Task Scheduling Algorithm in Cloud Computing Environment Based on Cloud Pricing Models

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Abstract—The Cloud Computing is a most widely spreading platform for executing tasks using virtual machines (VMs) as processing elements. Therefore, implementing HPC using Cloud Computing is considered a powerful approach by isolating tasks, reducing execution time, as well as, price, and satisfying load balance.

In this paper, an enhancement task scheduling algorithm on the Cloud Computing environment has been introduced to reduce the make-span, as well as, decrease the price of executing the independent tasks on the cloud resources. The principles of the algorithm is based on calculating the total processing power of the available resources (i.e., VMs) and the total requested processing power by the users' tasks, then allocating a group of users' tasks to each VM based on the ratio of its needed power relative to the total processing power of all VMs. The power of VMs has been defined based on Amazon EC2 and Google pricing models. To evaluate the performance of the enhancement algorithm, a comparative study has been done among this enhancement algorithm, the default FCFS algorithm, and the existed GA, and PSO algorithms. The experimental results show that the enhancement algorithm outperforms other algorithms by reducing make-span and the price of the running tasks.

Keywords-Cloud Computing; Task scheduling; Particle swarm optimization; Genetic Algorithm; Cloud Pricing.

I. INTRODUCTION

Cloud computing has become a great solution for providing a flexible, on-demand, and dynamically scalable computing infrastructure for many applications. Cloud computing also presents a significant technology trends, and it is already obvious that it is rearrange information technology processes and the IT marketplace [1].Cloud computing has emerged as a promising approach to rent IT Infrastructures on a short-term "pay-as-you-go". With Cloud Computing, companies can scale up to massive capacities at any time without the need to pay a new infrastructure, training issues, or license new software. Cloud Computing benefits cover all types of businesses (small or medium) who need to enlarge its resources without paying new servers [2].

On the other hand, the self-provisioning of IT resources is considered one of the main features of the Cloud Computing. The Cloud Computing deployment types are public, private, hybrid, community, and federated, while the Cloud Computing services are categorized as Software as a Service (SaaS), Platform as a Services (PaaS), and Infrastructure as a Services (IaaS) . Therefore, the users can easily choose the suitable cloud services and types which fit their requirements [1, 3].

The main issues to be concerned in the Cloud Computing are the resource management and task scheduling. Therefore, the Cloud providers should provide the services, and deploy virtual machines (VMs), as well as, define the scheduling policies to allocate VMs to the users' tasks [4].

There are two types of task scheduling in Cloud Computing; static task scheduling, dynamic task scheduling, Static scheduling allows for pre-fetching required data and pipelining different stages of task execution. Static scheduling imposes less runtime overhead. In case of dynamic scheduling, information of the job components/task is not known before hand. Thus, the execution time of the task may not be known and the allocation of tasks is done on the fly during running the application [5]. In cloud computing, pricing is the revenue that a service provider will receive from an end user in exchange for their services [8].

In this paper, an enhancement static task scheduling algorithm has been introduced. The main principle of the enhancement algorithm is the same as our previous work in [9]. Both algorithms are based on calculating the total processing power of the available resources (i.e., VMs) and the total requested processing power by the users' requests, then allocating a group of the users' tasks to each VM according to the ratio of its needed power relative to the total processing power of all VMs except that the enhancement algorithm considers the price of the VMs during the allocation based on Amazon EC2 and Google Pricing models [10, 11]. To evaluate the performance of the enhancement algorithm, a comparative study has been done among the enhancement algorithm, the default first-come-first-service (FCFS) algorithm, and the existed GA, and PSO algorithms. The experimental results show that the enhancement algorithm outperforms other algorithms by minimizing the total execution time of the users’ tasks and decreasing the total price of executing all tasks on the existed resources.

The remainder of the paper is organized as follows. In Section II, the related work is illustrated followed by the fundamental of the proposed task scheduling algorithm in Section III. In Section IV, the performance evaluation of the proposed algorithm via Cloudsim simulator and the

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comparative study are discussed. Finally, in Section V, conclude the contributions and point out the future work.

