MAP-REDUCE PROGRAMMING MODEL AND HADOOP DISTRIBUTED FILE SYSTEM FOR USE IN UNDERGRADUATE CURRICULUM*

TUTORIAL PRESENTATION

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ABSTRACT

In this tutorial we will discuss the details of the map-reduce programming model that has been brought to prominence by the Google File System (GFS) [1]. We will also demonstrate the application of MapReduce using Hadoop Distributed File System (HDFS)[2]. We will discuss two case studies (i) word count on a web log and (ii) financial analytics using Markovitz model [4]. Implementation of HDFS on a single node, two-node and multiple-node cluster will be demonstrated. The challenges in assembling a HDFS and using MapReduce will be discussed. Expected audiences are undergraduate teachers who want to learn about MapReduce and HDFS and those who are interested in introducing these in the curriculum. These two topics were featured very prominently in SIGCSE 2008.

1. MAPREDUCE PROGRAMMING MODEL

Processing of large volumes of data in parallel has been reincarnated with the invention of MapReduce methodology [1,3]. MapReduce is a programming model for processing large data sets. It uses a *map* algorithm that processes a key/value pair to generate a set of intermediate key/value pairs, and a *reduce* algorithm that merges all intermediate values associated with the same intermediate key. To understand this model let us consider a very simple example discussed in the paper [1,3].

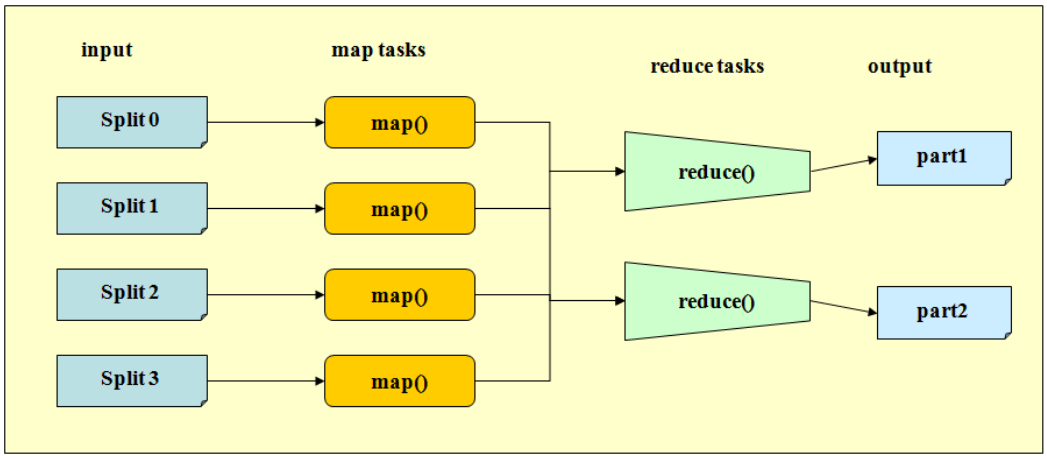

Figure 1 Map-Reduce Programming Model

Consider a web log file with data collected over a period of time. It is a very large file that records every hit that happens on the site. Our interest is the number of hits for a given time. We *split* our task into two sub-tasks: (i) map : gathers the hit information at a time from each line and (ii) reduce: accumulates the hits that occurred for each timestamp using timestamp as the key. The map algorithm is to extract the <timestamp hit> pairs (key,value pairs) from the original web log. The reduce algorithm accumulates the number of hits for each timestamp. Output of map stage is pairs like <1345 1 >, <1345 1 >, <1345 1>, <1345 1>, <1346 1> … that results in <1345 4> <1346 1> after the reduce stage. Depending on the data volume, the map and reduce tasks can be shared among many computational units. The example is depicted in figure 1. The figure shows the task split into four nodes running map algorithm and two nodes running reduce algorithm.

2. HADOOP DISTRIBUTED FILE SYSTEM

Hadoop is a software platform that lets one easily write and run applications that process vast amounts of data. Hadoop implements MapReduce, using the Hadoop Distributed File System (HDFS)[2]. Typical file size in HDFS is in the order of terabytes with a block size of 128MB. Blocks are replicated for reliability and rack-aware placement is used to improve bandwidth. The HDFS operates in a master-slave mode with one master node called the NameNode that holds the meta-data and manages the system and a number of slave nodes called DataNodes. Our tutorial will demonstrate a scaled down prototype of the HDFS that small schools can implement for instructional purposes.

3. PRESENTERS' BIO

K. Madurai has extensive industrial experience in clustered systems and distributed computing. B. Ramamurthy was one of the invitees at the NSF-CRA sponsored Data-

Intensive Hadoop Big-Data Conference in California, March 2008. She has successfully implemented an undergraduate curriculum development project called GridFoRCE (Grid for Research, Collaboration and Education) that was supported by NSF CCLI A&I program. She has a working HDFS cluster that is used in her undergraduate class. The authors have been collaborating on MapReduce and HDFS projects.

4. REFERENCES

[1] J. Dean and S. Ghemawat. MapReduce: Simplified Data Processing on Large Clusters. OSDI'04: Sixth Symposium on Operating System Design and Implementation, San Francisco, CA, December, 2004, 137-150, http://labs.google.com/papers/mapreduce.html, last visited December 2007.

[2] The Hadoop Project. http://hadoop.apache.org/, last visited March 2008.

[3] R. Lämmel. Google's MapReduce programming model - Revisited. Sci. Comput. Program. 70(1): 1-30, 2008.

[4] H.M. Markowitz, *Portfolio Selection: Efficient Diversification of Investments*. New Haven, Conn.:Yale University Press,1959.