

Load Balancing GridSim Architecture with Fault Tolerance

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Abstract—This Grid computing enables sharing, selection and aggregation of large collections of geographically and organizationally distributed heterogeneous resources for solving large-scale data and compute intensive problems. Resources are dynamic and heterogeneous in nature so the load of resources varies with change in configuration of Grid and also the probability of failure of resources is much greater, moreover the failure of the resources affects the job execution fatally. This makes load balancing and fault tolerance more important in case of grid environment. This paper introduces an algorithm which balances the load among the resources and also increases the reliability of the grid environment. This algorithm consists of two-phases. In the first phase, the resources are selected based on the user deadline and fault tolerant factor of the resources. In the second phase, the load balancing algorithm is applied to determine the status of the selected resources and then the jobs are scheduled to the resources if and only if the load is balanced. The proposed algorithm is simulated on the GridSim environment. The proposed algorithm may helps to reduce the Communication overhead and response time of the individual job and increase the throughput of the entire system.

Keywords— *load balancing; fault tolerance; user deadline; Grid computing; GridSim.*

I. INTRODUCTION

In today's pervasive world of needing information anytime and anywhere, the explosive Grid Computing environments have now proven to be so significant that they are often referred to as being the world's single and most powerful computer solutions. The Grid computing discipline involves the actual networking services and connections of a potentially unlimited number of ubiquitous computing devices within a grid. Grid computing [1] provides highly scalable, highly secure and extremely high performance mechanisms for discovering and negotiating access to remote computing resources in a seamless manner. This makes it possible for the sharing of computing resources, on an unprecedented scale among an infinite number of geographically distributed groups. So, the individual users can access computers and data transparently without having to consider location, operating system, account administration, and other details. Grids tend to be more loosely coupled, heterogeneous and geographically distributed across multiple administrative domains and owned by different organizations.

Grid computing environments must be constructed upon the following foundations coordinated resources-the infrastructure should provide coordination among the resources, based on respective policies and service-level agreements. Open standard protocols and frameworks-The use of the open standards provides interoperability and integration facilities. The standards must be applied for resource discovery, resource access and resource coordination.

The grid systems are classified into two types:- Computational grids, in which machines with set-aside resources stand by to crunch data or provide coverage for other intensive workloads. Data grids [2], which provide a unified interface for all data repositories in an organization, and through which data can be queried, managed, and secured.

The grid environment consists of several components such as schedulers, load balancer, grid broker, and portals. The schedulers are the types of applications that are responsible for the management of jobs, such as allocating resources needed for any specific job, partitioning of jobs to schedule parallel execution of tasks, data management, event correlation and a service level management capabilities. The resource broker provides pairing services between the service requester and the service provider. This pairing enables the selection of best available resources from the service provider for the execution of a specific task. The load balancer is responsible for distributing the workload among the resources. This load-balancing feature must always be integrated into the system in order to avoid processing delays and overcommitment of resources. The grid portals help free end users from the complexity of job management and resource allocation.

The performance of the Grid environment strongly affected by the improper distribution of load among resources and the frequent resource failures. This paper proposes an algorithm which considers the failure rate and user deadline as major deciding factor for the distribution of the load among the resources.

II. LITERATURE REVIEW

The grid environment consists of dynamic and heterogeneous resources. These resources changes with time i.e., any new resource can join or any of the old resources can exit the grid environment at any time. So the selection of the available resources meeting the user deadline [19] in such a

dynamic and time variant environment is very complex. Similarly designing a proper job scheduling algorithm considering the resource characteristics is very important. Blythe et al.[20] uses Min-min task scheduling algorithm which schedules the job based on the (ECT) Expected Computation Time value. The experimental results show that this algorithm reduces the makespan and the response time of the submitted jobs.

Due to uneven job arrival patterns and unequal computing capabilities, some resources in the grid environment get overloaded or some resources get underloaded or some resources remain idle. The load balancing mechanism helps to distribute the load among the resources from overloaded resource to underloaded resource. This helps to achieve high throughput, reduced response time, optimized utilization of the resources.

