International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 1 | ISSN : 2456-3307

Comprehensive Analysis of Job Scheduling Strategies to Attain Energy Efficiency in Heterogeneous Systems

Anil Kumar[1], Prabhdeep Kaur[2]
[1]Professor, Gurunank Dev University Amritsar, Punjab , India
[2]Computer science Department Of Gurunank Dev University Amritsar, Punjab , India

ABSTRACT

Heterogeneous system is a system which consists of multiple clusters of varying environment distributed over wide areas. It is a system which enhances the availability of resources to the users if the local environment is unable to perform that particular job. Job Scheduling is the main strategy to follow to increase the performance and efficiency of a system. It can be achieved by reducing the makespan , reducing the flowtime and mainly consider to reduce the energy consumption of a system. Moreover, energy consumption relates with the load carried by nodes in a system. Balancing a load is one of the key ingredient to achieve energy efficiency. This paper discusses the various job scheduling strategies in a Heterogeneous system and their comparisons.

Keywords: Heterogeneous, Job-scheduling, makespan, multi-cluster, environment

I. INTRODUCTION

Proper utilization of resources is the main concern of parallel computation. It is a type of computation in which a job is broken down into discrete tasks so that they can be executed on different processors at the same time. Distributed computing is really helpful for the user to obtain the result within stipulated time or sometimes earlier. This computing is mainly of three types such as Cluster computing, Grid computing and Cloud computing. Cluster computation consists of loosely coupled computing resources that work together closely as a single resource. These resources are connected each other by a local area network. Grid computing is a combination of multiple clusters
which are distributed over a large area. Cloud computing consists of remote servers which are hosted on the network to store, manage and process data. Our main focus is on Heterogeneous computing which is the most distributed form of Parallel computing. It involves the number of grid resources which are communicating over the network to allow the transparent use of resources to work on a given job if the local grid infrastructure is unable to satisfy the needs of a user. The basic unit of Heterogeneous system is a cluster which is highly responsible for the completion of tasks in a job. Scheduling of jobs over a Heterogeneous system is a very crucial task due to its large size and heterogenous environment. Analyzing the resource specifications during allocation of job , necessary to decrease the execution time of a job and increases the response time. Parallel execution of jobs in a system excerbates its performance although makes it more efficient. This system is also known as multi-cluster heterogenous environment.

II. APPROACHES OF JOB SCHEDULING

1. Centralized Approach- It is a approach in which there is one main scheduler who schedules all the jobs present in a service queue to the resources present in a system. As one knows Heterogeneous system consists of uncountable resources of varying environments, this approach is not suitable to manage all the resources and scheduling jobs to every other resource. It is highly prone to failure due to network congestion and moreover hardly reach to the idle resources in such a wide system network.

2. Decentralized approach enhances the utilization of resources by putting meta-scheduler at the top level of each grid system. Meta-scheduler maintains a queue on which number of jobs have to wait to be scheduled in a particular grid infrastructure. It is highly valuable in case of wide network to manage the resources by considering each specifications. It enhances the scalability of a system and if one system fails to performs its job, then it can easily transferred to the other system without much delay.

III. APPROACHES OF TASK SCHEDULING

These task scheduling approaches follow the decentralized workflow scheduling.

1. Non-Coordinated Approach- It is a approach in which the Meta-scheduler directly submits job to the resources without considering their load and utilization status.

2. Coordinated Approach is a approach in which the Meta-scheduler maintains the dynamic information of all the resources in a system before the allocation of job tasks.

IV. HETEROGENEOUS

Here, it follows decentralized approach of job scheduling.

