A Distributed Heuristic for Decentralized Workflow Scheduling in Global Grids

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Abstract

Efficient scheduling is a key concern for the effectual execution of performance driven Grid applications, such as workflows. Many list heuristics have been developed for scheduling workflows in centralized Grid environment. However, in this paper, we present a distributed list heuristic for decentralized scheduling of workflow applications in global Grids. The simulation results show that the proposed scheduling approach is scalable with respect to increased workload on the system.

1 Introduction

Grid computing enables the sharing, selection, and aggregation of distributed heterogeneous resources that are under the control of different Grid sites. For the effectual execution of performance driven Grid applications, such as workflows, efficient scheduling is a key concern. A list heuristic schedules tasks in a workflow according to their priorities. Over the last few years, several list heuristics, such as Heterogeneous Earliest Finish Time (HEFT) [3] have been developed for scheduling workflows in centralized Grid environment. However, these heuristics are not capable of scheduling workflow applications in decentralized Grid environment. Therefore, we extend the traditional HEFT and propose a Distributed HEFT (DHEFT) heuristic that can leverage decentralized Grids for mapping and executing workflow applications. The results show that the proposed scheduling approach is scalable with respect to increased workload on the system.

2 Related Work

Many list scheduling heuristics [4] have been developed for scheduling workflows in Grids. However, these list heuristics are proposed for centralized Grid environment, whereas the proposed distributed list heuristic is applicable to decentralized Grids.

K. Liu et al. [1] proposed a Min-Min average algorithm for scheduling workflows in decentralized Grid environment, SwinDeW-G. However, the peer-to-peer (P2P) communication in SwinDeW-G is implemented by JXTA protocol, which uses a broadcast technique. In this work, we use a DHT based P2P system for handling resource discovery and scheduling coordination.

3 Problem Definition

We propose the distributed heuristic, DHEFT to solve the problem of existing list heuristics' inability to exploit the decentralized Grid environment and develop a workflow scheduling technique accordingly. In order to demonstrate the efficiency of this DHEFT based decentralized workfow scheduling approach, we measure makespan, which is the response time of a whole workflow. If there are n number of Grid sites and each site has u number of users with each user submitting w number of workflows, then average makespan per workflow in the system can be defined as,

$$M_{average} = \frac{\sum_{\substack{1 \le i \le n \\ 1 \le j \le u \\ 1 \le k \le w}} M_{i,j,k}}{n \times u \times w}$$

Therefore, the objective of the proposed workflow scheduling technique is to minimize $M_{average}$.

4 Distributed List Heuristic and Decentralized Workflow Scheduling

The proposed DHEFT-based workflow scheduling algorithm utilizes the Grid-Federation model [2] in regards to resource organization and Grid networking, where a global virtual resource sharing environment is created using a Distributed Hash Table based *coordination space*. In depth discussion of this aspect of the system is discussed in our previous work [2].

In a Grid-Federation, each Grid site is managed by a Resource Management System called Grid Federation Agent (GFA). The task prioritization phase of DHEFT is undertaken at each GFA before mapping the workflow, where priority or *rank* value of all tasks are calculated using traditional HEFT. Then resource selection phase is carried out at distributed coordination space, where tasks are mapped to suitable resources based on their rank value. The basic steps involved with proposed scheduling approach are illustrated in Fig. 1.

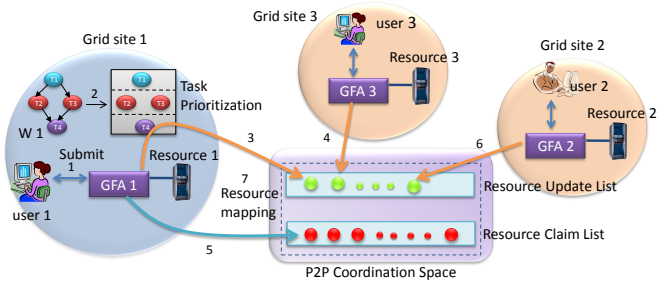

Figure 1: Task scheduling and resource provisioning.

5 Performance Evaluation

5.1 Simulation Setup

Our simulation infrastructure is created by combining two discrete event simulators namely *GridSim* and *PlanetSim*. In this study, we consider fork-join workflow and an example of such workflow is WIEN2K. We vary the number of tasks in a workflow over the interval [100, 500] and the size of each task is randomly generated form a uniform distribution between 50000 MI (Million Instruction) to 500000 MI.

The number of Grid sites in the network is fixed to 100. The distribution for different attributes of resources at various Grid sites is generated by utilizing the configuration of resources that are deployed in various Grids including NorduGrid, Grid5000, Naregi-Grid, and SHARCNET[1]. The resources update their information (submit ticket object) at every 300 seconds based on an exponential inter-arrival time distribution.

[1]http://gwa.ewi.tudelft.nl/

5.2 Results and Observations

Fig. 2 presents the results related to scheduling efficiency of proposed scheduling technique in terms of average makespan per workflow in the system, $M_{average}$. As we can see from the figure, with the increase of number of tasks in a workflwo, $M_{average}$ is increased piecewise linearly. For instance, $M_{average}$ is 13851, 16530 and 19864 seconds for workflow size 300, 400 and 500 respectfully. Therefore, our distributed list heuristic based scheduling approach is scalable in terms of workload on the system as its performance is not degraded with the increase in workflow size.

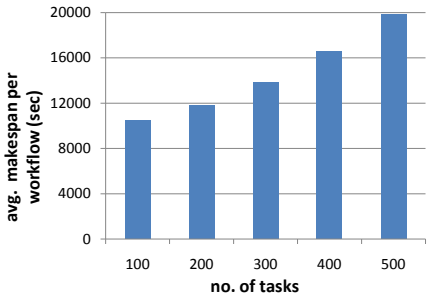

Figure 2: Average makespan for different sizes of workflow.

6 Conclusion and Future Work

In this paper, we have presented a distributed list heuristic, DHEFT for decentralized scheduling of workflow applications in global Grids. Using simulation, we have measured the performance of proposed DHEFT-based scheduling technique. Results show that it is scalable with respect to increased workload on the system. In future, we intend to investigate performance of this proposed technique against other list heuristics in decentralized workflow scheduling environment.

References

[1] K. Liu, J. Chen, H. Jin, and Y. Yang. A min-min average algorithm for scheduling transaction-intensive grid workflows. In *7th Australasian Symposium on Grid Computing and e-Research, New Zealand*, 2009.

[2] R. Ranjan, M. Rahman, and R. Buyya. A decentralized and cooperative workflow scheduling algorithm. In *8th IEEE International Symposium on Cluster Computing and the Grid, France*, May, 2008.

[3] H. Topcuouglu, S. Hariri, and M. Wu. Performance-effective and low-complexity task scheduling for heterogeneous computing. *IEEE Trans on Par and Dist Systems, 13(3): 260-274*, 2002.

[4] J. Yu, R. Buyya, and K. Ramamohanarao. *Workflow Scheduling Algorithms for Grid Computing, Metaheuristics for Scheduling in Distributed Computing Environments*. F. Xhafa and A. Abraham (eds), Springer, Germany, 2008.