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Comparative Study of Job Migration Algorithms for Autonomic Grid Management

Pankaj Kumar, Paritosh Kumar and Gajraj Singh

Assistant Professor, Ramjas College, University of Delhi-110007
Assistant Professor, College of Engineering and Management (Kapurthala), Punjab
Assistant Professor, Ramjas College, University of Delhi-110007
E-mail: pkumar240183@gmail.com, paritosh200623@gmail.com
gajraj76@gmail.com

Abstract

Resources form the basis of a Grid. Resource management and load balancing are the main areas of concern in a distributed, heterogeneous and dynamic environment like Grid. Load balancing may further cause Job migration or in some cases re-submission of Job. In this paper a number of job migration algorithms have been surveyed and studied which have resulted because of the Load balancing problem. A comparative analysis of these algorithms has also been presented which summarizes the utility and applicability of different algorithms in different environment and circumstances. *Keyword:* Load balancing, Grid Computing, Job Migration, Virtual Machine

1. Introduction

Grid has a number of resources working independently with different processing capability and processes different workloads accordingly. Grid computing joins all the scattered resources into a large problem solving heterogeneous environment for different types of applications, which can run in parallel. Considering the whole distributed system as one unit, workload should be evenly distributed over all the resources as per the configuration of the system, to minimize the job execution time. Therefore, Load balancing and resource management are major areas of concern for a Grid environment.

Main objective of load balancing is to optimize the response time of the application by which workload would be maintained according to resources. There are broadly three reasons which are the major causes of load balancing, resubmission of jobs and job migration; heterogeneity of resources, dynamic nature of resource's performance and diversity of applications incase of Grids [3]. This is even more

crucial in computational Grid where the main concern is to fairly assign jobs to resources and to minimize the difference between the heaviest and the lightest resource load [4].

This paper presents a survey of job migration algorithms and techniques, which is done to balance the load in a Grid environment. It also compares and construes the applicability of each technique as per the requirement. The paper is organized as: Section 2 contains background of load balancing, and job migration. In Section 3, existing job migration algorithms are discussed. Comparisons between these algorithms, based on Grid computing parameters, are included in Section 4. Finally Section 5 concludes the paper and provides the future scope of work.

2. Load Balancing and Job Migration

Load balancing is main area of concern in distributed environment whereas job migration is one of the best solutions to handle load balancing problems.

2.1 Load Balancing

An important issue of distributed and heterogeneous environment is the efficient assignment of tasks and utilization of resources, commonly referred to as load balancing problem [13].

Load balancing is required to disperse the resource's load evenly so that maximum resource utilization and minimum task execution time could be possible. This is very crucial concern in distributed environment to fairly assign jobs to resources. Generally, load balancing mechanisms can be broadly categorized as centralized or decentralized, dynamic or static, and periodic or non- periodic [5]. All load balancing methods are designed such as, to spread the load on resources equally and maximize their utilization while minimizing the total task execution time. Selecting the optimal set of jobs for transferring has a significant role on the efficiency of the load balancing method as well as Grid resource utilization. This problem has been neglected by researchers in most of previous contributions on load balancing, either in distributed systems or in the Grid environment [7].

Job migration is the only efficient way to guarantee that submitted jobs are completed reliably and efficiently in case of process failure, processer failure, node crash, network failure, system performance degradation, communication delay; addition of new machines dynamically even though a resource failure occurs which changes the distributed environment [12].

Load balancing strategies aim to adapt the load optimally to the environment. However, they mainly consider the application running on a parallel, homogeneous system.

2.2 Job Migration

Grid is inherently a dynamic system where environmental conditions are subjected to unpredictable changes like system or network failures, system performance degradation, addition of new machines, variations in the cost of resources etc. Job migration is the next step when there is no proper scheduling or resubmission of jobs.

Whenever any resources encounter problem, then job migration to the next eligible system is suggested. Migration behavior of jobs lead to the assumption that small sites tend to migrate resource- demanding jobs, while large sites confine to pass only small jobs to the central job pool. Job migration is the only efficient way to guarantee that the submitted jobs are completed and that the user restrictions are met [10].