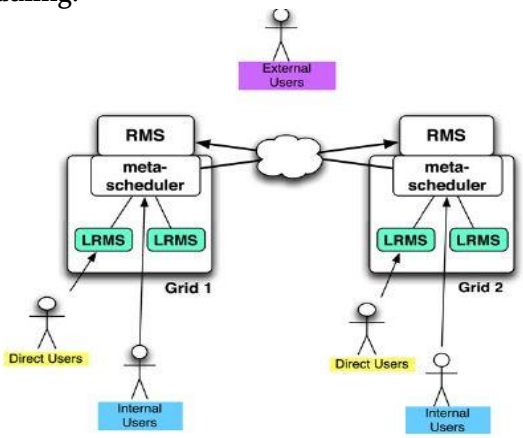

Figure 1. Heterogeneous System Architecture

It is a system which manages the internal resources of a grid infrastructure.

Meta-Scheduler- It consists of knowledge of all components of a grid and schedules the job according to the capacity of a resource.

RMS(Resource Management Service)- It is a component acts as a grid middleware that provides an interface for requesting and using remote system resources for the execution of jobs.

According to the perspective of a meta-scheduler, it performs function for two types of resources:-

Internal Resources- These are the resources that are directly accessible by the meta-scheduler through the corresponding LRMS.

External Resources- These are the resources that are remotely accessible by the meta-scheduler.
Users are defined by requesting to perform their jobs such as

1.Direct Users-Those users that submit jobs directly to the cluster through the LRMS.
2.Internal Users- Those users that submit jobs directly to the meta-scheduler. The jobs can then be executed in both internal and external resources.
3.External Users- Those users that submit jobs through the RMS interface to system and the meta-scheduler is the one that decides to submit jobs to the respective resources, this entire process is completely transparent to internal users.

Number of jobs present in a queue are partitioned in number of tasks and each task is to be scheduled to each node of a system to utilize all the resources judiciously without wasting the energy consumption. There are many features which are greatly affected by un-appropriate scheduling of jobs.

1. Makespan is the amount of time required to complete the whole job. It should be minimized in order to achieve the energy efficiency.

Makespan = Submission time – Response time

2. Flowtime is the sum of response times of all jobs which must be minimized.
Flowtime = Execution time + Waiting time

Energy- efficient system is a system which utilizes all the resources of a system judiciously , decreases the idle time of resources. In order to achieve the energy efficient system one should minimize the

execution time of a job. To compute the execution time , job can be characterize by two factors:

1. Processing Slowdown(PS)- The PS for job Jj is obtained from the slowest processing node Jj is assigned to, that is, the allocated node providing the maximum processing slowdown:

PS=MAX(PS)

2. Communication Slowdown(CS)- Certain amount of bandwidth(b_i) is required by the task within the cluster to communicate. If we n tasks within the job then total bandwidth required will be $n*b_i$.

This further helps in decreasing the consumption of power by a node in a system. It can be achieved by increasing the throughput and reliability of the system.

1.Throughput is the rate of processing of a job in a given amount of time. It should be maximized to achieve highly efficient system.

2.Reliability is the ability of a system to perform its job under stated conditions.

