Chapter X
Hierarchical Scheduling in Heterogeneous Grid Systems

Khaldoon Al-Zoubi
Carleton University, Canada

ABSTRACT

This paper proposes hierarchal scheduling schemes for Grid systems: a self-discovery scheme for the resource discovery stage and an adaptive child scheduling method for the resource selection stage. In addition, we propose three rescheduling algorithms: (1) the Butterfly algorithm in order to reschedule jobs when better resources become available, (2) the Fallback algorithm in order to reschedule jobs that had their resources taken away from the Grid before the actual resource allocation, and (3) the Load-Balance algorithm in order to balance load among resources. We also propose a hybrid system to combine the proposed hierarchal schemes with the well-known peer-to-peer (P2P) principle. We compare the performance of the proposed schemes against the P2P-based Grid systems through simulation with respect to a set of predefined metrics.

INTRODUCTION

The current status of computation is equivalent in some respects to the status of electricity circa 1910s (Foster & Kesselman, 2004). At that time, electrical power was generated by generators for specific individuals or organizational needs. Truly, the real influence of electricity in our lives was born with the creation of the electric power grid, which was provided via sharing generators. The “grid computing” term was adopted from the electricity grid to amplify computational power via sharing computational resources, since both grids are similar with respect to their infrastruc-
ture and purpose. The term “the grid” started in the mid-1990s (Foster, 2001; Foster & Kesselman, 2004) to portray the infrastructure of both scientific and commercial computing communities and has been gaining popularity ever since. The “grid” can be defined as a parallel and distributed system that enables a large collection of geographically distributed heterogeneous systems that usually span several organizations to share a variety of resources dynamically, depending on their availability, capability, user’s requirements, and any other predefined rules set by local systems and resources owners. The type of sharing in the grid gives the impression of a powerful self-managing virtual computer. The Internet is an ideal choice to link thousands or millions of computers, since it already connects the whole world—if a node’s IP address is known, it can then receive data from another node. Benefits of grids can be extensive. They include: (1) expanding computing power, since grids unleash the hidden computing power that is not being used most of the time (e.g., most machines in a typical organization are busy less than 5% of the time (Berstis, 2002)), (2) improving productivity and collaboration among organizations (i.e., wider audience) in a dynamic and geographically distributed manner to form one powerful computing system, and (3) solving complex problems that were previously unsolvable.

The rest of the article is organized as follows. In the next section, grid scheduling stages and some of the grid challenges are described. Then, the self-discovery method is presented. It is used in the resource discovery stage and the adaptive hierarchical scheduling (AHS) method, which is used in scheduling jobs on selected resources. Note that the AHS method is based on the AHS method for parallel and cluster systems presented in Dandamudi (2003). In addition, we present three rescheduling dynamic algorithms: the butterfly, the fallback, and the load-balance. Next the simulation model and samples of the results are given. Refer to Al-Zoubi (2006) for more a more in-depth discussion of the presented schemes and the complete set of results. The results are followed by conclusions.

GRID SCHEDULING STAGES

Grid characteristics must be taken into account in order to perform efficient scheduling. Grid schedulers must make scheduling decisions in a very challenging environment that includes: (1) no control over the resources, since they don’t own them; (2) distributed resources; (3) a dynamic existence of resources (i.e., resources may be added or removed from the grid at any time); (4) a dynamic information collection; (5) heterogeneous resources (jobs must match appropriate resources in order to be executed as requested by the users); and (6) tentative scheduling until the allocation of actual resources (i.e., resources may be taken from the grid before a job actually uses them).

In general, grid scheduling is performed in three stages (Nabrzyski, Schopf, & Weglarz, 2004). First is the resource discovery stage, which produces a set of matched resources. Schedulers are expected to collect static information (e.g., operating systems) from local schedulers or general information systems (GIS), in order to perform job matching. In the next stage, resources are selected (i.e., resource selection stage) from the list obtained during the first stage and are expected to meet user’s imposed constraints (e.g., deadlines). Then schedulers are expected to collect dynamic information (e.g., system load) for the third stage and transfer jobs to selected resources (i.e., job execution stage).

HIERARCHICAL SCHEDULING IN GRID SYSTEMS

Grid schedulers, in our proposed schemes, are structured in a tree form that we call a grid tree,
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