Job migration mechanisms, which take the non- dedicated and dynamic natures of Grids into consideration, become important for optimizing the application performance [13]. Job monitoring, re- scheduling and check pointing are some steps involved in job migration. Job monitoring contains all performance related data of all the resources so that it could initiate the migration. Further this information is reported to the re-scheduler, which evaluates if it is worth migrating the job, and in that case, decides a new allocation for the job. Check pointing is capturing a snapshot of the state of a running job, in such a way that the job can be restarted from that state in a later time in case of migration.

3. Survey of Existing Job Migration Algorithms

There are many mechanism but only five mechanism is surveyed here which is surveyed here. Which are Virtual machine migration, node reconfiguration method, checkpointing, Robin-hood algorithms and load based graph method.

3.1 Virtual Machine Migration (Live Migration)

In Virtual machine migration snapshots of machine are sent to other machine that's why it is called the virtual machine migration. There are two methods for virtual machine migration. First one is live migration and second one is regular migration [1]. In live migration, running domain between the different host machines is migrated without stopping the job. In between it stops job and gathers all required data then resumes. But this happens only in same layer –layer network and IP subnet. In regular migration generally stop the job then migrated.

An important aspect of this mechanism is to make the run-time job migration with non-dedicated shared resources in dynamic Grid environment. Virtual machine migration provides high isolation, security and customization environment in which administrator privileges the user to execute the work. EtherIP and IP tunneling are required while migrating in this mechanism. This algorithm redistributes the load coming to any particular node, which may be the old connected node or newly added node for that load.

3.2 Node reconfiguration by User Level Thread Migration

This mechanism makes application workload migrate from source node to destination node, and then let source node depart from original computing environment .There are two mechanism for this, first one is node reconfiguration by user-level thread migration and another one is node reconfiguration by kernel level thread migration. Node reconfiguration by user level thread migration has been discussed in this survey.

There is two-implementation fashion of node reconfiguration. One is synchronous method and the other is asynchronous method. In synchronous method, all nodes are

paused during reconfiguration. On the other hand, in asynchronous method all nodes continue to work simultaneously with reconfiguration. Synchronous method may make performance down even though it is easier to design. Alternatively, better performance can be obtained by asynchronous method as long as more attention paid to correctly maintain the order of node reconfiguration messages [1].

Information regarding redistribution of workload and how to add/delete nodes is present in the implementation of node reconfiguration mechanism. With the help of user level thread migration, which is already supported by the thread package workload, is redistributed here.

Same as virtual machine migration, node reconfiguration mechanism also needs to transfer in memory states from source node to destination node.

3.3 Check-Pointing Approach

Checkpoint is defined as a designated place in a program at which normal processing is interrupted specifically to preserve the status information necessary to allow resumption of processing at a later time. By periodically invoking the check pointing process, one can save the status of a program at regular intervals. If there is a failure one may restart computation from the last checkpoint thereby avoiding repeating the computation from the beginning. The process of resuming computation by rolling back to a saved state is called rollback recovery [2].

There are three types of check pointing implementations: kernel-level, user-level and application-level. These implementations differ in level of transparency, efficiency and mechanism used to initiate checkpoint and restart. In kernel level check pointing user does not have to change the application at all so least efficient, because system does not have the knowledge about the application. Developer achieves user level check pointing, and he puts or implements some set of procedures that handle check pointing and restart. Developer knows all about the application that's why this approach is more efficient. The developer itself achieves application-level check pointing. This approach is the most efficient, because developer has detailed knowledge about application.

This is very useful in case of preemption and migration and is used in making fault tolerant systems. Most common benefit of the check pointing technology is the high level of fault tolerance offered by the applications that can be check pointed. Besides it used to recover from failures, check pointing is also used in playback debugging distributed programs, migrating processes in a multiprocessor system, software rejuvenation and optimistic simulation.

Check pointing balances the load of processors in a distributed system; processes are moved from heavily loaded processors to lightly loaded ones. Check pointing process periodically provides the information necessary to move it from one processor to another.

3.4 Robin Hood: An Active Objects Load Balancing Mechanism for Intranet

Robin Hood algorithms present a new totally non- centralized solution, multicast channel to communicate, and synchronize the processors and proactive tools to migrate jobs between them. Proactive techniques are very useful and provide the

mobility and security in uniform framework. This work focuses on dynamic load balancing. Main objective of this algorithm is to improve the decision time in non-centralized environment.

In this mechanism two basic things have been considered, first one to know about the local load and second one transfer the load from high dense node to the less loaded node. This uses the non-centralized architecture and non-broadcasting of the balance of each node to reduce the overload in network. This is totally non-centralized load balancing mechanism, using the proactive library for the migration of jobs, and a multicast channel for node coordination.

