MIN-MIN APPROACH FOR SCHEDULING IN GRID ENVIRONMENT

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Abstract:- Scheduling jobs on computational grids is identified as NP-complete problem due to the heterogeneity of resources; the resources belong to different administrative domains and apply different management policies. This paper presents a novel metaheuristics method based on min min approach for scheduling of jobs in the grid environment. The proposed method schedules the jobs providing QOS to the jobs. Jobs are classified on the basis of their communication and computational requirement. Depending on this it is scheduled to the required type of processor providing the desired QOS. The algorithm is better than the typical scheduling algorithms as it not just schedules the jobs based on processor speed but also considers the bandwidth requirements.

1. INTRODUCTION

The popularity of the Internet and the availability of powerful computers and high-speed networks as low-cost commodity components make it possible to construct large-scale high-performance Grid computing systems. These technical opportunities enable the sharing, selection, and aggregation of geographically distributed heterogeneous resources for solving large-scale problems in science, engineering, and commerce [1,2]. To achieve the promising potentials of tremendous distributed resources, effective and efficient scheduling algorithms are fundamentally important. The scheduling problem deals with the coordination and allocation of resources so as to efficiently execute the users' applications.

A major issue in Grid Environment is how to distribute the tasks among processors to improve performance so that some jobs do not suffer unbounded delays. Dandamudi[3] defines task routing as the method that tasks are assigned to processors and task scheduling as how tasks are scheduled on the assigned processor. Task routing policies may be either static or adaptive. The former uses only information about the average behavior of the system, ignoring the current state, while the latter reacts to system state.

Adaptive policies are more complex but produce significantly better performance results than static policies. Static policies are separated into deterministic and probabilistic. Probabilistic policies adjust the routing decision to a probability distribution. In deterministic policies once the set of currently ready tasks has been specified, the routing discipline is applied [3]. Task routing algorithms can also be separated into immediate mode and batch mode routing algorithms. Immediate mode algorithms forward the tasks of each job as soon as they arrive in the system [4]. On the contrary, batch mode algorithms allocate a batch of tasks of many jobs which are in the queue of the scheduler [5].

While considering the scheduling of the resources many factors such as CPU utilization rate, throughput, turnaround time, waiting time, response time should be focused for all the processors when assigned with the jobs [6]. The jobs are assigned to the resources considering the system's performance. Thus the scheduling plays an important role in achieving the best utilization of resources and the better completion of the submitted jobs. The scheduling problem is a NP hard problem and the solutions for these problems need heuristics [7]. Many heuristic scheduling algorithms have been designed for this purpose.

2. NEED FOR GRID TECHNOLOGY

Computers have been proven to be very efficient to solve complex scientific problems. They are used to model and simulate problems of a wide range of domains; for instance medicine, engineering, security control and many more. Although their computational capacity has shown greater capabilities than the human brain to solve such problems, computers are still used less than they could be. One of the most important reasons to this lack of use of computational power is that, despite the relatively powerful computing environment one can have, it is not adapted to such complicated computational purposes. The following are given the reasons for why we need grid computing.

2.1 Exploit Unused Resources

In most organizations, computing resources are underutilized. Most desktop machines are busy less than 25% of the time (if we consider that a normal employee works 7 hours a day and that 42 hours a week and that there are 168 hours per week) and even the server machines can often be fairly idle. Grid computing provides a framework for exploiting these underutilized resources and thus has the possibility of substantially increasing the efficiency of resource usages. The easiest use of Grid computing would be to run an existing application on several machines. The machine on which the application is normally run might be unusually busy, the execution of the task would be delayed. Grid Computing should enable the job in question to be run on an idle machine elsewhere on the network.

2.2 Increase Computation

To provide users with more computational power, some crucial areas have to be considered. These areas are: hardware improvement, periodic computational needs capacity of idle machines sharing of computational results

3. CHALLENGES IN GRID SCHEDULING

Although Grids fall into the category of distributed parallel computing environments, they have a lot of unique characteristics, which make the Scheduling in Grids highly difficult. An adequate Grid Scheduling system should overcome these challenges to leverage the promising potential of Grid Systems, providing High-Performance services.