II. RELATED WORK

J.Huang [6] has proposed a workflow task scheduling algorithm based on the genetic algorithms (GA) model in the Cloud Computing environment. The experimental results proved that the efficiency of resource allocation has been satisfies, and in the same time, minimized the completion time. Lei Zhang et al. [7] have proposed a PSO algorithm. This proposed algorithm is similar to the genetic algorithms (GA). The aim of this algorithm is to improves the efficiency of resource allocation and minimize the completion time simultaneously. They have claimed that the PSO algorithm is usually spent shorter time to accomplish the various scheduling tasks and specifies better result comparing to the GA algorithm. Also, they have proved that the PSO algorithm can get better effect for a large scale optimization problem. This scheduling algorithm measures both resource cost and computation performance. Also, it improves the computation/ communication ratio.

May Al-Roomi, et al [8] has proposed Cloud Computing Pricing Models, This work focuses on comparing many employed and proposed pricing models techniques and highlights the pros and cons of each. The comparison is based on many aspects such as fairness, pricing approach, and utilization period.

III. THE PROPOSED ALGORITHM

The proposed algorithm is considered an enhancement and practical implementation of our previous work in [9] which allocate each VM a part of the total requested power according to it is power factor but applying this rules to some case studies (not practical models like Amazon EC2 or Google) . This is because the power of the VMs has been defined based on the Amazon EC2 and Google pricing models. So, the VMs configurations by using the enhancement algorithm is changed. The VMs configuration according to our previous work are shown in Table [1]. It is noticed that the VMs include only one core [9]. The VMs power, as well as, number of cores form each VM according to the Amazon EC2 and Google pricing models are presented in Tables [2] and Table [3] respectively.

Table [1] VMs configurations as in [9].

VM_type	MIPS	CPUs
1	500	1
2	1500	1
3	3000	1
4	4000	1
5	5000	1

According to Table[1], the VMs used is a single core and there is no pricing models used it considered to be case study not practical work.

Table [2] VMs configurations of Amazon EC2 [10]

VM_type	MIPS	CPUs	Total_MIPS
1	500	4	2000
2	1000	7	7000
3	1500	20	30000

Table [3] VMs configurations of Google [11]

VM_type	MIPS	CPUs	Total_MIPS
1	500	2	1000
2	1000	4	4000
3	2000	8	16000
4	4000	16	64000
5	8000	32	256000

According to Tables [2] [3], MIPS is the million instruction per second of each core of the VM, CPUs is the number of cores in each VM, and the Total_MIPS is the total power of the cores in each VM.

The main idea of the enhancement algorithm is that allocating the available VMs to the requested tasks according to the following steps:-

[1] Calculate the processing power of each VMi (i.e., VMi_ Total_MIPS) using equation (1)

$$\textbf{Total\_MIPS=CPUs*MIPS}\ldots \textbf{(1)}$$

CPUs as mentioned above is the number of cores, MIPS is the million instruction per second of the single core of the VM.

[2] Calculate the total available processing power of all available VMs which equal the sum of all VMs (VMs_MIPS) using equation(2).

$$\sum \textbf{VMi\_MIPS (of VMs)}\ldots\ldots\textbf{(2)}$$

[3] Calculate the total requested processing power by the users' tasks (TASKS_MIPS) using equation(3).

$$\sum \textbf{Taski\_MIPS (of tasks)}\ldots\textbf{(3)}$$

[4] Calculate the power factor (PF) of each available resource (VMi) using equation (4).

$$\textbf{PF of VMi} = \frac{\textbf{VMi\_MIPS}}{\textbf{VMs\_MIPS}}\ldots\ldots\ldots (4)$$

[5] Calculate the quota of each existed resource (VMi) from all the requested power using equation (5).

$$\textbf{VM}_\textbf{i} \textbf{ allotment = PF *(TASKS\_MIPS))} \ldots (5).$$

[6] Search the requested tasks to find a task or a group of tasks which need processing power equal to or less than the quota of the VMi as calculated in step (4) by considering that the different between the selected tasks processing power and VM quota to be minimum.