3.5 Load Graph Based Transfer Method

Load based graph method is based on network graph where each node is represented with its load, whereas load can be the number of users, average queue length or the memory utilization. It uses analytic model and single load determination policy throughout the system and load is determined on the basis of memory utilization and average queue length. This algorithm is based on three- layered structure. Top layer is load balancing layer which takes care of token generation, taking decision about task transfer; middle one is called monitoring layer and acts as an interface between top and middle and monitors load changes and third one called communication layer which take care of actual task transfer.

Here token is generated on the basis of outgoing and incoming edges and initialized on the basis of some specific value HWM & LWM (Highest Water Mark, Lowest Water Mark). Specific values are decided on the basis of load value of neighbors. Nodes having load value greater than HWM and are local maxima or nodes having load value less than LWM and are the local minima, can initiate token [9].

Maximum message transfer per node, if N is number of nodes and X is maximum message transfer per node Total message transfer =NX

And transfer of task will occur only if there would be proper load difference between the nodes as

1. La - Lb > M where M is the required

Load difference for the task transfer.

Token will be generated if following conditions will be satisfied

1. For nth node (Load) n > L where L is maximum Load where load balancing is not required.

2. (Load) n > $\sum$ sum of load of all nodes

If both conditions are satisfied then the token is generated in more than sixty percent of the cases where load imbalance exists token finds out the proper node for the task transfer which improves the system performance[9]. In this algorithm along with the task transfer among the neighboring nodes with the token transfer method care is taken to avoid the starvation of those nodes for which neighbors are not suitable for the task transfer.

The major parameter, network-partitioning issues along with inter-cluster and intra-cluster transfers for decision-making of load balancing for the transfer is

considered here.

4. Comparison between existing Job Migration Algorithms

The Job migration algorithms mentioned in previous section have been compared on the basis of parameters which have been chosen on the basis of which type of scheduling policy is used, selection criterion to choose the better resources, nodes communication, monitoring policy to monitor the whole system, type of environment in which algorithms is being used, completion of work correctly after migration, protocol being used.

Table 1: Comparison between existing Job Migration Algorithms

Parameter Techniques	Node Reconfiguration by User Level Thread Migration	Virtual Machine Migration(live migration	Check-Pointing	Robin Hood: An Active Objects Load Balancing Mechanism	Load Graph Based Transfer Method
Designing & Implementation of Algorithm	Easy to design	Hard to design	Depends upon type of check pointing	Easy to design	Easy to design
Efficiency	Depends upon type of jobs and platform	Good	More efficient in uni-processors systems	Not good due to preemptive scheduling	Good
Performance	High performance in intra cluster scenario	High performance in inter cluster scenario	For long lasting check pointing process performance is low but for small	Not good	Good for larger network due to network intimation frequency and task execution time
Security	Security measures not taken here	High security here due to same layer network and same IP subnet	Security could be here if required	High security due to simple Meta-object protocol	No security measures taken here

Migration time	It depends upon distance b/w synchronization points and For small problems it is low	For small problems it is high	Depends upon distance of node and network	Weak migration due to proactive libraries	Time is low here
Fault Tolerance	Medium	Fault tolerant at better level due to using pre-copy phase	High	Less	Medium
Resource Selection	Not so good only finds the under load machine	Optimal resources are selected here	Depends upon scheduling strategy which would be used here	Based on percentage loading at node	High

The comparative analysis shows that in case of non-preemptive scheduling and centralized environment virtual machine migration is good for load balancing and additionally provides high security and optimal resource selection. In large distributed environment multiple token policy is good because it gives good migration time and optimal resource selection. Mostly algorithms discussed here based on non-preemptive scheduling but Robin-hood algorithm is based on preemptive scheduling and provides security measures. Check pointing is good technique if security and fault tolerant system are required.

Conclusion

Load balancing is a key issue in Grid resource management and results in Job migration or re- submission of job. In this paper Job migration algorithms have been surveyed and studied which have been designed for different scenarios. These algorithms have been compared on design and implementation, security, migration time, fault tolerance and resource selection parameters. Different algorithms do well in their respective contexts like multiple token policy results in optimal resource selection and minimum migration time whereas Robin-hood provides better security and check- pointing provides good results for fault tolerant systems.

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