The load balancing mechanism is generally based on four policies namely information policy, triggering policy, resource type policy, selection policy. The Information policy specifies what workload information to be collected, when it is to be collected and from where. Triggering policy determines the appropriate period to start a load balancing operation. The Resource type policy uses the results of the resource type policy to find a suitable partner for a server or receiver. Selection policy defines the tasks that should be migrated from overloaded resources (source) to most idle resources (receiver).

Yagoubi and Slimani [2][3][4] were proposed the layered load balancing algorithm, which is based on the tree model representation. This model transforms any grid architecture into a unique tree with at most four levels. The main features of this algorithm are (i) it is layered. (ii) it supports heterogeneity and scalability. (iii) it is totally independent of any physical architecture of grid.

Kokilavani [18] has proposed a Load Balanced Min-Min algorithm which reduces the makespan and increases the resource utilization. This algorithm consists of two-phases. In the first phase, the Min-Min algorithm is executed and in the second phase, the tasks in the overloaded resources are rescheduled to use the unutilized resources.

Hao et al.[12] used a dynamic, distributed load balancing scheme for a grid environment which provides deadline control for tasks. Initially the resources check their state and make a request to the Grid Broker according to the change of state in load. Then, the Grid Broker assigns Gridlets between resources and scheduling for load balancing under the deadline request. The experimental results shows that this algorithm can reduce the makespan, improve the finished rate of the gridlet and reduce the submitted time.

Samuel et al [13] introduced a Augmenting Hierarchal Load Balancing algorithm. To evaluate the load of the cluster, probability of deviation of average system load from average load of cluster is calculated and checked for the confinement within a defined range of 0 to 1. The fittest resources are allocated to the jobs by comparing the expected computing power of the jobs with the average computing power of the clusters. The evaluation results show that the makespan is reduced and the idle time of the clusters is also reduced.

Balasangameshwara and Raju [14] were proposed a fault tolerant hybrid load balancing algorithm. This algorithm is carried out in two –phases. In the first phase, a static load balancing policy selects the desired effective sites to carry out the submitted job. If any of the sites is unable to complete the assigned job, a new site will be located using the dynamic load balancing policy. By this way the job failure is identified and load is redistributed to the underloaded resource. The experimental results show that this algorithm performs well in large grid environment.

Fathy [21] has proposed a two-level load balancing policy for the multi-cluster grid environment where each cluster is located in different local area networks. This algorithm distributes the load on the resources based on the processing elements capacity. This leads to minimization of the overall job mean response time and maximization of the system utilization and throughput.

Fernandes et al [8] were proposed a route load balancing algorithm, which is designed to equally distribute the load of tasks of parallel applications. This algorithm uses the message routing concepts from the computer networks to define the computer neighbourhood. If any resource is overloaded, then the neighbour's load is evaluated. If the neighbour node is not overloaded then the tasks are transferred to it. The task transfer is based on the migration model.

Cao et al [5] were designed a load balancing algorithm in combination with intelligent agents and multi-agent approaches. This algorithm assumes grid as two-level grid. In the local grid, each agent is responsible for scheduling and load balancing across multiple nodes in grid environment. In the global level grid, each agent is a representative of resources and acts as a service provider.

Due to the resource characteristics in the grid environment, the resource failure may frequently occur in any grid system. This affects the job execution fatally. Detecting the resource failure in advance in grid environment is a complex task. Once the resource failure occurs, the resubmission of the same task to another resource dynamically involves many problems such as selecting appropriate resource meeting the user deadline, increase in response time, etc. So providing reliability in the grid environment is another challenging task which affects the performance of overall grid environment.

Latchoumy and Sheik [16] discussed various fault tolerance techniques, fault management in different systems and related issues. Some of the techniques are check-point recovery, replication and so on.

Hwang and Kesselman [15] proposed a flexible failure handling framework, which addresses some failure recovery requirements. Dabrowski [17] pointed out some important issues and problems to overcome the resource failures in the grid environment.