1.8.1 Resource Heterogeneity

A Grid has mainly two categories of resources: networks and computational resources. Heterogeneity exits in both of the two categories of resources. First, networks used to interconnect these resources may differ significantly in terms of their bandwidth and communicational protocols. A wide area Grid may have to utilize the best effort services provided by the internet. Second, computational resources are usually heterogeneous in that

these resources may have different hardware, such as instruction set, computer architecture, number of processors, physical memory size, CPU Speed and so on and also different software such as different operating systems, file systems, cluster management software and so on. The heterogeneity results in differing capability of processing jobs. Resources with different capacity cannot be considered uniformly. An adequate Scheduling system should address the heterogeneity and further leverage different computing powers of diverse resources.

1.8.2 Site Autonomy

Typically a Grid may compromise multiple administrative domains. Each domain shares a common security and management policy. Each domain usually authorizes a group of users to use the resources in the domain. Thus applications from non authorized users should not be eligible to run on the resources in some specific domains.

Furthermore, a site is an autonomous computational entity. A shared site will result in many problems. It usually has its own Scheduling policy, which complicates the prediction of a job on the site. A single overall performance goal is not feasible for a Grid system since each site has its own performance goal and Scheduling decision is made independently of other sites according to its own performance goal.

1.8.3 Local Priority

It's another important issue. Each site within the Grid has its own Scheduling policy. Certain classes of jobs have higher priority only on certain specific resources. For example, it can be expected that local jobs will be assigned higher priorities such that local jobs will be better served on the local resources.

1.8.4 Resource Non-Dedication

Because of non-dedication of resources, resource usage contention is a major issue. Competition may exist for both computational resources and interconnection networks. Due to the non-dedication of resources, a resource may join multiple Grids simultaneously. The workloads from both local users and other Grids share the resource concurrently. The underlying interconnection network is shared as well. One consequence of contention is that behaviour and performance may vary over the time; Contention free at the guaranteed level Schedulers must be able to consider the effects of contention and predict the available resource capabilities.

1.8.5 Application Diversity

This problem arises because the Grid Applications are from a wide range of users, each having its own special requirements. For example, some applications may require sequential execution, some applications may consist of a set of independent jobs, and others may consist of a set of dependent jobs. In this context, building a general-purpose Scheduling system seems extremely difficult. An adequate Scheduling system should be able to handle a variety of applications.

1.8.6 Dynamic Behaviour

In Traditional parallel computing environments such as a cluster, the pool of resources is assumed to be fixed or stable. In a Grid Environment, dynamics exists in both the networks and computational resources. First, a network shared by many parties cannot provide

guaranteed bandwidth. This is particularly true when wide areas networks such as the internet are involved. Second, both the availability and capability of computational resources will exhibit dynamic behaviour. On one hand new resources may join the Grid and on other hand, some resources may become unavailable due to problems such as network failure. The capability of resources may vary overtime due to the contention among many parties who share the resources.

An adequate scheduler should adapt to such dynamic behaviour. After a new resource joins the Grid, the scheduler should be able to detect it automatically and leverage the new resources in the later Scheduling decision making. When a computational resource becomes unavailable resulting from an unexpected failure, mechanisms such as check pointing or rescheduling should be used to guarantee the reliability of Grid systems. These challenges pose significant obstacles on the problem of designing an efficient and effective Scheduling system for Grid Environments.

4. RELATED WORK

Xiaoyong Tang et al.[10] proposed a stochastic scheduling algorithm for precedence constrained tasks on Grid. He addressed the problems in scheduling a precedence constrained tasks of parallel application with random tasks processing time and edges communication time on Grid computing systems so as to minimize the makes pan in stochastic environment. This is a difficult problem and few efforts have been reported on its solution in the literature. The problem is first formulated in a form of stochastic scheduling model on Grid systems. Then, a stochastic heterogeneous earliest finish time (SHEFT) scheduling algorithm is developed that incorporates the expected value and variance of stochastic processing time into scheduling. The HEFT algorithm [10] selects the task with the highest upward rank (an upward rank is defined as the maximum distance from the current node to the exiting node, including the computational cost and communication cost) at each step. The selected task is then assigned to the processor which minimizes its earliest finish time with an insertion-based approach which considers the possible insertion of a task in an earliest idle time slot between two already-scheduled tasks on the same resource.

