ACADGILD

Session 09: Hbase Assignment 3

Explain the below concepts with an example in brief.

✓ NoSQL Databases

NoSQL is an approach to databases that represents a shift away from traditional relational database management systems (RDBMS). To define NoSQL, it is helpful to start by describing SQL, which is a query language used by RDBMS. Relational databases rely on tables, columns, rows, or schemas to organize and retrieve data. In contrast, NoSQL databases do not rely on these structures and use more flexible data models. NoSQL can mean “not SQL” or “not only SQL.” As RDBMS have increasingly failed to meet the performance, scalability, and flexibility needs that next-generation, data-intensive applications require, NoSQL databases have been adopted by mainstream enterprises. NoSQL is particularly useful for storing unstructured data, which is growing far more rapidly than structured data and does not fit the relational schemas of RDBMS. Common types of unstructured data include: user and session data; chat, messaging, and log data; time series data such as IoT and device data; and large objects such as video and images.

BENEFITS OF NOSQL

NoSQL databases offer enterprises important advantages over traditional RDBMS, including:

- Scalability: NoSQL databases use a horizontal scale-out methodology that makes it easy to add or reduce capacity quickly and non-disruptively with commodity hardware. This eliminates the tremendous cost and complexity of manual sharding that is necessary when attempting to scale RDBMS.
- Performance: By simply adding commodity resources, enterprises can increase performance with NoSQL databases. This enables organizations to continue to deliver reliably fast user experiences with a predictable return on investment for adding resources—again, without the overhead associated with manual sharding.
- High Availability: NoSQL databases are generally designed to ensure high availability and avoid the complexity that comes with a typical RDBMS architecture that relies on primary and secondary nodes. Some “distributed” NoSQL databases use a masterless architecture that automatically distributes data

equally among multiple resources so that the application remains available for both read and write operations even when one node fails.

- Global Availability: By automatically replicating data across multiple servers, data centers, or cloud resources, distributed NoSQL databases can minimize latency and ensure a consistent application experience wherever users are located. An added benefit is a significantly reduced database management burden from manual RDBMS configuration, freeing operations teams to focus on other business priorities.
- Flexible Data Modeling: NoSQL offers the ability to implement flexible and fluid data models. Application developers can leverage the data types and query options that are the most natural fit to the specific application use case rather than those that fit the database schema. The result is a simpler interaction between the application and the database and faster, more agile development.

Types of NoSQL Databases

Several different varieties of NoSQL databases have been created to support specific needs and use cases. These fall into four main categories:

- Key-value data stores: Key-value NoSQL databases emphasize simplicity and are very useful in accelerating an application to support high-speed read and write processing of non-transactional data. Stored values can be any type of binary object (text, video, JSON document, etc.) and are accessed via a key. The application has complete control over what is stored in the value, making this the most flexible NoSQL model. Data is partitioned and replicated across a cluster to get scalability and availability. For this reason, key value stores often do not support transactions. However, they are highly effective at scaling applications that deal with high-velocity, non-transactional data.
- Document stores: Document databases typically store self-describing JSON, XML, and BSON documents. They are similar to key-value stores, but in this case, a value is a single

document that stores all data related to a specific key. Popular fields in the document can be indexed to provide fast retrieval without knowing the key. Each document can have the same or a different structure.

- Wide-column stores: Wide-column NoSQL databases store data in tables with rows and columns similar to RDBMS, but names and formats of columns can vary from row to row across the table. Wide-column databases group columns of related data together. A query can retrieve related data in a single operation because only the columns associated with the query are retrieved. In an RDBMS, the data would be in different rows stored in different places on disk, requiring multiple disk operations for retrieval.
- Graph stores: A graph database uses graph structures to store, map, and query relationships. They provide index-free adjacency, so that adjacent elements are linked together without using an index.

