CSCI/ECEN 5673: Distributed Systems
Spring 2022
Homework 4
Due Date: 04/28/2022

Please submit a PDF copy of your answers via the submission link on Canvas by April 28, 2022. Write your answers in the space provided. Please DO NOT use any extra space. The space provided is sufficient for answering the questions.

Honor Code Pledge: On my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this work.

Name:

1. Both Dynamo and BigTable accepts a new server and makes it responsible for handling one part of the requests.
    a. How do both Dynamo and BigTable accepts a new server into the group?

In Dynamo, a new node is assigned one or more positions on the ring. A full membership model is used where every node is aware of every other node. A gossip prototcol is used to disseminate the membership information.

In BigTable, master server detects new Tablet servers and then assigns tablets to the new tablet. Information about which tablets are being served by which servers is managed using Chubby.

    b. Which portion of the data is assigned to this new server in BigTable and Dynamo?

In BigTable, a table is divided into tablets and a tablet server manage operations on the tablet assigned to it. Master decides the assignment of tablet(s) to tablet servers based on fault tolerance requirements – same rack, across racks with in a data center or across data centers.

In Dynamo, data is mapped based on hashed value of the key. A node stores and is the coordinator of all keys that map in the interval between the node location and the immediate previous location where another node is located. In addition, a node stores all the keys that the previous two nodes in the ring are coordinators for.

    c. Explain the assignment process and what happens when any client tries to access this data.

In BigTable, a client accesses data by providing the row id, column id, etc. The tablet server serving the tablet that contains this row is retrieved from Chubby and then the request is sent to the tablet server. The tablet server then retrieves the requested row by using GFS operation.

In Dynamo, a client specifies the key and the Dynamo client library hashes this key and determines the node that is the coordinator of this key, since Dynamo adopts a full membership model with zero-hop DHT. The client library then forwards the request to the coordinator node.

2. What are the key abstractions in Storm and how do they work together to process tasks?

   To do scalable realtime computations, Storm uses a couple of abstractions to represent the data and its flow within the system. The core abstraction is "stream", which is defined as an unbounded sequence of tuples. Storm uses "sprouts" and "bolts" to transform the stream for the subsequent processing. Multi-step stream transformations are organized into another abstraction called "topology", which is the top-level abstraction in Storm. A topology is a graph of stream transformation and computation. Each node in the topology is either a sprout or a bolt, and edges in the topology indicate the stream flows between nodes.

   All nodes (Sprouts and Bolts) run in parallel, and each node can execute as many threads across the cluster as it is set. Messages are never relayed by intermediate queues or nodes, instead they are directly transmitted between two nodes.

3. (a) Traditional databases are based on tables with fixed rows representing different attributes of that record. Cassandra is a distributed database which is a “map of all maps”. Why do you think distributed databases deviate from the traditional database model? Discuss the advantages and disadvantages of both.

   Distributed database design allows Cassandra to be highly available, highly scalable, provide high performance and fault tolerance.

   Advantage of traditional databases include strong consistency model with ACID properties and support for complex queries. Disadvantages include low scalability and poor performance.

   Advantages of distributed database include high scalability, high performance, and high availability. Disadvantages include lack of support for complex queries.

   b) Give an example of a query which is easier to represent in SQL than in Cassandra. Explain your answer.

   Queries that involve JOIN, GroupBy, etc are well supported in SQL but not in Cassandra.

4. Read the following paper about Yahoo's PNUT database service:

   B. Cooper, R. Ramakrishnan, U. Srivastava, A. Silberstein, P. Bohannon, H. Jacobsen, N. Puz, D. Weaver and R. Yerneni. PNUTS: Yahoo!'s Hosted Data Serving Platform. VLDB 2008.

   a) **[7 Points]** What are the motivations behind PNUTS design?

   b) **[7 Points]** Describe the consistency model of PNUTS.

   c) **[11 Points]** What types of failures can PNUTS tolerate? Explain how PNUTS recovers from these failures.