[7] Allocate the task or a group of tasks to each VM.

[8] Calculate the execution time of each task on each VM by using equation (6).

$$\text{Task(j)\_execution\_time} = \frac{\text{task(j)\_MIPS}}{\text{VM(i)\_MIPS}} \ldots\ldots (6).$$

[9] Calculate the price of each task by using equation (7) [14].

Cloudlet(j)_price=VM(i)_price* Task(j)_execution_time (7).

VM (j) _price can be deduced from Table [4] or Table [5] based on Amazon EC2 and Google pricing models respectively [10, 11].

Table [4] Amazon EC2 instance types and price [10]

Instance Type	VM_type1	VM_type2	VM_type3
CPUs	4	7	20
Price($/hour)	0.34	0.5	.64

Table [5] Google Cloud instance types and price [11]

Machine type	CPUs	Price($/HOUR)
n1-highmem-2	2	$0.126
n1-highmem-4	4	$0.252
n1-highmem-8	8	$0.504
n1-highmem-16	16	$1.008
n1-highmem-32	32	$2.016

According to Tables [4] [5], CPUs is the number of cores in each VM, and price($/HOUR) is the cost of using the VM per HOUR.

The pseudo code of the enhancement algorithm is as follows:

```
Input:
        Number n of cloudlets (i.e., tasks).
        Number m of VMs (i.e., resources).
Output:
        Mapping Scheme for the requested tasks (cloudlets) on the available resources (VMs).

// calculate the total processing power of cloudlets

1 for i=1 to n do

2     Define MIPS of the cloudlet
3 end for
// calculate the total processing power of VMs.
4 for i=1 to m do
5     Define MIPS of the VMs
// calculate the power factor of each VM, and the allotment of each VM
6 for i=1 to m do
7      PF of VMi = processing power of VMi / total processing power of all VMS
8      VMi allotment =PF *(total requested processing power (TASKS_MIPs).
9     find the sum of set (VMi allotment).
10 end for
11     Select a set of cloudlets with the sum of their MIPS equal to/or less VMi allotment.
12     return the set.
13 Calculate the execution time of each cloudlet by using equation (3).

14 Calculate the price of each cloudlet by using equation (4).
```

IV. PERFORMANCE EVALUATION

To evaluate the performance of the enhancement algorithm, a comparative study has been done among the proposed algorithm the GA, the PSO, and First-Come-First-Serve (FCFS) algorithms by considering the Make-span.

A. Experimental Environment

The proposed task scheduling algorithm has been written by java programming language using eclipse program in Intel(R) Core(TM) 2 Duo CPU in 2.10 GHZ of processor and 4.00 GB of RAM, through the CloudSim simulator. On the other hands, CloudSim is an extensible simulation toolkit that enables modeling and simulation of Cloud Computing systems and application provisioning environments. The CloudSim toolkit supports the Clouds components such as data centers, virtual machines (VMs), and resource provisioning policies. On the other hand, the Cloudsim could implement generic application provisioning techniques that can be extended easily with limited efforts [12].
According to the implementation using Cloudsim, the VMs are considered the cloud resources and Cloudlets as tasks/jobs. The make-span of different algorithms have been measured by considering varying the cloudlets while VMs are fixed, as well as, varying VMs.
Cloudlets were generated from a standard formatted workload of a High performance computing center called HPC2N in Sweden as a benchmark. According to this benchmark, Each row in the workload represents a cloudlet where the first column is the id of the cloudlet, the length of the cloudlet from the fourth column (the runtime value multiplied by the rating which is defined as 1 MI in CloudSim), and finally the number of the requested processing elements from the eighth column [13].
The calculation of the price has been conducted using price models of Amazon EC2, and Google Clouds [10, 11].

B. *Experimental Results*

The experimental results are divided into parts; make-span, price of execution.

