Cluster Computing

Sumit Yadav Rahul Yadav Mentor: Dr. Sunita Negi
Cluster Innovation Centre, University of Delhi (110007)

Motivation

Computing resources are limited. Every now and then we can find people complaining about problems regarding low hard-disk space or low RAM in their computer systems. This project aims to combine multiple computer systems at the Cluster Innovation Centre to utilize the computational power in that network. Hadoop and Parallel Python Execution Server, commonly known as PP-server are the two approaches exploited to achieve the goal of harnessing computing power in unison. Computer systems were merged in varying numbers to create different clusters that could be used for computational purposes. The computing power (cores) and disk space were tested during cluster benchmarking.

Cluster vs Grid vs Cloud

A cluster is a group of computers connected via a local network (LAN or Wi-Fi). Cloud and Grid are wide scale and can be geographically distributed. We can say cluster is tightly coupled whereas a Grid or a cloud is loosely coupled. Clusters are made up of machines with similar hardware whereas clouds and grids are made up of machines with possibly very different hardware configurations. Cloud refers the applications delivered as services over the Internet and the hardware and software that provide those services. The datacentre hardware and software is what we call a Cloud. People can be users or providers of Software as a Service, or users or providers of Utility Computing..
Cloud computing examples includes Amazon Web Services, Google APP Engine etc. and that of grid includes Future Grid, WLCG etc.

Parallel Processing

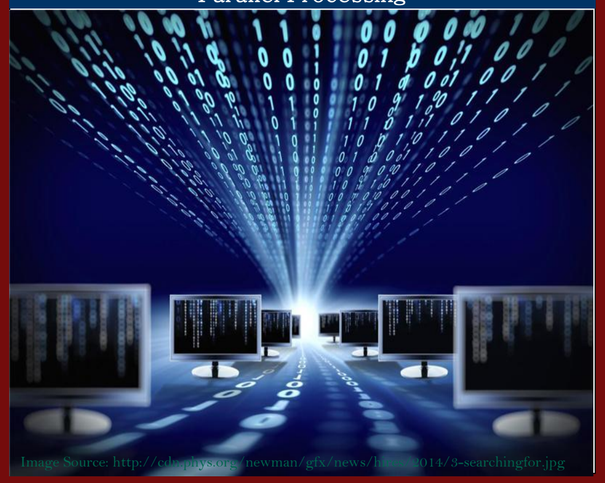


Image Source: http://cdsagenys.org/newman/gfx/news/hires/2014/3-searchingfor.jpg

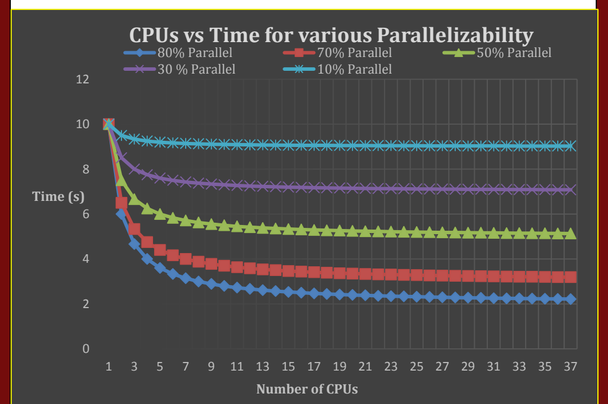
Parallel Processing is running or dividing a job into multiple jobs and running those jobs on multiple cores in order to complete the job in lesser time. But not all jobs are parallelizable. The maximum expected improvement we can achieve is thus limited and is given by Amdahl's Law which states that:

For given $n \in \mathbb{N}$, the number of threads of execution, $B \epsilon [0,1]$, the fraction of algorithm that is strictly serial, the time $T(n)$ an algorithm takes to finish when being executed on n thread(s) of execution corresponds to:

$$T(n) = T(1)\{B + \frac{1}{n}(1 - B)\}$$

Therefore, the theoretical speedup $S(n)$ that can be had by executing a given algorithm on a system capable of executing n threads of execution is:

$$S(n) = \frac{T(1)}{T(n)} = \frac{1}{B + \frac{1}{n}(1 - B)}$$



Parallel Processing Tools

MPI: Message Passing Interface is a standardized and portable message-passing system designed to function on a wide variety of parallel computers. The standard defines the syntax and semantics of library routines and allows users to write portable programs in the main scientific programming languages (FORTRAN, C, C++ or Python). MPI specifies a library of functions–the syntax and semantics of message passing routines–that can be called from the main scientific programming languages. MPI specification has become the leading standard for message-passing libraries for parallel computers.

