Workflow Scheduling in Mobile Cloud Computing Environment

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***Abstract*—Mobile Cloud Computing (MCC) is a new emerging technology that has revolutionized the way in which mobile subscribers across the globe can enjoy abundant multimedia applications on the go. MCC integrates cloud computing into the mobile environment and overcomes obstacles related to performance (e.g., battery life, storage, and bandwidth), security (e.g., reliability and privacy) and environment (e.g., scalability, availability). The scheduling of massive multimedia flows is a complicated task in the mobile cloud environment. The goal of this paper is to propose a model for job-oriented resource scheduling in a mobile cloud computing environment. The workflow is allocated or scheduled to the process which gives the available resources such as RAM, Bandwidth, MIPS etc. In this paper we construct the analysis of resource scheduling algorithms. The waiting time and turn-around time of two algorithms, viz. First Come, First Serve and Priority have been taken into consideration. From this, it has been computed that Priority Algorithm has the lowest time parameters and is the most efficient algorithm for resource scheduling.**

Keywords: Cloud Computing, Mobile Cloud Computing, Workflow, Resource Scheduling

I. INTRODUCTION

The market of mobile phones has expanded rapidly. "According to IDC [1], the premier global market intelligence firm, the worldwide Smartphone market grew 42.5% year over year in the first quarter of 2012. The growth of mobility has changed our lives fundamentally in an unprecedented way." According to Cisco IBSG [2], close to 80 percent of the world's population has access to the mobile phone, Android smart-phones, tablets that have brought a host of applications at the palms of people's hands.

NIST (National Institute of Standards and Technology, USA) definition [3] from September, 2011 released in its "Special Publication 800–145" of Cloud Computing is:

"Cloud Computing is a model that enables on-demand access to a shared pool of resources (e.g., storage, applications, networks, servers and services) that can rapidly be utilized with minimal management effort or service provider interaction."

A. Mobile Cloud Computing

Mobility has rapidly increased in today's computing area. With the development of wireless technology such as WiFi and WiMAX, users are en-able to surf the internet in much easier way and that also not limited by the cables as before. Thus, the mobile devices have been accepted by more and more people as their first choice of working and entertainment in their daily lives.

"So, what exactly is Mobile computing? In Wikipedia, it is described as a form of human-computer interaction by which a computer is expected to be transported during normal usage". [2] Mobile computing is based collectively on three major concepts: hardware, software and communication. The hardware can be considered as mobile devices, such as Android phone and laptop. The mobile computing software is comprised of the numerous mobile applications installed the devices, such as the anti-virus software, browser, g-mail and games. The communication is comprised of the infrastructure, protocols and data delivery techniques which must be transparent to the end users.

MCC is defined as "a mobile computing technology that makes use of elastic resources of various clouds and network technologies providing unrestricted functionality, storage, and mobility to mobile devices anywhere, anytime based on the pay-as-you-go principle."

B. Workflows

The workflow is defined as "the automation of a business process in which tasks are passed from one participant to another to perform action, according to a set of rules." A workflow models a process as a series of steps that simplify the execution complexity and applications management.

Scheduling is an important term when to talk about the managing requests and users in a computing environment. Scheduling is nothing but a set of task versus set of processors.

Workflow scheduling can be defined as the automation in workload scheduling where the workload is the requests and tasks generated by number of user s or clients in cloud. A scheduling can be categories into two categories: Job Scheduling and Job Mapping and Scheduling. Job Scheduling is what in which independent jobs gets scheduled among various available processors of distributed computing for optimization. A Job Mapping and Scheduling requires the allocation of multiple interacting tasks of a single parallel program in order to minimize the completion time on parallel computer system [8].

A task is an (sequential) activity that uses a set of inputs to produce a set of outputs. Processes are

statically assigned to processors in a fixed set, either at compile-time or at run-time. There are two types of scheduling: static and dynamic. In static load balancing, all information is known in advance and tasks are allocated according to the prior knowledge and will not be affected by the state of the system. Dynamic load balancing mechanism tasks are allocated to the processors dynamically when they arrive. Redistribution of tasks has to take place when some processors become overloaded [7].