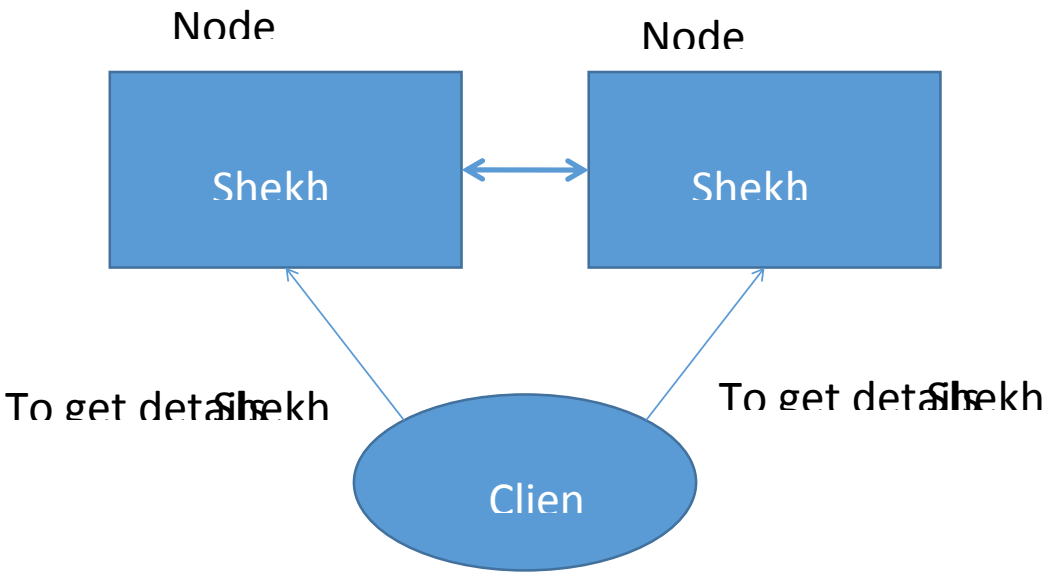
  Multi-modal databases leverage some combination of the four types described above and therefore can support a wider range of applications.

✓ *CAP Theorem*

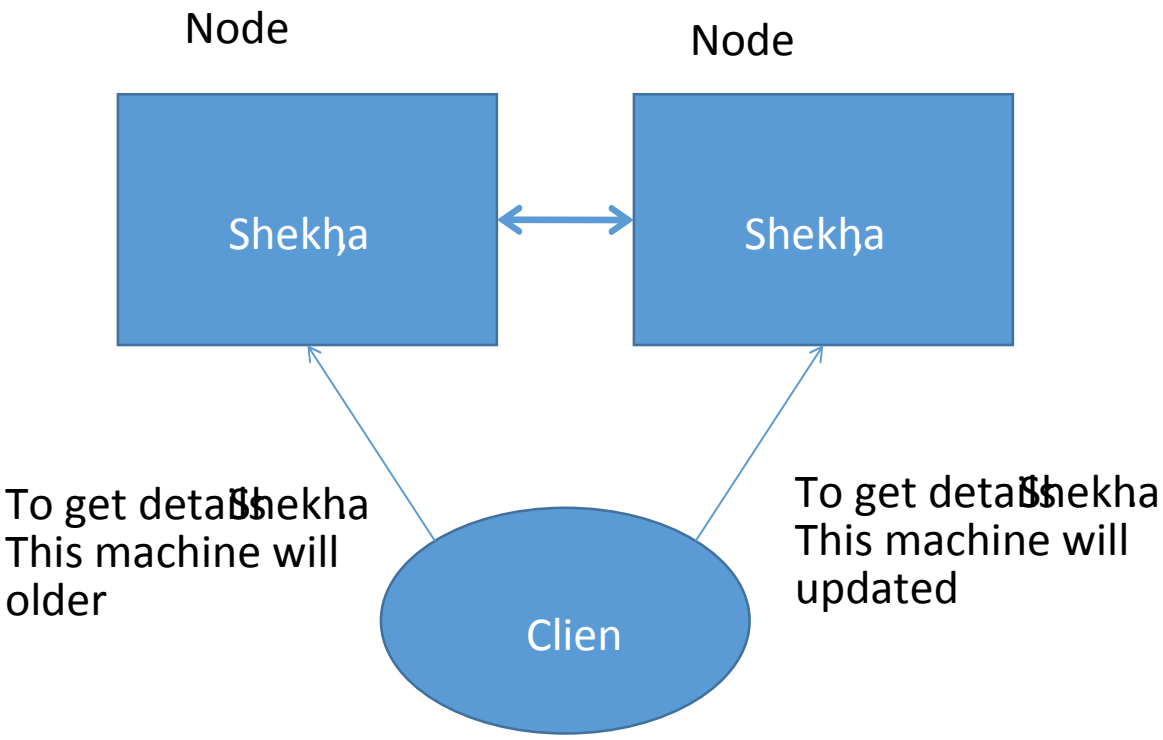
- **Consistency** - This means that the data in the database remains consistent after the execution of an operation. For example, after an update operation, all clients see the same data.
- **Availability** - This means that the system is always on (service guarantee availability), no downtime.
- **Partition Tolerance** - This means that the system continues to function even if the communication among the servers is unreliable, i.e. the servers may be partitioned into multiple groups that cannot communicate with one another.