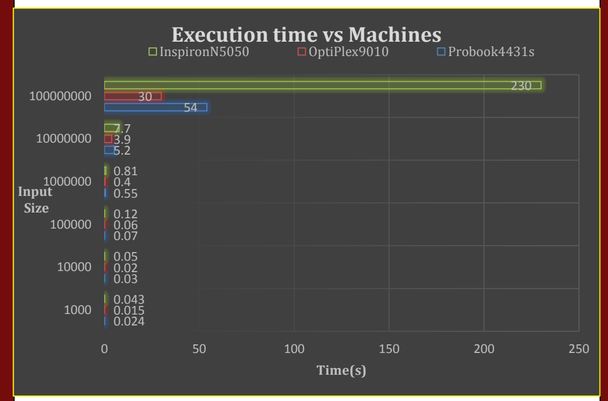
Hadoop: Hadoop is an open source framework for distributed storage and distributed processing of large data sets (or Big Data) on cluster of hardware. Hadoop is a set of algorithms or framework which allows storing huge amount of data and processing it in a much more efficient and faster manner. Apache Hadoop comprises of two things: a storage part (HDFS) and a processing part (Map reduce). HDFS splits files into large blocks and distributes the blocks amongst the nodes in the cluster and process data in parallel taking advantage of data locality.

Parallel Python Execution Server: PP is a Python module which provides interface to use the cores for parallel execution of an algorithm. Internally pp server uses processes and IPC (Inter Process Communications) to organize parallel computations.

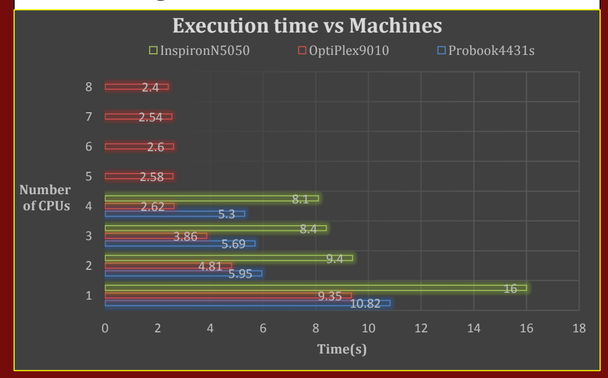
Results

[PP Server] Problem Statement: To generate random integer X between two bounds B1 and B2 repeated N times and compute the sum of primes from below X.

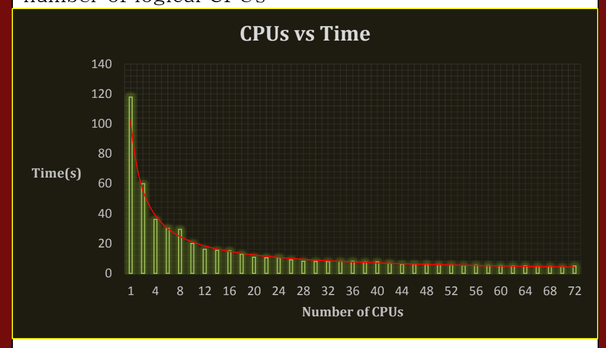
1. Execution on stand-alone machines with two cores:



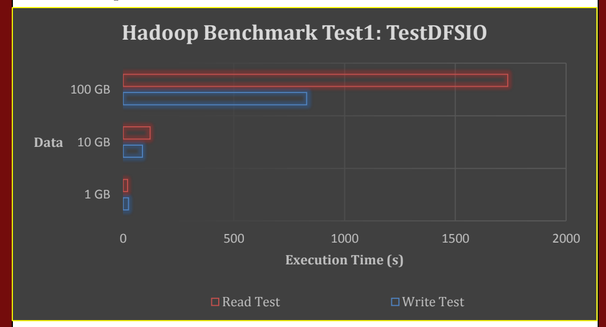
2. Execution on stand-alone machines with varying number of logical CPUs:



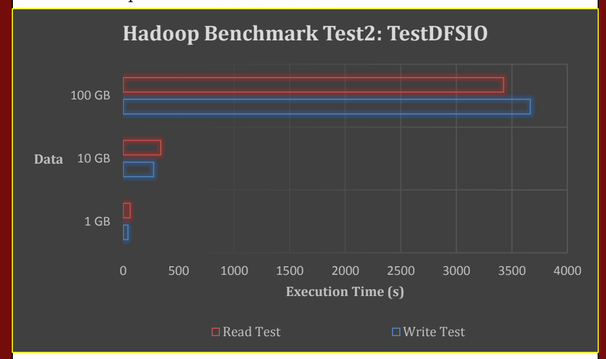
3. Execution on cluster of machines with varying number of logical CPUs:



Hadoop Cluster Testing (TestDFSIO)
1. Dell OptiPlex9010 Cluster



2. Dell Inspiron N5050 Cluster



Conclusions

Parallel processing amazingly scales down the time required to perform a parallelizable job. Computer systems can be combined to form a cluster to perform scientific computing even with wireless network. Hundreds of Gigabytes of data can be processed within minutes using Hadoop although, reading and writing time of certain amount of data depends upon the hardware used as evident from the results.