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An Uncertainty-Based Task Scheduling for Heterogeneous Multi-Cloud Systems

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Cloud Computing is changing the landscape of the information technology industry by providing on-demand self-service. The services are offered to the clients by deploying virtual machines in the data center. In order to meet the peak clients demand, the data center collaborates with other data centers, as no data center has unlimited resources. Therefore, the data center needs an efficient task scheduling algorithm to map the clients requests with the available resources. Moreover, the requests may not be completed in the desired time due to dynamic and uncertain nature of the cloud resources. As a result, the completion time of the request will be delayed or saved. In this paper, we present Uncertainty-Based Task Scheduling (UBTS) for heterogeneous multi-cloud system. It is a two-phase algorithm, namely normalization and scheduling which aims to minimize the makespan, uncertainty with respect to makespan and maximize the average cloud utilization. We perform rigorous experimental analysis using benchmark and synthetic datasets to measure the performance of the proposed algorithm. The experimental results are compared with the existing algorithm batch uncertain dynamic Min-Min (BUD_Min-Min) in terms of makespan, uncertainty, save makespan, delay makespan and average cloud utilization. The results clearly show the effectiveness of the proposed algorithm in cloud computing environment.

Keywords : Cloud Computing, Makespan, Multi-Cloud, Normalization, Task Scheduling, Uncertainty.

1. INTRODUCTION

Cloud computing is a ubiquitous model that offers virtualized, distributed and elastic resources in the form of Virtual Machines (VMs) [1,2]. These resources are delivered to the users using pay-per-use basis. Therefore, cloud computing has gained numerous attentions in business and research communities. The primary objectives of cloud are to minimize the overall processing time and efficiently utilize the available resources. Hence, task scheduling is an important and challenging issue in cloud computing [3]. Moreover, scheduling of the tasks in the clouds has been shown to be an NP-Complete problem in heterogeneous computing environment [4-5]. Many heuristics [6-16] have been developed for task scheduling in cloud environment to deal with the primary objectives. However, these heuristics [6-16] have not considered the dynamic and uncertain nature of the cloud. The authors of [17] have introduced the concept of uncertainty in task scheduling and applied it to a well-known algorithm, *i.e.*, Min-Min [5]. The uncertainty is presented in the form of a soft computing method called Set Pair Analysis (SPA). The key concepts of SPA are set pair and its connection degree. Set pair is made up of two related sets (say, A and B) whereas their relationship is represented in the form of connection degree (say, μ). Mathematically [17],

$$\mu(A, B) = a + bi + cj \quad (1)$$

Table 21
Comparison of Delay Makespan for BUD_Min-Min and UBTS in synthetic ETC Matrix

Instances	BUD_Min-Min	UBTS
100 × 4	21469	19276
200 × 8	21353	17751
300 × 12	21555	17469
400 × 16	21284	16946
500 × 20	21201	16747
600 × 24	21148	16639
700 × 28	21142	16642
800 × 32	21145	16562
900 × 36	21123	16604
1000 × 40	21098	16548

Table 22
Comparison of Average Cloud Utilization for BUD_Min-Min and UBTS in synthetic ETC Matrix

Instances	BUD_Min-Min	UBTS
100 × 4	0.8764	0.9906
200 × 8	0.8141	0.9905
300 × 12	0.7952	0.9854
400 × 16	0.7839	0.9878
500 × 20	0.7776	0.9869
600 × 24	0.7744	0.9893
700 × 28	0.7702	0.9888
800 × 32	0.7681	0.9870
900 × 36	0.7665	0.9840
1000 × 40	0.7656	0.9828

quire $O(n^2m)$ time for n tasks and m clouds.

We have experimented the proposed as well as the well-known existing algorithm BUD_Min-Min using two benchmark and one synthetic datasets. The experimental results show the efficacy of the proposed algorithm over the existing one in terms of makespan, uncertainty, save makespan, delay makespan and average cloud utilization performance measures.

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