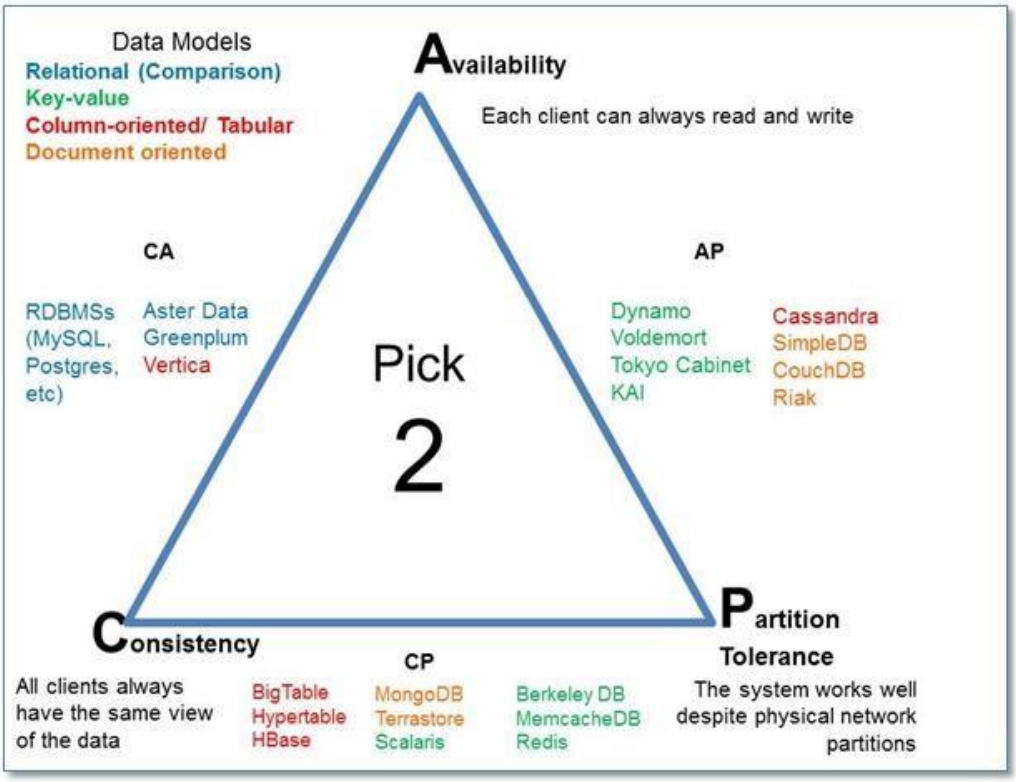
- Duplicate Copy of same data is maintained on Multiple Machines.