Job scheduling algorithms in cloud computing can be categorized into two main groups. They are Batch mode heuristic scheduling algorithms (BMHA) and online mode heuristic algorithms. In BMHA, Jobs are collected and queued into a set as they arrive and the scheduled after a fixed time slice. The main examples of BMHA based algorithms are; First Come First Served scheduling algorithm (FCFS), Round Robin scheduling algorithm (RR), Max–Min algorithm and Min–Min algorithm. In On-line mode heuristic scheduling algorithm, Jobs are scheduled as they arrive in the system. On-line mode heuristic scheduling algorithms are more appropriate for a cloud environment, as the cloud environment is a heterogeneous system and the speed of each processor varies quickly [11].

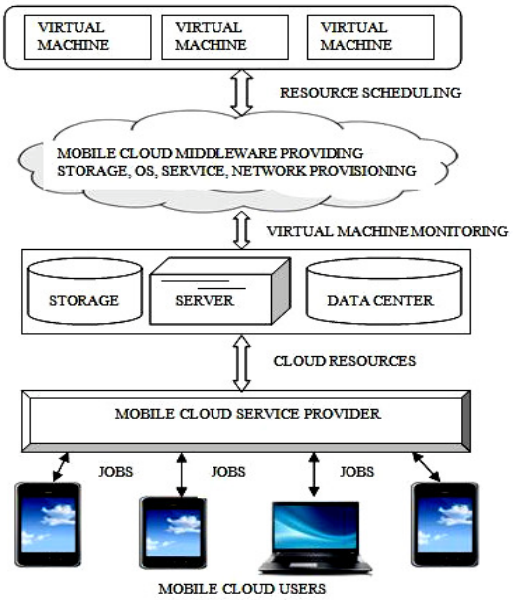

Fig. 1 Basic Resource Scheduling in Mobile Cloud Computing Environment

II. Related Works

Mayank Mishra *et al*. [2] in his paper has told that," the users of cloud services pay only for the amount of resources (a pay-as-use model) used by them. This model is quite different from earlier infrastructure models, where enterprises would invest huge amounts of money in building their own computing infrastructure. The traditional data centers results in wastage of resources during non-peak periods. The modern day data centers are shifting to the cloud to alleviate the above problem. The cloud-based data centers make resources available on demand. The cloud model provides users with a computing environment without investing a huge amount of money. As per the dynamic requirements, cloud model provides ability to dynamically scale or shrink the provisioned resources. This enables the pay as-use-go model. Thus, a cloud-based solution is an attractive provisioning alternative to exploit the computing-as-service model."

Anton Beloglazov and Rajkumar Buyya [5] have proposed "the plan for the future research work that consists of several steps listed in a table. Once the algorithms for all of the proposed optimization stages are developed, they will be combined in an overall solution and implemented as a part of a real-world cloud platform like Aneka".

Venkatesa Kumar V. and S. Palaniswami [6], in their paper, have proposed "the effective way of resource utilization and thus reduce the processing cost. Our experimental results clearly show that our proposed preemptive scheduling algorithm is effective in this regard. In this study, we present a novel Turnaround time utility scheduling approach which focuses on both the high priority and the low priority takes that arrive for scheduling."

Liang Luo *et al*. [9] in their paper have discussed "about, a new VM Load Balancing Algorithm is proposed and then implemented in Cloud Computing environment using CloudSim toolkit. He proposed an algorithm, in which the VM assigns a varying (different) amount of the available processing power to the individual application services. These VMs of different processing powers, the tasks/requests (application services) are assigned or allocated to the most powerful VM and then to the lowest. They have optimized the performance parameters such as response time and data processing time, by proposing an efficient VM Load Balancing algorithm i.e., Weighted Active Load Balancing Algorithm".

