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Performance Evaluation of High Performance Computing Resources and Job Management

Anika Karwal[1*], O.P. Gupta[2]

[1]Department of Electrical Engineering and Information Technology, Punjab Agricultural University, Ludhiana, Punjab, India
[2] IT Section, College of Agriculture, Punjab Agricultural University, Ludhiana, Punjab, India

Corresponding Author: anikakarwal0013@gmail.com

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Abstract-- High Performance Computing (HPC) is a highly emerging concept in the field of computer science and technology. HPC makes the use of parallel computing to solve complex computational problems at a very high speed. Data and compute intensive applications require distinct and different resources, so it becomes utmost important to manage resources and schedule jobs accordingly. HPC is a hard and complex concept to be understood so most of it remains under-utilized. To improve operational functionality and enhance utilization of HPC many systems have been developed. The system used in this research is PBS. Resource management and job scheduling is a major research area in high performance computing. Portable Batch System (PBS) is a scheduling and resource management system. It is used for job accounting and extensible batch job queueing. Three primary goals of PBS are queueing, scheduling and monitoring the jobs. Along these lines, the fundamental objective of this paper is to give novel powerful resource management and job planning and scheduling techniques that is reasonable for all the above purposes and can be coordinated with HPC frameworks.

Keywords-- High Performance Computing (HPC), Job Scheduling, Portable Batch System (PBS), Resource Scheduling

I. INTRODUCTION

High Performance computing is a term used to describe the practice of integrating and combining the computing power from multiple units so as to receive much greater performance than the power produced from a single desktop computer. It is a highly emerging concept in the field of computer science and technology. High Performance Computing is an exclusive term used for referring to systems whose functionality is above teraflop or 1012 floating point operations per second. It is a similar concept to Parallel Computing and Super Computing. HPC cluster conventionally offers a very high speed of processing and has equipments to enhance communication between the nodes[3]. Each node is dedicated to exclusively different task to run. HPC itself is a single term comprising of many aspects like shared and distributed memory system, high level parallelism, storage, job scheduling, resource management, algorithms to maximize performance and input output systems Also, HPC is known for providing quality of service in terms of data size, time of processing, job scheduling and management etc. HPC systems are equipped to run large variety of jobs. Data and compute intensive applications require distinct and different resources, so it becomes utmost important to manage resources and schedule jobs accordingly. HPC is a hard and complex concept to be understood so most of it remains under-utilized [5]. To improve operational functionality and enhance utilization of HPC many systems have been developed.

The system software used to improve HPC resource utilization and job management used in this respective research is PBS. Three primary goals of PBS are queueing, scheduling and monitoring the jobs. It is a robust, efficient, technically effective and portable system that supports different schedulers.

Rest of the paper is organized as follows, Section I contains the introduction of research paper, Section II contain the methodology being followed to carry out the study, Section III contain the some information about experimental setup, Section IV comprises the results, Section V concludes the research work and Section VI describes the future scope of the study.

The aim of the study is to improve the usage of resources for High Performance computation using work management and job Scheduling concepts. Optimal resource utilization and job scheduling will lead to the reduction in waiting time and high-speed processing. With faster processing abilities faster results will be delivered, and thus, turnaround time will be decreased and throughput of the system increases. Hence, ultimately the performance of the HPC will be efficiently high.

II. METHODOLOGY

PBS is one of the various batch line schedulers for processor resources. Job and resource managers and schedulers are programming systems that allocates assets and resources to various clients depending upon their demands while aiming to expand asset use and limit obstruction between various jobs. PBS programming ensures efficient job scheduling and management of workload in high-performance computing (HPC) situations by improvising system's effectiveness and its efficiency. In case of HPC systems, PBS is quick, adaptable, secure, and versatile, and supportive for all advanced foundation, middleware, and applications. [1]

II.I Components of PBS

Following are the major components of PBS:

- Commands:

PBS is composed of command line commands which conforms with graphical interface and POSIX 1003.2d. The major tasks of these commands include job submission, modification, monitoring and job deletion.

- Job Server:

The center of focus for PBS is the job server. It can also be referred as server or pbs_server.

- Job Executor:

The daemon which is responsible for placing the jobs into execution phase is called the job executor.

- Job Scheduler:

This daemon is responsible for maintaining the which, when and where questions in case of all the incoming jobs.

II.II PBS Algorithm :

```
Step I.       While TRUE do
Step II.      Obtain the resource list and
              information from pbs_server
Step III.     Obtain workflow and job queue
              information from pbs_sever
Step IV.      Prepare new list according to current
              resource allocation
Step V.       Refresh previous reservations
Step VI.      Set up the jobs according to priority and
              activate PSA
Step VII.     If no prioritization is done, select
              other job scheduling technique
Step VIII.    Schedule the jobs in the job queue
Step IX.      Backfill jobs in case of FCFS
Step X.       End While
```

II.III Comparative Study

Following table shows the comparative study of the system which does scheduling with PBS and the system that does not uses PBS.