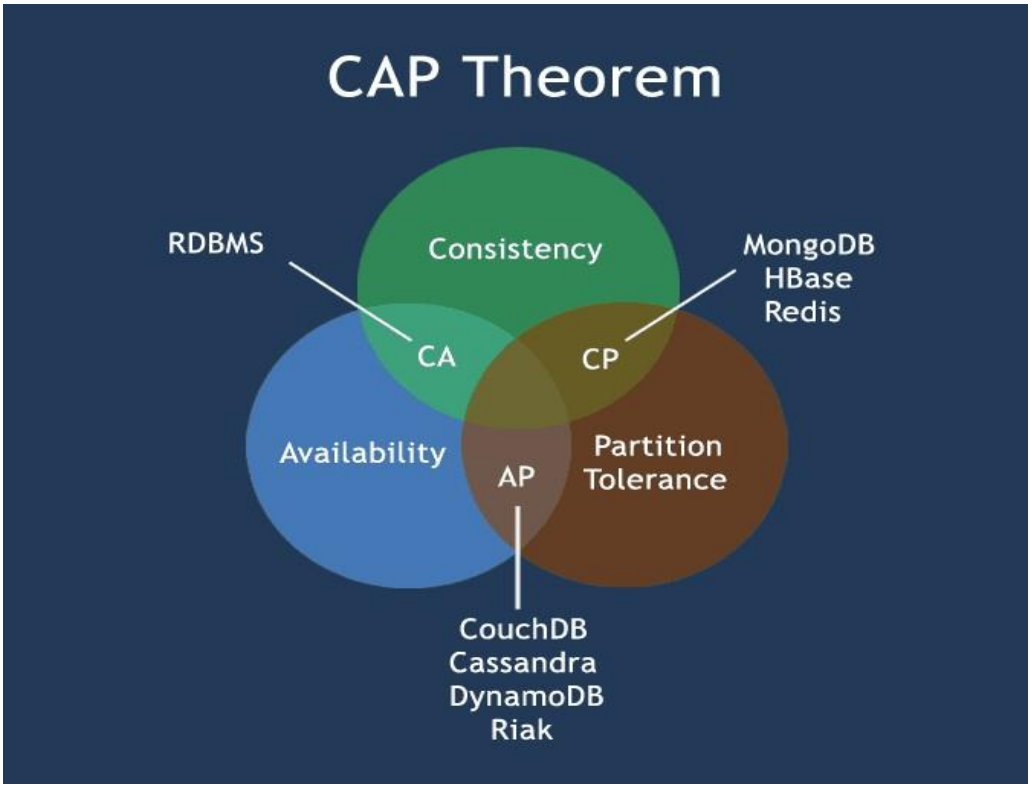
- This increases availability, but decreases consistency.



- If data on one machine changes, the update propagates to the other
- Machine, system is inconsistent, but will become eventually consistent.


Node
Node
Shekha
Shekha
To get details
This machine will
older
Shekha
Clien
To get details
This machine will
updated
Shekha