V. LITERATURE SURVEY

(Leal,2015)[1] presents the Heterogeneous system follows such a strategy which helps in achieving the best possible makespan. This strategy is based on anticipating the specifications of all resources in a system. It follows non-coordinated workflow scheduling. (Leal,2013)[2] proposes a strategy which saves both time and communication bandwidth by reducing the number of jobs migrations. It is a self adjusting resource sharing policy which maintains the systems complete autonomy and improves its resource performance. (E.Gabaldon et al,2015)[16] considers load on various machines. Multi criteria approach is followed in this case. It means that the criteria for job scheduling are not fixed and it is dynamic in nature. (Ranjan, Harwood and Buyya,2012)[4] proposes a coordinated Heterogeneous systems, which efficiently coordinating resources by using the Distributed Hash Table(DHT) technique. (Leal et al,2010)[5] have presented various variations of a job scheduling algorithm in a Heterogeneous system to check the suitability of performance and they have concluded that PT-RR is the best strategy. (Rahman et al,2010)[5] introduces cooperative and decentralized workflow scheduling in grids.This approach explains distributed hash table index space. (Leal et al,2009)[6] presents a decentralized model which consists of a set of meta-schedulers on each of the grid infrastructure for scheduling independent tasks in Heterogeneous. They considers the performance of the grid infrastructures and introduces algorithms for scheduling on Heterogeneous , reveals that DO-AS is the best mechanism for scheduling in Grid-Federation.(Vazquez et al,2008)[7] derives an federation model to calculate the performance of a system which allows us to calculate the number of jobs submit to each of the grid system using integer linear programming. (Bruin et al,2008)[8] have presented the non-coordinated decentralized meta-scheduler which performs scheduling strategies without taking into account the current load of the grid infrastructures which causes suboptimal schedules. (Juhasz and Paul,2008)[9] presents negative effects of contract net communication overhead on job execution time in a multiple agents grid computing system. (Losup et al,2007)[10] introduces the delegation matchmaking architecture for inter-operating grids. When a site manager cannot serves locally a request then it decides to delegate it to the neighbours according to the information about the current state of the system such as the number of free processors present in a cluster. (Assuncao et al,2007)[11] proposed Intergrid architecture consists of many gateways responsible for managing resources arrangement between different grids. It follows the decentralized resource management in which every grid has to specify its policies, resources which are available for the other grids but retaining control over its resources and to whom it wants to provide access. (Yin et al,2007)[12] elaborates the mechanism for scheduling independent jobs by introducing Genetic algorithm(GA) in a grid environment because of its simplicity but it is a time consuming process. This mechanism wholly depends upon the number of jobs and resources.(Ranjan,2007)[13] have

introduced the coordinated resource provisioning in Heterogeneous. It aims towards decentralized and coordinated coupling of distributed grid resources as a part of a single cooperative system. Decentralized organization enhances the scalability and reliability of the whole system. (Ranjan et al,2007)[14] illustrates centralized and hierarchical information services have several design limitations including: single point of failure ,lack of scalability, high network communication cost, and computational power to serve queries. (kertesz and kacsuk,2006)[15] provides Meta-Brokering approach in which meta-broker sits on the top of the resource brokers and uses meta data from them to decide where to send a user job. This is a centralized solution with a single point of failure.(Salehi et al,2012)[17] illustrates the concept of preemption policies during the execution of jobs coming from different type of users. Local and external requests to the same cluster creates contention among the whole system which makes the whole process more complicated, they described some allocation policies which are to be followed during the execution of jobs in a system.

Table 1. Comparison of different Job Scheduling Strategies

Name	Title	Environment	Scheduling Model	Parameters	Advantages	Disadvantages
Ranjan et al. [1], 2007	Decentralised resource discovery service for large scale Heterogeneous	Java,Condor	Decentralised	Reliable,Secure, Limited Scalability	Fault-tolerance	Dynamic resource cluster formation is missing
Assancao et al. [2],2007	InterGrid: A case for internetworking islands of grids",Concurrency and Computation	DMM Architecture	Decentralised	Scalable, Secure	Reducing Traffic, Minimizing cost	Reliability metric could be improved by considering mean time between failure
Losup et al. [3],2007	Inter-operating grids through delegated matchmaking	Nimrod-G system	Decentralised	Scalable,High completion time,Reliable	Easy to control, Reducing traffic	Execution time is a problem that can be reduced further
Leal et al.[9],2010	Performance-based scheduling strategies for HTC applications in complex Heterogeneous	GridSim	Decentralized	Scalable, Secure	Easy to maintain, Best algo. defined for scheduling	Consistency is low as redundant data is allowed
Ranjan, Buyya, Harwood [10],2012	Coordinated load management in Peer-to-Peer coupled Heterogeneous systems	Java, Matlab	Decentralized Coordinated	Reliable, Scalable	Reducing traffic, minimized cost	Execution time of simulation is not considered
Leal [11],2013	Self-adjusting resource sharing policies in Heterogeneous	GridSim 5.2	Decentralized Non-Coordinated	Scalable, Reliable, Secure	Saving time and Comm. bandwidth	Coordination of resources is missing which means interdependent tasks cannot be executed
Leal [12],2015	Anticipating resource saturation in Heterogeneous Environment	GridSim 5.2	Decentralized Non-Coordinated	Scalable, Reliable, Secure, Good Response time	Saving time Comm. Bandwidth, Reallocation Already scheduled tasks	Smaller jobs consume time as long as complex jobs since homogeneous clusters are not available
E.Gabaldon et al,2015	Multi-criteria genetic algorithm applied to	Matlab	Decentralized	Scalable, Secure, maximized	Efficient Resource Management	Convergence rate is poor in other words it takes large amount