TABLE 1. Comparison between system that uses PBS and system that does not used PBS

S. No	With PBS	Without PBS
1.	Maximization of resource utilization.	Comparatively less percentage of resource utilization.
2.	System partitioning and prioritization is carried out at large extent.	Smaller range for system partitioning.
3.	Broad track for historical resource utilization is maintained.	Not much of history is considered for resource utilization.
4.	Concept of resource reservation is followed.	Resource reservation is not carried out.
5.	High possibility for backfilling scheduling.	No such scheduling possible.
6.	Allocation bank is available for resource sharing environment.	There is no such availability.
7.	Concrete control over QOS levels.	Not much control over QOS levels.
8.	Availability of meta-scheduling with data pre-staging.	Data pre-staging unsustainable.
9.	Short-pooling for blocks of machines is implemented.	No short-pooling can be done.
10.	Down-time scheduling is accomplished for repair and upgradation of running components in dynamic environment.	No such scheduling is sustained.
11.	Resource monitoring is done keenly to improve job efficiency as it is highly important for maintaining accuracy.	Job efficiency is comparatively a less important factor.
12.	SMP communication standards are highly	Less utilization of SMP approach.

	utilized.	

II.IV Scheduling

Scheduling is a major factor that needs to be taken care of in HPC. Scheduling is very important factor which helps to calculate CPU utilization.

Job management system in HPC is disintegrated into three stages which are job scheduling, management and resource management. [2]

TABLE 2. Stages of job scheduling

Stage Concept	Function
Job Scheduling	• Scheduling Algorithms • Queuing • Advanced Reservations
Job Management	• Job Declaration • Job Control • Monitoring • Quality of service
Resource Management	• Job Treatment • Job Launching • Task Placement

III. EXPERIMENTAL SETUP

Following are the contents of apparatus being used:

- Master Node - Two master nodes hn1, hn2
- Compute Nodes - 40 compute nodes
- Network Interconnect
    - infiniBand
    - Ethernet
    - Cores SMP (Symmetric Multiprocessing) SAN (Storage Area Network

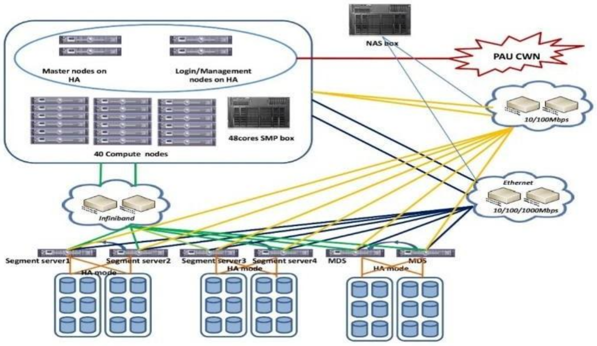

Fig. 1 HPC Architecture (Experimental Setup)

IV. RESULTS AND DISCUSSION

In present study, job management in High Performance Cluster (HPC) is analyzed with portable batch system (PBS) and without using PBS.

IV.I Performance Evaluation:

No. of Nodes	RR	CPU Utilization (%) without PBS	CPU Utilization (%) with PBS	%age improvement in CPU utilization
1	Non PBS to PBS	57.13	73.6	22.38
2	Non PBS to PBS	49.84	63.9	22.3
3	Non PBS to PBS	40.85	51.8	21.1
4	Non PBS to PBS	27.34	34.6	20.9

CPU Utilization: CPU utilization is carried out for the system with PBS and without PBS using FCFS, RR and PSA algorithms.

IV.II Performance analysis with PBS and without PBS:

The following utilization of the CPU was monitor with the help of Linux TOP Command. The important scheduling algorithm listed below are used in the PBS software.

