CS157C HW1

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1. Compare the consistency of ACID properties to that of CAP theorem.

Consistency of ACID properties: data moves from one correct state to another correct state. Correct means valid according to constraints, triggers and common sense. For example, after transaction, the total amount of money should be the same.

Consistency of CAP theorem: concurrent operations see the same valid and consistent data state. The system appears as if there are only one copy of data, and all operations on it are atomic.

1. Explain trade-off between isolation level and throughput in relational database systems.

If the isolation level is high, there are fewer concurrency problems. However, the system will be slow. It is possible to have deadlocks.

If the isolation level is low, there will be more concurrency problems. However, the system will be faster.

1. Write ahead log protocol:

d. The log of this update is written in the memory.

c. The log is persisted on disk.

b. Data is updated in memory.

a. Updated data is persisted on disk.

1. Explain why JDBC is not considered object-oriented.

Data is still relational data in the form of result set. We get rows one at a time. It is different from object-oriented system in storing data. In object-oriented system, we can get values of fields directly.

1. Compare hash partitioning and range partitioning of NoSQL database systems.

Hash partitioning finds values by hashing the partition key. It can evenly distribute rows into nodes.

Range partitioning holds the data whose partition keys are in a certain range. It may have hot spots, but range scan becomes easy.

1. Explain schema-on-read and schema-on-write along with one example of a database system for each.

Schema-on-read: It is required to have a schema. Example: relational database.

Schema-on-write: Schema is not required. In application, there should be logics to identify the structure of data to manipulate. Application can extract necessary values from data.

1. What is the main difference between key-value stores and document stores? How does this difference affect the ability of the database to query data and to create an index?

Key-value stores: The database doesn’t know how values are structured. It is only a block to database. Entire values will be returned to application. Only through application, we can get values of individual fields. We cannot build index on these databases.

Document databases: They can answer individual fields. We can retrieve part of aggregation. We can build index on individual fields.

1. Column-oriented databases are often deployed to support OLAP applications. Present an example SQL query based on a star-schema and explain how column-oriented database can efficiently support this query.

In column-oriented database, each column family defines a record type, for example, customer profiles with rows for each of the records. Column-based database saves their data grouped by columns. For specific user queries, not all values in the records are needed. Columnar database is more efficient in OLAP applications. For example, a database contains user account information. If a query is to extract the name of all users, since a column-oriented database save values from a column together, it is very efficient.

1. Explain the trade-off between consistency level and availability of distributed database systems in the context of CAP theorem.

Consistency means concurrent operations see the same valid data.

Availability means if users can talk to a non-failing node in the cluster, it can read and write data.

Since in CAP theorem says that any database can support only two of the three characteristics: consistency, availability, partition tolerance. Since database must support partition tolerance in distributed data system, there is trade-off between consistency and availability.

For example, master-slave replication is a database strongly supporting consistency. All writes are done on the master node, so consistency is high. However, if the master node is down, a node becomes unavailable because user can talk to the slave node but cannot write on it.

Peer-to-peer replication is a database strongly supporting availability. Any node can read and write, so availability is high. However, inconsistency becomes longer.

1. Select a NoSQL database system of your choice that follows the aggregate data model. Answer the following questions specific to the system you selected. Exclude MongoDB and Cassandra from your choice.
2. Explain its data model.
3. Explain the unit of sharding (partitioning) and replication of the system.
4. Is there any index created by the database by default? Briefly explain it.
5. Apache Hadoop’s Hbase has wide-column data models. The structure is a two-level map: Row key -> column key -> column values. The table is indexed by a row key, column key and a timestamp. Column is the unit for access. Columns are grouped into column families. A column name is made up of its column family prefix and a qualifier.
6. Basic unit of sharding is called a Region in HBase. A region is a contiguous and sorted range of rows of a table stored together on disk. Initially, there is only one region for a table. When regions become too large, a region is split into two at the middle key. Regions are served by RegionServer. The underlying principle of HBase replication is to reply all the transactions from the mater to the slave.
7. HBase does not support indexes.