	scheduling in multi-cluster environments			throughput	strategy	of time in order to reach at the solution

VI. COMPARATIVE ANALYSIS

In [6], authors stated the different algorithms for meta-schedulers in a decentralized model to schedule the jobs effectively. Among different algorithms ,one DO-AS (Dynamic Objective and Advance Scheduling) mechanism is transparent to all the users to reduce the makespan of jobs and increase the performance of grid infrastructure but it does not consider the dynamic information of all resources before allocating job. Moreover it detects the system performance by considering only one local resource and one external resource. Then in [4] author stated the three variations of DO-AS mechanism, among them PT-RR(Per Type- Resources with results) strategy is a superior one to follow. It maps jobs according to the performance of all resources by considering their results. Then this strategy is to be followed by [1], [2], [3] in their research to reduce the makespan and maximized the throughput of the system. In [17] author stated policies to reduce the preemptions in the job requests comes from local and external sources. This contention creates idle resources in the clusters which decreases the performance of the system. It creates problem for the local resource manager in satisfying first local or external job. It increases the energy consumption of the resources by staying idle without getting shut down. There are two perspectives which enhances energy consumption such as-

1. 1.From the local manager perspective preemption creates a notable overhead to the system and effects the utilization of various resources.
2. 2.From the external user perspective preemption enhances the response time of the jobs these two affect the objective of achieving efficient Heterogeneous system.

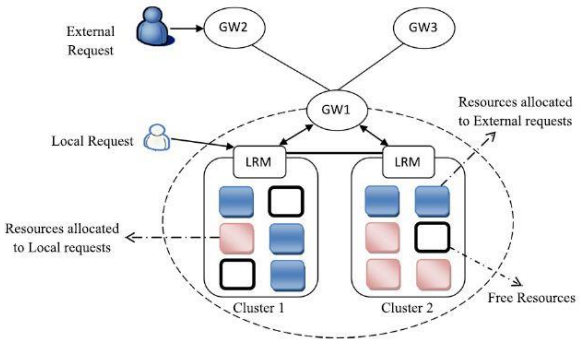

Figure 2. Contention between local and external requests

Then the author proposes two allocation policies such as workload allocation policy and dispatch policy which reduces 60% of preemptions during allocation and enhances the performance of system.

VII. RESEARCH GAPS

In the existing literature energy efficiency is achieve however the hetrogenous nature of cloud is not considered. Resource requirements of every job would be different, according to the different types of resources at different interval of time. If this requirement is not satisfied makespan and flowtime will increase. the study of literature indicates that this area is not worked upon as yet my any researches.

VIII. PROBLEM DEFINATION

In the existing literature problem of scheduling independent tasks is considered. The environment considered is heterogeneous in nature. A mathematical model of each sub problem is formulated and 638 a LP solver is used in order to solve it. Then, the reduced cost values of 639 non basic variables are examined and based on these values new columns are 640 incorporated in the next mathematical problem formulation. Column pricing method is considered for evaluation against the resources available.

The problem of multi objective job consideration is missing in the existing literature. Multi objective jobs

require multiple resources based on memory requirements, CPU requirements etc. In order to tackle the issue, CPR can be incorporated in heterogeneous multi objective environment.