Qiang Li and Yike Guo [10] have proposed "a model for optimization of SLA-based resource schedule in cloud computing based on stochastic integer programming technique. The performance evaluation has been performed by numerical studies and simulation. The experimental result shows that the optimal solution is obtained in a reasonably short time."

W. Zhu [11], in their paper have discussed that, "by monitoring performance parameters of virtual machines in real time, the overloaded is easily detected once these parameters exceeded the threshold. Quickly finding the nearest idle node by the ant colony algorithm from the resources and starting the virtual machine can bears part of the load and meets these

performance and resource requirements. This achieves the goal of load balancing and realizes the load adaptive dynamic resource scheduling in the cloud services platform."

III. Problem Formulation

"Scheduling becomes a very complicated task in a cloud computing environment in order to efficiently allocate computing resources where many alternative computers with varying capacities are available." [4] To improve the resource utilization and to meet user requirements, efficient task scheduling is required. Many users simultaneously submit lots of computing requests with different requirements to the cloud service providers. The lower and higher computing ability tasks require varying computing resources, such as cost, RAM and bandwidth. "When the cloud computing service providers receive the tasks from users, the cloud computing providers negotiate with the users on the requirements of tasks including network bandwidth, complete time, energy cost, and reliability of task. The computing resource or storage resource in a cloud computing environment can be assigned to the corresponding task according to the various scheduling policies." [5] The scheduling algorithm must be optimal and good enough to meet each user request by providing them proper resources for their execution and the task must be completed in least execution time. In our work, we have compared two scheduling algorithms to schedule the task to the various cloudlets i.e., FCFS (First Come, First Serve) and Priority Algorithm.

A. *FCFS (First Come, First Serve) Scheduling Algorithm*

FCFS follows a service policy in which the process that requests the CPU (processor) first, is allocated the CPU first without other biases or preferences.

B. *Priority Scheduling Algorithm*

Priority of jobs is an important issue in scheduling because some jobs should be serviced earlier than other those jobs can't stay for a long time in a system. So, we have proposed a prioritized Workflow Scheduling Algorithm and implemented in simulated environment. The algorithm works as follows:

Step 1: Submit the set of Jobs and set of resources say J and R respectively.
Step 2: Form the cluster of the jobs based on the certain attributes, from the given set of jobs.
Step 3: Apply the priority algorithm within each cluster to prioritize the jobs.
Step 4: Assign these clusters the computing environment which is capable of performing execution of jobs taking least time.

IV. Experimental Setup

The scheduling algorithms have been executed and resulted in a simulated environment using a simulator named CloudSim. CloudSim is a java based tool especially for the execution of cloud based application or simulation.

A. *Simulation Description*

CloudSim version 3.0.2 is used to implement Workflow Scheduling in Mobile Cloud Computing. The computer running Window 7 operating system is used for simulation.

We have implemented the "Prioritized Workflow Scheduling" model and compared it with first come first serve scheduling algorithm initially by taking into account the various parameters like waiting time and turnaround time.

B. *Virtual Machine*

A virtual machine (VM) is a software implementation of a machine (i.e., a computer) that executes programs like a physical machine [13]. In our simulation work we have considered 10 virtual machines. Table I describes the configuration of VMs.

TABLE I VIRTUAL M/C CONFIGURATION

Configuration	Value
RAM	512 MB
Image Size	10000 MB
MIPS	1000
PE's	1
Bandwidth	1000
Processor Type	Xen

C. *Cloudlet*

Cloudlet will work as Input job/task to the Cloud Environment. Cloudlet is an extension to the cloudlet. It stores all the information that is encapsulated in the Cloudlet, such as the ID of the VM running it.

V. Results and Analysis

We have done the comparison of waiting time and turnaround time of jobs when executed by applying "prioritized workflow Scheduling" versus the waiting time and turnaround time when using FCFS scheduling algorithm.

