any shared-data system
- Very large systems will "partition" at some point:
  - That leaves either **C** or **A** to choose from (traditional DBMS prefers **C** over **A** and **P**)
  - In almost all cases, you would choose **A** over **C** (except in specific applications such as order processing)

Brewer's CAP Theorem



Visual Guide to NoSQL Systems



Storage Architecture for Cloud DB

Shared-nothing Storage Architecture

- It involves data partitioning which splits the data into independent sets - physically located on different database servers.
- suitable for Cloud.
- Needs piece of middleware to route database requests to the appropriate server.
- IBM, Oracle, Amazon's SimpleDB, Hadoop Distributed File System and Yahoo's PNUTS also implement shared-nothing architecture

Storage Architecture for Cloud DB

Shared-disk Database Architecture

- Treats the whole database as a single large piece of database stored on a Storage Area Network (SAN) or Network Attached Storage (NAS) storage that is shared and accessible through network by all nodes.
- Middleware is not required to route data requests to specific servers as each node/client has access to all of the data.
- Oracle RAC, IBM DB2 pureScale, Sybase etc. support this architecture

Apache Cassandra

CouchDB

MongoDB

Comparison of RDBMS and NoSQL databases

RDBMS	NoSQL Databases
• Data within a database is treated as a "whole"	• Each entity is considered an independent unit of data and can be freely moved from one machine to the other
• RDBMS support centrally managed architecture.	• They follow distributed architecture.
• They are statically provisioned.	• They are dynamically provisioned.
• It is difficult to scale them.	• They are easily scalable.
• They provide SQL to query data	• They use API to query data (not feature rich as SQL).
• ACID (Atomicity, Consistency, Isolation and Durability) Compliant; DBMS maintains Consistency.	• Follow BASE (Basically Available, Soft state, Eventually consistent); The user accesses are guaranteed only at a single-key level.
• They support on-line Transaction Processing applications.	• They support web2.0 applications.

Challenges to Develop Cloud Databases