Concurrency & Parallel Programming

Hadoop

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Datum: 03-12-2012

1 What is Hadoop

Hadoop is a piece of software software that allows certain programs to be split in smaller parts in such a way that multiple computations can be done on multiple nodes at the same times. In that way the time needed to compute the code decreases. It is however necessary that the parts have no dependencies of one another.

1.1 Hadoop's origin

Hadoop was created by looking at the MapReduce and Google File System papers made by Google. The essence of MapReduce is used by Hadoop. The master node takes input. This input is then divided in smaller parts and distributed onto worker (or slave) nodes. These worker nodes do all the computing. The workers cannot communicate with eachother, this is why there must be no dependencies what so ever in the given parts. When the workers are done they send their results back to their master. The master waits for all the answers and combines all the results to form an output.

1.2 Scalable

Hadoop is scalable. This means that the speedup increasement will stay roughly the same, despite the amount of work you give to Hadoop. For example, a small job can have a speed up of 20% with Hadoop on four worker nodes. A bigger job will also have around 20 % speedup on four worker nodes.

1.3 Architecture

Hadoop uses a special Distributed File System called the Hadoop Distributed File System or HDFS. HDFS uses location awareness to tell the master where and what each worker is doing. This way, work that must be done can be scheduled more efficiently. Also, if an exception is caused on a worker, the master will know what happened. If an exception occured it resends the job to be computed again.
To know all this, a master node consists of four parts: a JobTracker, a TaskTracker, a NameNode and a DataNode. The worker however, only has a TaskTracker and a DataNode. NameNodes contain information about where data is kept, but does not store data itself. Data is kept inside DataNodes. The NameNodes connect to DataNodes to tell them where the data is. The JobTracker talks to the NameNode to see what data can be sent. If data is found it makes contact with a TaskTracker of an open node and sends the information of the NameNode to this node. Preferably it sends the task to an empty slot of a node on the same server, else the task is send to any empty slot in the same rack of machines. If the TaskTracker accepted the node it either tells the JobTracker it is completely full or that it still has room for more work. These TaskTrackers then start sending messages back, telling the JobTracker that everything is ok, or if something went wrong that they failed at their job. If the latter happened, JobTracker can send out the task to a new node again. When everything happened according to plan, the JobTracker changes the status of the worker from occupied to free.

2 BioHadoop speedup

As an example, the speed up is measured for a program that searches, arranges and aligns sequences of proteins. This can be done sequential. Hadoop can be used to parallelize the program. To measure the speed up, multiple tests are run with an increasing amount of worker nodes. The Hadoop results can then be compared with the results from the sequential code.

2.1 Results

These are the results gathered from the test runs.

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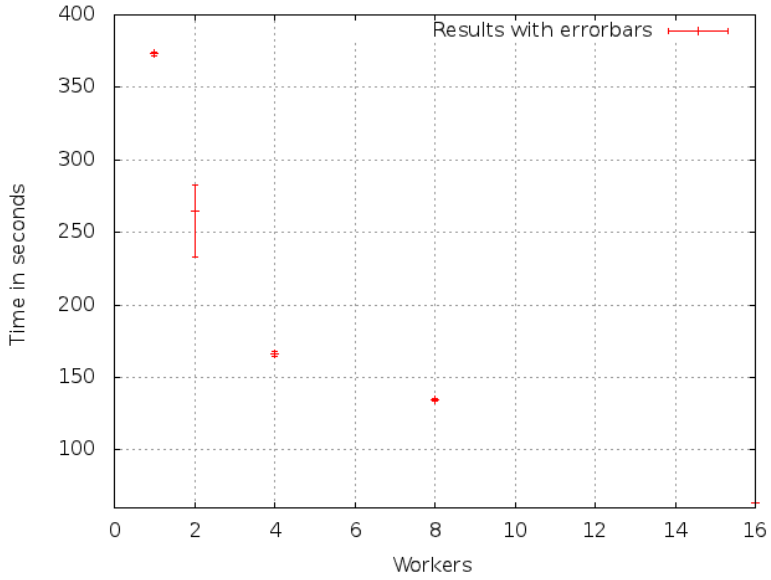
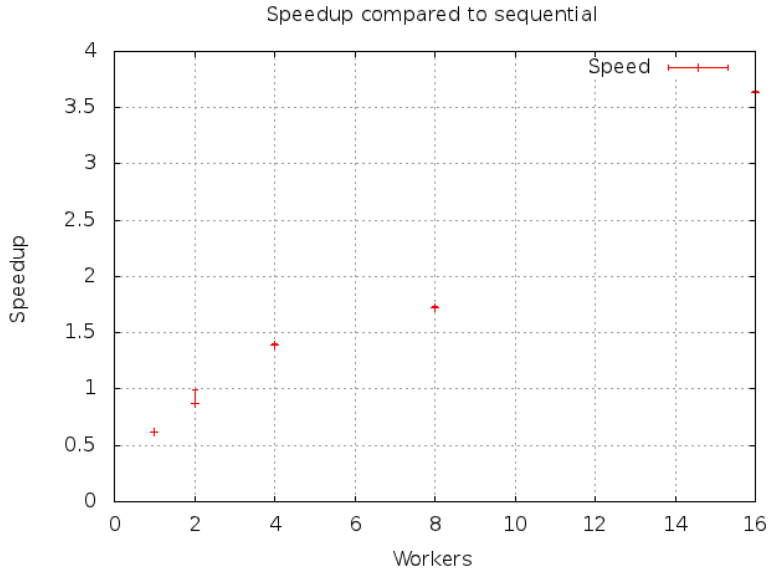
Table 1: Numerical speedup with increasing splits in Hadoop

Sequential	1 Split	2 Splits	4 Splits (+1)	8 Splits (+1)	16 Splits (+1)
3m 51.018s	6m 11.580s	4m 39.198s	2m 47.940s	2m 15.707s	1m 3.840s
3m 53.448s	6m 13.266s	3m 53.196s	2m 44.663s	2m 13.942s	1m 3.763s
3m 50.621s	6m 14.353s	4m 42.668s	2m 45.363s	2m 14.414s	1m 3.453s
Average time:					
3m 51.696s	6m 13.066s	4m 25.021s	2m 45.989s	2m 14.688s	1m 3.685s



In these test runs there where 47550 records to split in total. If Hadoop splits these records, it will only assign whole records. Alls records that are not assigned are given to an extra node. This is why some of the values in the table have a (+1) behind the number of splits. The sequential test was run on node069.fs0.das3.cs.vu.nl.
The speedup is shown in the graph below, with one being the speed for the sequential code to compute. The speedup seems to be fairly linear



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2.2 Discussion

Hadoop is faster then the sequential code if it has 4 or more workers available with this program. This has to do with the communication between the TaskTracker(s). When there are only a few nodes, this takes more time to setup then the sequential code needs to compute. Hadoop also reads the inputfiles twice. The first time to see how many each split will get and the second time to really read the file for the program. The time needed to compute the program seems to be decreasing exponentially when more workers are added. This seems logical, due to the fact that parallalization only works onto a certain point when it comes to faster computations.