- First Come, First Serve (FCFS)
- Round Robin (RR)
- Priority Scheduling Algorithm (PSA)

TABLE 3. Improvement in CPU utilization for FCFS

No. of Nodes	FCFS	CPU Utilization (%) without PBS	CPU Utilization (%) with PBS	%age improvement in CPU utilization
1	Non PBS to PBS	55.02	70.6	21.46
2	Non PBS to PBS	47.66	60.2	21.16
3	Non PBS to PBS	38.92	49.3	21.05

4	Non PBS to PBS	25.25	31.9	20.08

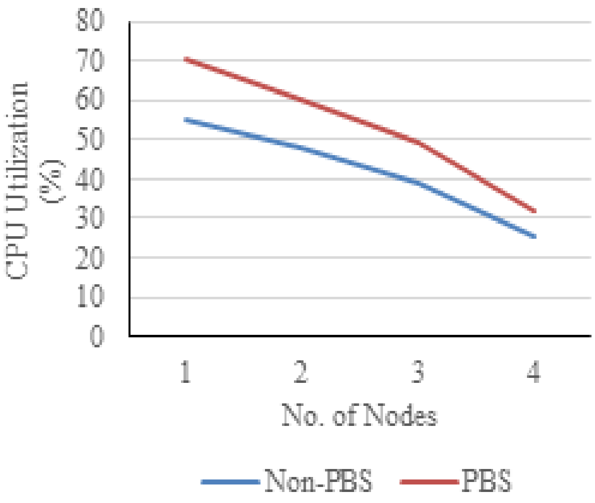

Figure 2. Improvement Graph with FCFS Algorithm

TABLE 3. Improvement in CPU utilization for RR

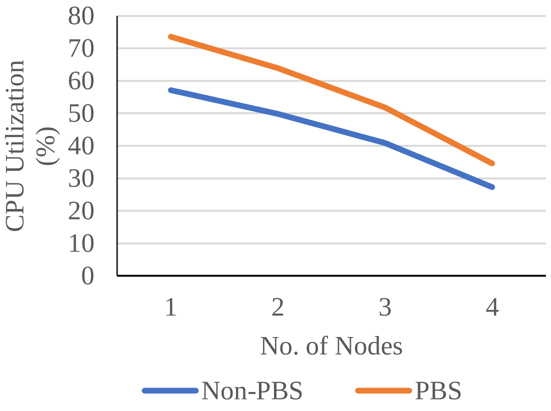

Figure 3. Improvement Graph with RR Algorithm

Table 4. Improvement in CPU utilization for PSA

No. of Nodes	PSA	CPU Utilization (%) without PBS	CPU Utilization (%) without with PBS	%age improvement in CPU utilization
1	Non PBS to PBS	56.36	72.5	22.32
2	Non PBS to PBS	49.01	62.8	21.9
3	Non PBS to PBS	40.09	50.8	21.08
4	Non PBS to PBS	25.85	32.7	20.9

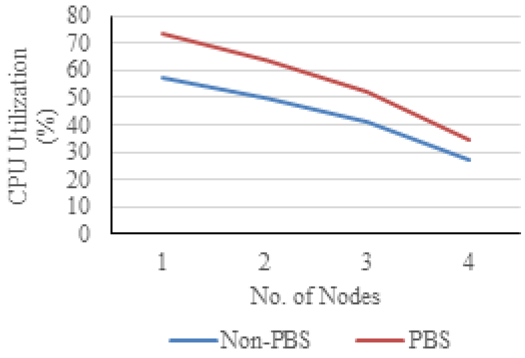

Figure. 4 Improvement Graph with PSA Algorithm

V. CONCLUSION

Following points have been concluded on the basis of this research:

- First come first serve algorithm has the least percentage of system resource utilization and Round Robin algorithm has the maximum percentage for the same. On an average a difference of 3-4% was always seen between RR and FCFS in case of system resource usage. Thus, the best algorithm to have the optimal resource usage and CPU utilization is RR.
- RR algorithm resulted in the maximum improvement in case of CPU utilization from non PBS to PBS using system.

- PSA showed a mediocre trend in all the cases and kept a medium paced performance of the system.
- RR shows the maximum vertical variance for PBS system.
- As the number of nodes increase the utilization for system resources decreases for all the scheduling algorithms for cases with PBS and without PBS.

VI. FUTURE SCOPE

There can be the forthcoming of energy efficient resource management strategies for improving incorporate forecast calculations to more readily manage the unutilized periods and abatement the holding up times of jobs that need the resources. These techniques will consider data concerning the workload at hand like highest instances of usage yet in addition to thermodynamical data of the frameworks like outside and inward temperatures of specific territories of the room or equipment in hardware segments. A lot of research can be carried out to develop such system.

Also, the energy efficient system can be more improved with additional equipment of high-end schedulers to make the scheduling process better. Network topology awareness can be done, fault tolerance can be adapted to improve the goodness of hardware components. This contiguous evolution of scheduling system will be highly useful in creating the passage of HPC from the scale to petaflop to exaflop.

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Author's Profile

Ms. Anika Karwal did her graduation from Guru Nanak Dev Engineering College in the year 2017 and currently she is pursuing her masters from Punjab Agricultural University in computer science and engineering.

Mr. O.P. Gupta holds a doctorate degree in the field of computer science and engineering and is currently working as an associate professor in Punjab Agricultural University.