- Make-span

Using EC2 Price Model [10]:

The experimental results of the enhancement algorithm, PSO, GA, and FCFS algorithms are presented in Figs 1, 2, and 3, using different VMs, as well as, different cloudlets (jobs/tasks). According to the experimental results in Fig 1 with considering 5 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total execution time (i.e., make-span) by 92.59%, 24.39%, and 17.33 % respectively. The overall performance of the proposed algorithm (i.e., average improvement) is 44.77 % relative to the PSO, GA, and FCFS algorithms.

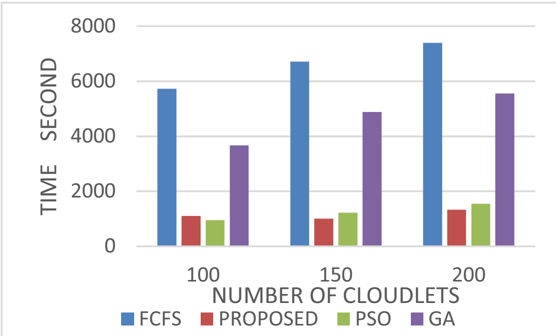

Fig 1: Make-span by considering 5 VMs (EC2)

According to the experimental results in Fig 2 with considering 8 VMs, it is found that the performance of the v algorithm outperforms PSO, GA, and FCFS algorithms by 55 %, 30.11 %, and 28.51 % respectively. The overall performance of the v algorithm performance is 37.87% relative to the PSO, GA, and FCFS algorithms.

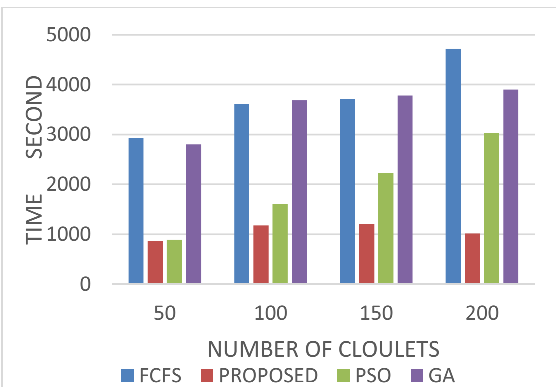

Fig 2: Make-span by considering 8 VMs (EC2)

By considering 10 VMs, the experimental results in Fig 3 proved that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms by 46.62%, 24.3%, and 28% respectively. The overall performance of the v algorithm performance is 39 % relative to the PSO, GA, and FCFS algorithms.

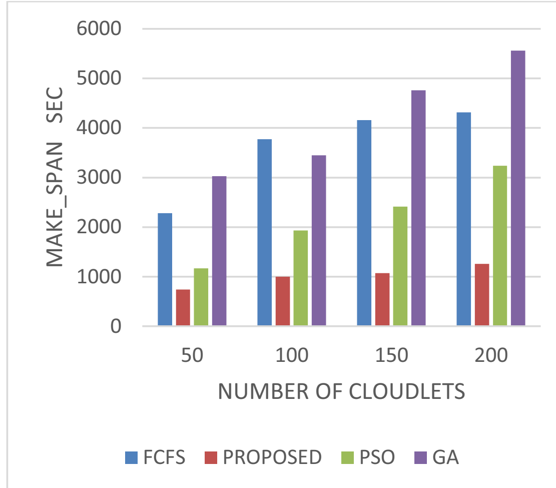

Fig 3: Make-span by considering 10 VMs (EC2)

Using Google Price Model [11]:

According to the experimental results in Fig 4 with considering 5 VMs, it is found that the performance of the proposed algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total execution time (i.e., makespan) by 38.51 %, 2.68 %, and 1.32 % respectively. The overall performance of the proposed algorithm (i.e., average improvement) is 14.17 % relative to the PSO, GA, and FCFS algorithms.