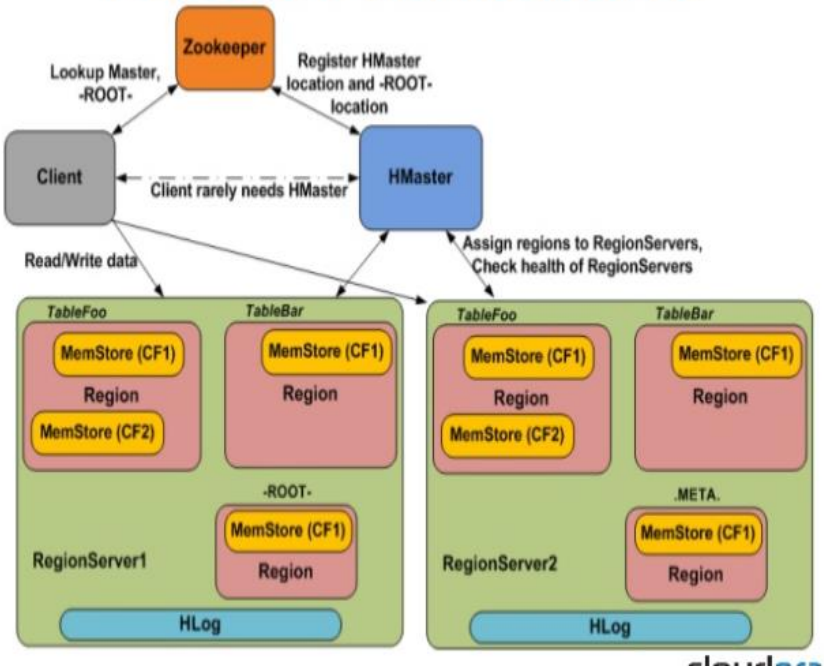

Data Models
Relational (Comparison)
Key-value
Column-oriented/ Tabular
Document oriented
Availability
Each client can always read and write
CA
AP
RDBMSs (MySQL, Postgres, etc)
Aster Data
Greenplum
Vertica
Dynamo
Voldemort
Tokyo Cabinet
KAI
Cassandra
SimpleDB
CouchDB
Riak
Pick 2
Consistency
Partition Tolerance
CP
All clients always have the same view of the data
BigTable
Hypertable
HBase
MongoDB
Terrastore
Scalaris
Berkeley DB
MemcacheDB
Redis
The system works well despite physical network partitions


CAP Theorem
RDBMS
Consistency
MongoDB
HBase
Redis
CA
CP
Availability
Partition
Tolerance
AP
CouchDB
Cassandra
DynamoDB
Riak

✓ *HBase Architecture*

HBase provides low-latency random reads and writes on top of HDFS. In HBase, tables are dynamically distributed by the system whenever they become too large to handle (Auto Sharding). The simplest and foundational unit of horizontal scalability in HBase is a Region. A continuous, sorted set of rows that are stored together is referred to as a region (subset of table data). HBase architecture has a single HBase master node (HMaster) and several slaves i.e. region servers. Each region server (slave) serves a set of regions, and a region can be served only by a single region server. Whenever a client sends a write request, HMaster receives the request and forwards it to the corresponding region server.

HBase Architecture



HBase can be run in a multiple master setup, wherein there is only single active master at a time. HBase tables are partitioned into multiple regions with every region storing multiple table's rows

Components of Apache HBase Architecture

HBase architecture has 3 important components- HMaster, Region Server and ZooKeeper.

i. HMaster

HBase HMaster is a lightweight process that assigns regions to region servers in the Hadoop cluster for load balancing. Responsibilities of HMaster –

- Manages and Monitors the Hadoop Cluster
- Performs Administration (Interface for creating, updating and deleting tables.)
- Controlling the failover
- DDL operations are handled by the HMaster

- Whenever a client wants to change the schema and change any of the metadata operations, HMaster is responsible for all these operations.

ii. *Region Server*

These are the worker nodes which handle read, write, update, and delete requests from clients. Region Server process, runs on every node in the hadoop cluster. Region Server runs on HDFS DataNode and consists of the following components –

- Block Cache – This is the read cache. Most frequently read data is stored in the read cache and whenever the block cache is full, recently used data is evicted.
- MemStore- This is the write cache and stores new data that is not yet written to the disk. Every column family in a region has a MemStore.

- Write Ahead Log (WAL) is a file that stores new data that is not persisted to permanent storage.
- HFile is the actual storage file that stores the rows as sorted key values on a disk.

iii. *Zookeeper*

HBase uses ZooKeeper as a distributed coordination service for region assignments and to recover any region server crashes by loading them onto other region servers that are functioning. ZooKeeper is a centralized monitoring server that maintains configuration information and provides distributed synchronization. Whenever a client wants to communicate with regions, they have to approach Zookeeper first. HMaster and Region servers are registered with ZooKeeper service, client needs to access ZooKeeper quorum in order to connect with region servers and HMaster. In case of node failure within an HBase cluster, ZKquoram will trigger error messages and start repairing failed nodes.