Anand et al. [11] have presented a probabilistic load scheduling algorithm within distributed systems. The proposed algorithm in considers local and global tasks for each of the systems existing in the network and tries to find the best distribution of the tasks among the resources. Since different priorities for each of the local and global tasks are considered, the model uses a priority queuing optimization model to formulate a NLP problem to find the scheduling probabilities. Applying the scheduling probabilities obtained from solving the NLP problem to the global tasks arrival rate, load distributed among the resources can be balanced.

Jiang et al. [12] have presented two probabilistic priority scheduling disciplines for high speed and multi-service networks. In the starvation of low priority packets against to the high priority ones is considered and a solution to avoid this problem is presented. To achieve this, a parameter is assigned to each of the priority queues in each of the servers. This parameter determines the probability in which its corresponding queue is served when the queue is sampled by the server. Using this mechanism, a new packet scheduling discipline named probabilistic priority (PP) is presented.

Salami and Chan [13], Salami et al. [14] have presented two probabilistic scheduling algorithms for IP traffic. In an iterative probabilistic scheduling (IPS) algorithm has been

presented to model virtual output queuing strategy in each of the input queues implemented in routers. IPS algorithm considers the first in first out (FIFO) mechanism for each of the output queuing strategies. First, IPS orders the packets using estimating the transmission bandwidth and the waiting time. Then the weight of each packet is calculated using these two parameters. The algorithm uses these weights to determine the probability of transmitting each of the packets retrieved during a specific time slot. After determining the related probabilities for each of the packets, the packets can be scheduled among output ports.

J. Díaz, C. Muñoz-Caro and A. Niño et al. [15] proposed a an adaptive approach to task scheduling optimization in Dynamic Grid Environment. He addressed that scheduling algorithms play an important role in heterogeneous computing systems. These algorithms guarantee a good load balance, also reducing the communication overhead. In particular, Quadratic Self-Scheduling (QSS) and Exponential Self-Scheduling (ESS) are flexible enough to adapt to distributed systems, thanks to their adjustable parameters. This flexibility becomes very important when the environment is dynamic because only algorithms that can shape the workload will be able to handle dynamic environment such as an Internet-based Grids of computers. However, it is shown that the performance of ESS decreases when there is a large number of tasks. Finally, the overall time spent by the adaptive approach to generate new optimal sets of parameters is just a bit higher than the time to obtain just once. However, it is not proportional to the number of new sets of parameters generated. This is because the number of tasks decreases each time that we obtain new optimal parameters.

4. PROBLEM DEFINITION

In grid environments, the shared resources are dynamic in nature, which in turn affects application performance. Workload and resource management are two essential functions provided at the service level of the Grid software infrastructure. To achieve the desirable goals i.e. increase throughput, maximum system utilization, and fulfill economical system and user constraints of these environments, effective and efficient task scheduling algorithms are fundamentally important. The focus of our study is to consider factors which can be used as characteristics for decision making to initiate task scheduling.

At first, we discover the set of potential resources suitable for the proposed tasks. Second, we select scheduling constraints such as minimization of the run time. After the matching problem is resolved we conduct the final job execution and data transfers with the selected environment. The main objective of this paper is to provide a good scheduling algorithm for Grid environment. In the Grid environment, it is desirable to compete for the best QOS provided by and for remote resources to fulfill application constraints. The scheduler in the Grid environment needs to consider application and QOS constraints to get a better match between applications and resources.

5. PROPOSED ALGORITM

The term quality of service (QOS) is used differently based on the different context while applying it to grid resources. For example when QOS is used in the network context it means the desirable bandwidth for the application. Similarly when it use for CPU it means the requested speed like FLOPS or the utilization of the underlying CPU. In our proposed approach both QOS of a network and QOS for CPU is considered. In current Grid job scheduling, the job with different levels of QOS request compete for resources. It may be possible that a job with low QOS requested can be executed on a resource providing high

quality of service. So when the job with high QOS requested is come for execution it has to wait till the low QOS requested job completed, this will increase the jobs completion time, makes pan time and decrease the overall performance of the Grid. To overcome this shortcoming we modify the Min-Min algorithm to take the QOS matching into consideration while scheduling.

There are two types of jobs in grid, computation based and communicational based. The communication based jobs like transfer a file from one node to another node require high bandwidth for its operation. The computational based jobs like solving scientific computation based problems which require high speed CPU to complete the assigned task in minimum delay of time. If the computational jobs submitted to high bandwidth resource then it will not utilize its bandwidth effectively, similarly if a communication based jobs submitted to a resource having high speed CPU and low bandwidth then it does not fully utilize the resource and also increase its job completion time. So we proposed an algorithm which considered the QOS in scheduling should lead to a better scheduling algorithm.