III. PROPOSED SYSTEM

In this section, the brief description of the proposed algorithm is presented. The proposed algorithm works at three levels: Broker, Resource and Machine. When a job is

submitted to the Machine, the algorithm works at two phases namely:-Selection of fittest resource and load balancing algorithm.

A. Selection of Fittest Resource

Each job is submitted to the Machine in the grid environment with the user deadline. Then for each available job, ECT (Expected Completion Time) value for each resource is found. Then the resources that are satisfying the user deadline (less than or equal to ECT value of the job) alone are considered.

$$ECT = EET + EAT + ECOT \quad (1)$$

Where ECT is the Expected Computation Time, EET is the Expected Execution Time, EAT is the Expected Availability Time and $ECOT$ is the Expected Communication Time.

Now, the fittest value for each selected resource is calculated to find the fittest resource for each job. The fittest value for each job is calculated is based on the Fault Tolerance value and the Expected Completion Time of the job in that particular resource. The Fault tolerance value is defined as the ratio of number of submitted jobs failed in that node to the total number of jobs submitted. Finally, the resource with highest fittest value is considered to be the fittest resource for that job.

$$FR = Jf / Js \quad (2)$$

Where FR is the Fault Rate, Jf is the number of jobs failed in the resource and Js is the number of jobs successfully completed in the resource.

B. Load Balancing algorithm

The load balancing mechanism is performed at all the three levels. After the selection of resources in the first phase, the load balancing mechanism is performed. The load balancing algorithm classifies the nodes at three levels into three lists:-overloaded list, normally loaded list and underloaded list based on the load threshold values namely:-PE level threshold, Machine level threshold and Resource level threshold. Overloaded list means set of nodes with overcommitment of jobs. Normally loaded list is a list of nodes, if any job is further submitted to these nodes then they are shifted to the overloaded list. The underloaded list is a list of nodes which can be submitted with jobs.

If the selected node is present in the underloaded list, then the job is scheduled to the same resource else check for the presence of the next fittest resource in the underloaded list. Before scheduling the job, expected load of the selected resource should be calculated by adding the load of the job with current load of that particular resource. If the expected load exceeds the load threshold value then it is assumed that the submission of job may lead to the overloaded node condition. If the expected load value below the load threshold, then the job can be submitted. So, each time before the submission of jobs the expected load of the node is verified and submitted.

Finally if the load is unbalanced at the PE level, then few jobs are selected and forwarded to the Machine level. If the load is unbalanced at the Machine level, then few jobs are selected and forwarded to the Resource level. Almost the load is balanced at the Machine level itself.

By this way the load balancing mechanism is performed at each level considering the fault tolerance factors.

IV. PERFORMANCE ANALYSIS

The performance of the proposed algorithm can be evaluated by the following parameters:-Communication overhead, Makespan, Response time, Hit rate and Miss rate. The Communication overhead can be calculated by determining the number of messages over resources. The Makespan determines the Expected Computation time of resource. The Response time is the total Simulation time. The decrease in response time and Communication overhead will increase the performance of the overall system. Consequently the throughput of the system is increased.

The hit rate can be defined as the ratio of number of jobs successfully completed to the total number of jobs so far submitted.

$$Hit Rate = JSucc / Jsub \quad (3)$$

The miss rate can be defined as the ratio of number of jobs failed to the total number of jobs so far submitted to the resource.

$$Miss Rate = Jf / Jsub \quad (4)$$

Both hit rate and miss rate determines the efficiency of each resource. These parameters may help to evaluate the performance of the proposed algorithm. And also this proposed algorithm may significantly increase the overall performance of the entire system.

V. CONCLUSION

This paper addresses the issues of load balancing and resource failures. The proposed algorithm helps in reducing the makespan and achieving high reliability. The first phase of the algorithm selects the appropriate resource for the jobs and in second phase, the load of the entire system is balanced and the jobs are scheduled properly. So, the proposed algorithm may reduce the communication overhead and response time of the individual job and increases the overall performance by increasing the throughput.

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