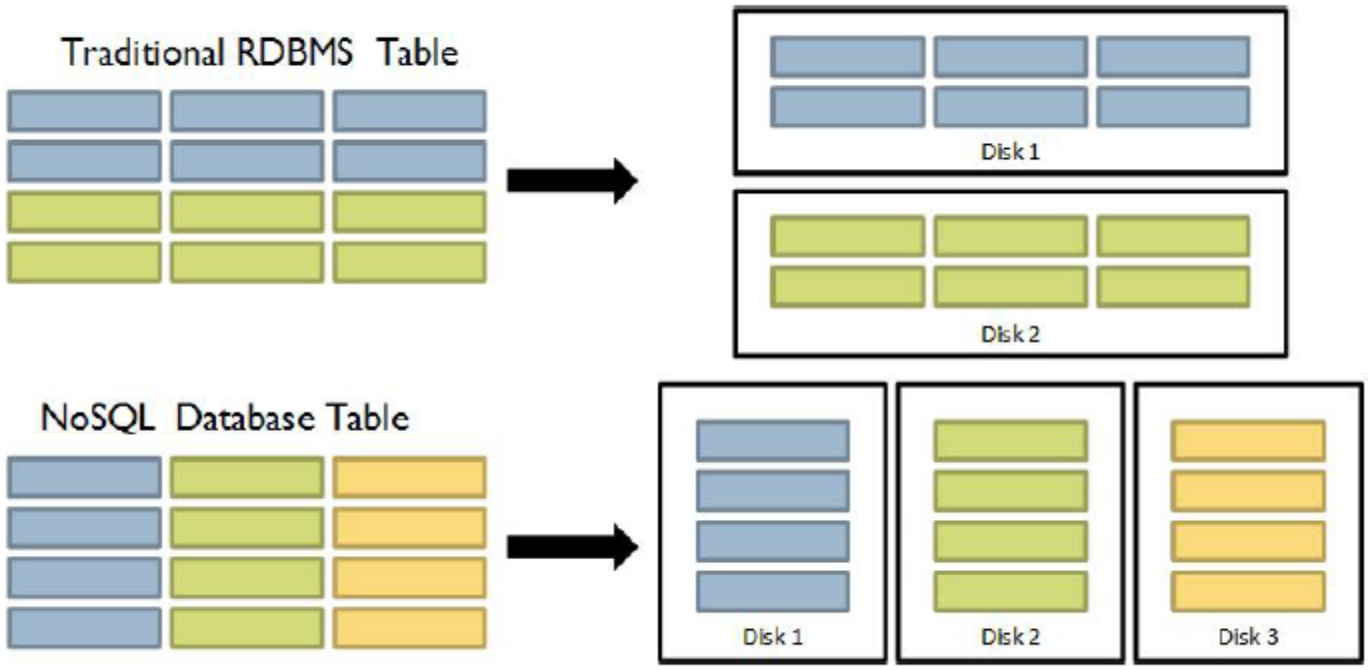
ZooKeeper service keeps track of all the region servers that are there in an HBase cluster- tracking information about how many region servers are there and which region servers are holding which DataNode. HMaster contacts ZooKeeper to get the details of region servers. Various services that Zookeeper provides include –

- Establishing client communication with region servers.
- Tracking server failure and network partitions.
- Maintain Configuration Information
- Provides ephemeral nodes, which represent different region servers.

✓ *HBase vs RDBMS*

There differences between RDBMS and HBase are given below.

- Schema/Database in RDBMS can be compared to namespace in Hbase.
- A table in RDBMS can be compared to column family in Hbase.
- A record (after table joins) in RDBMS can be compared to a record in Hbase.
- A collection of tables in RDBMS can be compared to a table in Hbase.


Traditional RDBMS Table
Disk 1
Disk 2
NoSQL Database Table
Disk 1
Disk 2
Disk 3

HBase	RDBMS
Column-oriented	Row oriented (mostly)
Flexible schema, add columns on the fly	Fixed schema.
Good with sparse tables,	Not optimized for sparse tables.
Joins using MR –not optimized	Optimized for joins.
Tight integration with MR	Not really...
Horizontal scalability –just add hardware	Hard to shard and scale
Good for semi-structured data as well as Un-structured data	Good for structured data