Table II shows the comparison of two algorithms based on the waiting time of jobs. Fig. 2 shows a graphical representation of comparison between two algorithms considering waiting time.

TABLE II COMPARISON WITH RESPECT TO WAITING TIME

Sr. No.	Cloudlet ID	Waiting Time Using FCFS	Waiting Time Using Priority Algorithm
1	1	0.6825	0.6528
2	2	0.4207	0.2494
3	3	1.8794	1.2507
4	4	1.4196	0.1076
5	5	0.7725	0.3817
6	500	0.1494	0.4554

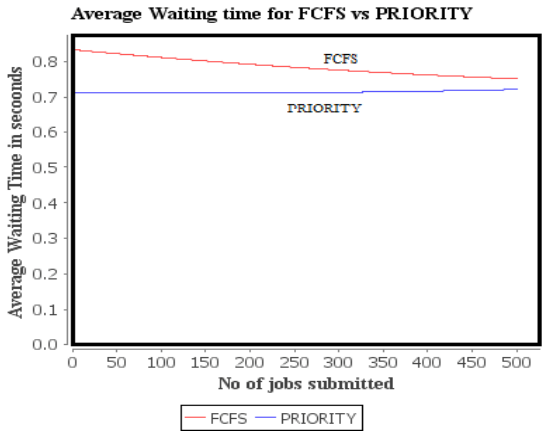

Fig. 2 Comparison of FCFS and Priority Algorithm Based on their Average Waiting Time

Table III shows the comparison of two algorithms based on the turnaround time of jobs. Fig. 3 shows a graphical representation of comparison between two algorithms considering turnaround time.

TABLE III: COMPARISON WITH RESPECT TO TURNAROUND TIME

Sr. No.	Cloudlet ID	Turn-Around Time Using FCFS	Turn-Around Time Using Priority Algorithm
1	1	28.322	13.461
2	2	13.891	13.801
3	3	14.165	13.971
4	4	14.397	14.200
5	5	29.044	13.801
6	500	0.4	0.1

VI. CONCLUSION

Scheduling is one of the most important tasks in mobile cloud computing environment. In this paper, we have analysed two scheduling algorithms i.e., FCFS and PRIORITY algorithm and tabulated various parameters.

From the observed results, it is concluded that:

1. The Prioritized Workflow Scheduling in mobile cloud computing has reduced the waiting time of jobs when compared with simple First Come First Serve algorithm.
2. The turn-around time for the jobs has been reduced in case of Priority Workflow Scheduling Algorithm as compared to FCFS algorithm.
3. The execution time has also been improved using Priority Workflow Scheduling Algorithm. Hence, Prioritized Workflow Scheduling Algorithm proves to be a more efficient Scheduling algorithm for allocating mobile cloud computing resources to the jobs submitted by the users.

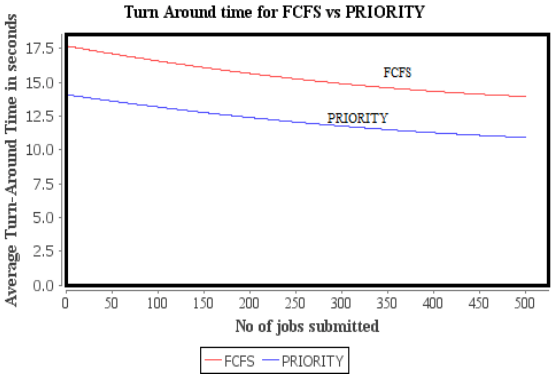

Fig. 3 Comparison of FCFS and Priority Algorithm Based on their Average Turn-Around Time

In virtual environment, we have noticed that disk space management is a critical issue. Despite of giving least execution time and cost effective, the existing scheduling algorithms do not consider reliability and availability issue. In future enhancement will propose a new algorithm considering reliability and availability issue for resource scheduling. The efficiency of the user request first may be optimized the processor and execute the request.

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