Step1. We divide the resources in the four different classes. Class1 Low QOS and Class2 high QOS in term of bandwidth. Class3 Low QOS and Class4 high QOS in term of CPU speed.

Step2. Calculate the job is communication based or computational based by computing CCR Value (Communication to computation ratio).

Step3. If the job is communication based and requested for high QOS then it is submitted to the class2 resources.

Else If the job is communication based and requested for low QOS then it is submitted to the class1 resources.

Else if the job is computational based and requested high QOS then it is submitted to the class4 resources.

Else Job is submitted to class3 resources.

End if

Step 4. We apply Min-Min algorithm and computes the completion time of all the jobs on all the host of that class.

Step 5. Submit the job to resource which requires least completion time to execute that job.

With the help of this min-min approach together with the division of classes helps in providing very high degree of QOS. It helps in providing the communication based jobs high degree of bandwidth and those computational based jobs, the processors with high CPU speed. The algorithm also considers the priority of jobs i.e. those requiring low QOS and those requiring high QOS. The resources that require low QOS in terms of bandwidth are allotted to processors of class 1 and those with high QOS in terms of bandwidth are allotted to processors of class 2. The resources that require low QOS in terms of CPU speed are allotted to processors of class 3 and those with high QOS in terms CPU speed are allotted to processors of class 4. Therefore, the algorithm helps to better manage the grid resources by scheduling them in such a way as to provide the lowest execution time plus better QOS.

The flow- chart of the algorithm can be represented as:

