Cassandra - A Decentralized Structured Storage System

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ABSTRACT

Cassandra is a distributed storage system for managing very large amounts of structured data spread out across many commodity servers, while providing highly available service with no single point of failure. Cassandra aims to run on top of an infrastructure of hundreds of nodes (possibly spread across different data centers). At this scale, small and large components fail continuously. The way Cassandra manages the persistent state in the face of these failures drives the reliability and scalability of the software systems relying on this service. While in many ways Cassandra resembles a database and shares many design and implementation strategies therewith, Cassandra does not support a full relational data model; instead, it provides clients with a simple data model that supports dynamic control over data layout and format. Cassandra system was designed to run on cheap commodity hardware and handle high write throughput while not sacrificing read efficiency.

1. INTRODUCTION

Facebook runs the largest social networking platform that serves hundreds of millions users at peak times using tens of thousands of servers located in many data centers around the world. There are strict operational requirements on Facebook's platform in terms of performance, reliability and efficiency, and to support *continuous growth* the platform needs to be highly scalable. Dealing with failures in an infrastructure comprised of thousands of components is our standard mode of operation; there are always a small but significant number of server and network components that are failing at any given time. As such, the software systems need to be constructed in a manner that treats failures as the norm rather than the exception. To meet the reliability and scalability needs described above Facebook has developed Cassandra.

Cassandra uses a synthesis of well known techniques to achieve scalability and availability. Cassandra was designed to fulfill the storage needs of the Inbox Search problem. Inbox Search is a feature that enables users to search through their Facebook Inbox. At Facebook this meant the system was required to handle a very high write throughput, billions of writes per day, and also scale with the number of users. Since users are served from data centers that are geographically distributed, being able to replicate data across data centers was key to keep search latencies down. Inbox Search was launched in June of 2008 for around 100 million users and today we are at over 250 million users and Cassandra has kept up the promise so far. Cassandra is now deployed as the backend storage system for multiple services within Facebook.

This paper is structured as follows. Section 2 talks about related work, some of which has been very influential on our design. Section 3 presents the data model in more detail. Section 4 presents the overview of the client API. Section 5 presents the system design and the distributed algorithms that make Cassandra work. Section 6 details the experiences of making Cassandra work and refinements to improve performance. In Section 6.1 we describe how one of the applications in the Facebook platform uses Cassandra. Finally Section 7 concludes with future work on Cassandra.

2. RELATED WORK

Distributing data for performance, availability and durability has been widely studied in the file system and database communities. Compared to P2P storage systems that only support flat namespaces, distributed file systems typically support hierarchical namespaces. Systems like Ficus[14] and Coda[16] replicate files for high availability at the expense of consistency. Update conflicts are typically managed using specialized conflict resolution procedures. Farsite[2] is a distributed file system that does not use any centralized server. Farsite achieves high availability and scalability using replication. The Google File System (GFS)[9] is another distributed file system built for hosting the state of Google's internal applications. GFS uses a simple design with a single master server for hosting the entire metadata and where the data is split into chunks and stored in chunk servers. However the GFS master is now made fault tolerant using the Chubby[3] abstraction. Bayou[18] is a distributed relational database system that allows disconnected operations and provides eventual data consistency. Among these systems, Bayou, Coda and Ficus allow disconnected operations and are resilient to issues such as network partitions and outages. These systems differ on their conflict resolution procedures. For instance, Coda and Ficus perform system level conflict resolution and Bayou allows application level