Scalability Limits of HDFS

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Abstract

1 Introduction

2 HDFS Architecture

Hadoop claims to be built on five core principles that govern the architectural decisions. These are (1) hardware failure is the norm. As a result, HDFS wants to be highly reliable in the face of hardware failure so the architecture incorporates replication of data across multiple nodes. Then HDFS wants to (2) allow streaming data access and (3) support very large data sets. With these goals in mind, HDFS wants to use a distributed system to accommodate large files and implement distributed reads to prevent streaming access from clogging the system. Next HDFA wants to (4) provide simple concurrency control with a write-once read-many model. This is less a feature and more a decision to weigh reads over writes by providing highly available and concurrent reads at the expense of allowing concurrent writes. And lastly, HDFS wants (5) portability, which makes sense as HDFS must work on different computer architectures

To satisfy these principles, the HDFS architecture was designed as follows. An HDFS cluster will have one unique NameNode and many DataNodes. Briefly, the NameNode holds the metadata of each file in the system. This metadata consists of (inode, mapping) pairs where the inode is a unix-style inode representing the file and the mapping holds the information about where the file resides in disk on the DataNodes. The NameNode holds all of this metadata in memory to facilitate fast metadata operations.

This single NameNode architecture is beneficial in a few ways. First, this facilitates large reads since the reads are distributed among the DataNodes and the relatively inexpensive metadata operations all happen on the NameNode and never block each other. If each node had to handle its own metadata operations,

2.1 Namenode

2.2 Datanode

3 Limitations of Single Namenode Architecture

3.1 Physical Memory Size

3.2 Namenode CPU Bottleneck

4 Performance Evaluation

4.1 Experiment 1: Memory Experiments

4.2 Experiment 2: CPU Experiments

4.3 Analysis

5 Improvements to Single Namenode Architecture

6 Conclusion