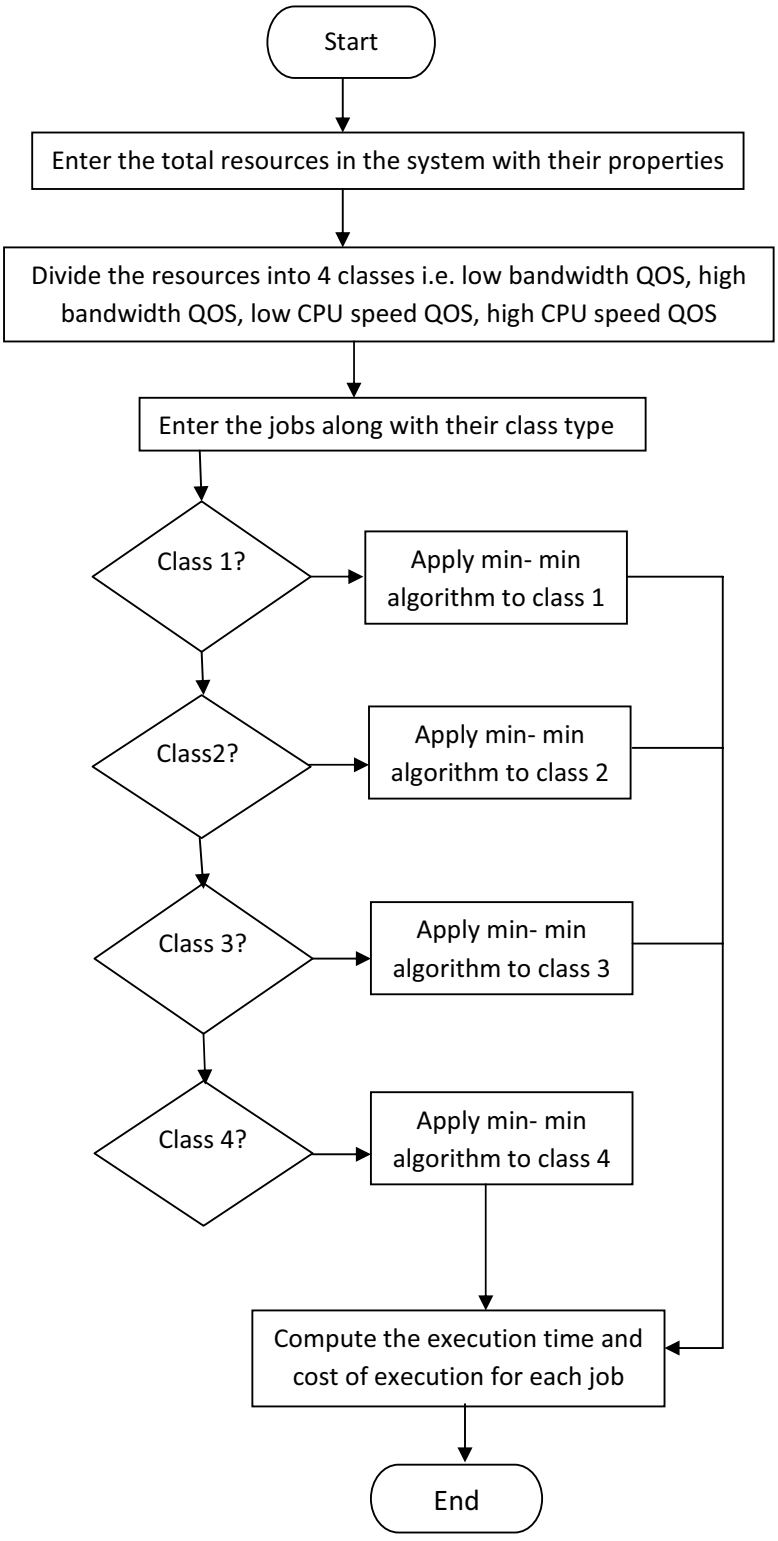

Figure 1: Flowchart of the proposed task scheduling algorithm

6. EXPERIMENTAL SETUP

We have setup a simulated Grid environment to evaluate the proposed QOS guided Min-Min scheduling algorithm. In our experiment, we fixed the parameter for the hosts and used six task submission scenarios three for communicational based jobs and three for computational based jobs. The QOS guided Min-Min and the conventional Min-Min are compared by their makespan on the same set of tasks.

First Scenario :- Most of the jobs(80% jobs) require high QOS.
Second Scenario :- Half of the jobs(50% jobs) require high QOS.
Third Scenario :- Very few of the jobs(20% jobs) require high QOS.

For each of the scenarios, we compare the performance of the conventional Min-Min heuristics and the QOS guided Min-Min. For each scenario and each heuristic we create 100 tasks 100 times independently and get the average makespan of the 100 times. Table 1 and Fig. 1 shows the comparison. The data is in seconds.

TABLE 1. Makespan for Three Scenario for Two Heuristics

Scenario	Min-Min	QoS Guided Min-Min	Improvements
First	125.40	90.78	27.61%
Second	172.55	110.28	35.77%
Third	258.87	240.77	6.99%

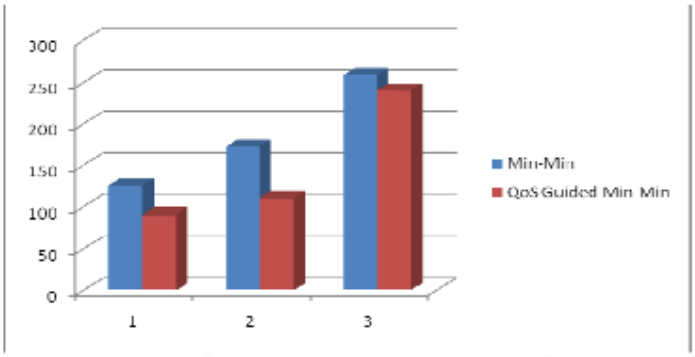

Fig.1 makespan for communicational based for two heuristics

As shown in Fig. 1, for all three scenarios the QOS guided Min-Min outperforms the traditional Min-Min heuristics by 23.46% shorter makespam. For scenario (a), where the tasks that require high QOS are in higher density (80%), a satisfactory performance gain 27.61% is acquired. For scenario (b) where the tasks that require high QOS and the tasks that require low QOS are evenly distributed, the performance gain reaches as high as 35.77%. For scenario (c), where the tasks that require high QOS is only 20%, the performance gain of the QOS guided Min-Min is relatively small, i.e., 6.9% better than the conventional Min-Min.

6. CONCLUSION

Job scheduling is one of the well-known problems in distributed computing systems such as grid environments. In this paper we propose an adaptive scheduling algorithm which considers QOS for network as well as CPU based upon the types of jobs. In proposed method

we enhance the Min-Min algorithm by classifying it according to the QOS parameters. The experimental results shows that QOS guided Min-Min scheduling algorithm outperform the traditional Min-Min heuristic on the same set of task.

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