IX. CONCLUSION

After discussing all Job scheduling Strategies and their algorithms to achieve the basic objective of energy efficient system is still not wholly achieved. The reduced response time and efficient utilization of resources are key ingredients of a Heterogeneous system which must be achieved. Many algorithms and techniques are used in the research papers to satisfy the user needs in one aspect but not with all aspects.

X. REFERENCES

[1]. Leal,"Anticipating resource saturation in Heterogeneous.", Future Generation Computer Systems, vol.45,pp. 114-122,2015.

[2]. Leal,"Self-adjusting resource sharing policies in Heterogeneous.", Future Generation Computer Systems,vol. 29,pp. 488-496,2013.

[3]. Ranjan et al.,"Coordinated load management in Peer-to-Peer coupled Heterogeneous systems.", J Supercomput ,vol. 61,pp.292-316, DOI 10.1007/s11227-010-0426-y,2012.

[4]. Leal et al.,"Performance-based scheduling strategies for HTC applications in complex Heterogeneous.",Concurrency Computat.: Prac.Exper.2010; vol.22, pp.1416-1432 DOI:10.1002/cpe.1498.

[5]. Rahman et al.,"Cooperative and Decentralized workflow scheduling in global grids",Future Generation Computer System,vol. 26 , no.5 ,pp.753-768,2010.

[6]. Leal et al.,"A decentralized model for scheduling independent tasks in Heterogeneous.", Future Generation Computer Systems ,vol.25,pp. 840-852,2009.

[7]. Vazquez et al.,"A performance model for Heterogeneous infrastructures",in: Proceedings of the 16th Euromicro International Conference on Parallel,Distributed and Network based processing,pp.188-192,2008.

[8]. Bruin et al.,"Job submission to grid computing environments",Concurr. Comput.:Prac.Exp.20 ,vol.11,pp. 1329-1340,2008.

[9]. Juhasz and Paul,"Scalability analysis of the contract net protocol", in: Proceedings of the 2nd IEEE/ACM International Symposium on Cluster Computing and Grid, (CCGRID 02),IEEE Computer Society,Los Alamitos,CA,USA,2008.

[10]. Losup et al.,"Inter-operating grids through delegated matchmaking.", International Conference for High Performance Computing,Networking Storage and Analysis (SC07),Reno,USA,November,2007.

[11]. Assuncao et al.,"InterGrid: A case for internetworking islands of grids",Concurrency and Computation: Practice and Experience(CCPE), vol. 20,pp.997-1024, 2007.

[12]. Yin et al.," An improved genetic algorithm with limited iteration for grid scheduling",Proceedings of the Sixth International Conference on Grid and Cooperative Computing, GCC2007,pp.221-227 ,2007.

[13]. Ranjan.,"Coordinated Resource Provisioning in Heterogeneous",Thesis,Department of Computer Science and Software Engineering, The University of Melbourne,July 2007.

[14]. Ranjan et al.,"Decentralised resource discovery service for large scale Heterogeneous",in: Proceedings of the Third IEEE International Conference on e-Science and Grid computing,IEEE Computer society,pp.379-387,2007.

[15]. Kertesz and Kacsuk, “Grid Meta-Broker Architecture: Towards an interoperable grid resource brokering service",Proceedings of CoreGRID Workshop on Grid Middleware in Conjunction with Euro-Par 2006(Lecture Notes in Computer Science), vol. 4375, Springer: Berlin,pp.112-116, 2007.

[16]. E.Gabaldon et al.,"Multi-criteria genetic algorithm applied to scheduling in multi-cluster environments," J.Simul, vol.9, no.4, pp. 287-295,2015.
[17]. Salehi et al.," QoS and Preemption aware scheduling in federated and virtualized grid computing environments," J.Parallel Distrib. Comput.72(2012) 231-245.
[18]. "GridSim Toolkit" available at http://www.cloudbus.org/gridsim/,2012.
[19]. "Introduction to Grid Computing" available at http://www.gridcomputing.com/.
[20]. "Introduction of Parallel Computing" available at https://computing.llnl.gov/tutorials/parallel_comp/.