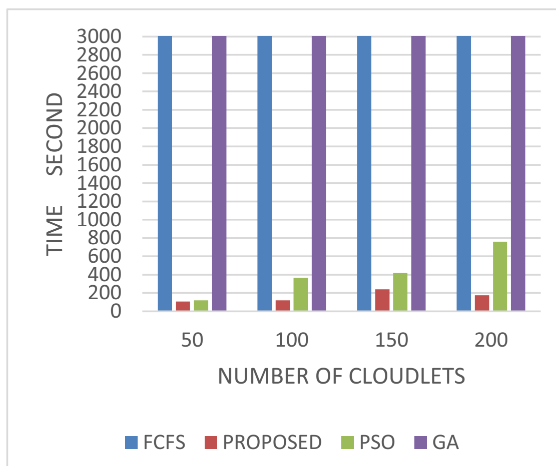

Fig 4: Make-span by considering 5 VMs (Google)

According to the experimental results in Fig 5 with considering 8 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total execution time (i.e., make-span) by 29.33 %, 9.21 %, and 9.82 % respectively. The overall performance of the enhancement algorithm (i.e., average improvement) is 16.12 % relative to the PSO, GA, and FCFS algorithms.

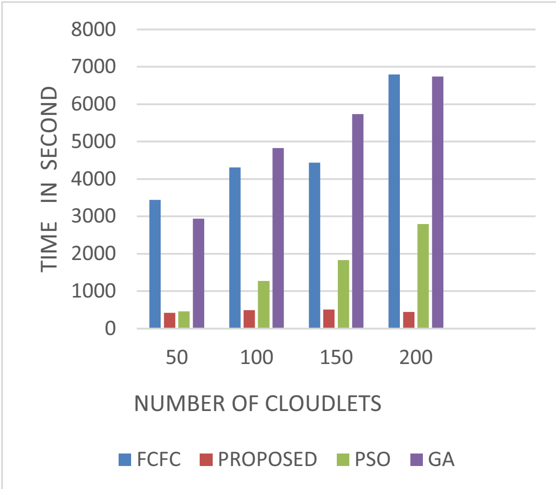

Fig 5: Make-span by considering 8 VMs (Google)

According to the experimental results in Fig 6 with considering 10 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total execution time (i.e., makespan) by 7.6 %, 3.68 %, and 2.21 % respectively. The overall performance of the enhancement algorithm (i.e., average improvement) is 4.49 % relative to the PSO, GA, and FCFS algorithms.

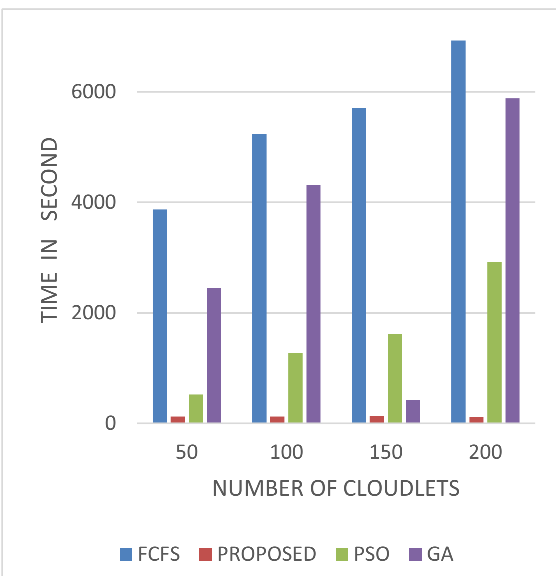

Fig 6: Make-span by considering 10 VMs (Google)

Generally, by calculating the average make_span of the proposed algorithm, PSO, GA, and FCFS algorithms, it is found that the proposed algorithm outperforms PSO, GA, and FCFS by 47.94 %, 15.72 %, and 14.53 % respectively. And the overall make_span of the proposed algorithm is 26.06 % relative to PSO, GA, and FCFS algorithms.

- EXECUTION PRICE

Using EC2 Price Model [10]:

The price of executing a cloudlet on a VM is calculated using equation (5).

According to the used VM_type to run a cloudlet and the running time of this cloudlet, the price of this cloudlet can be calculated.

According to the experimental results in Fig 7 with considering 5 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total price($/hour) by 115.3%, 75.64%, and 69 % respectively. The overall performance of the enhancement algorithm (i.e., average improvement) is 86.65 % relative to the PSO, GA, and FCFS algorithms.

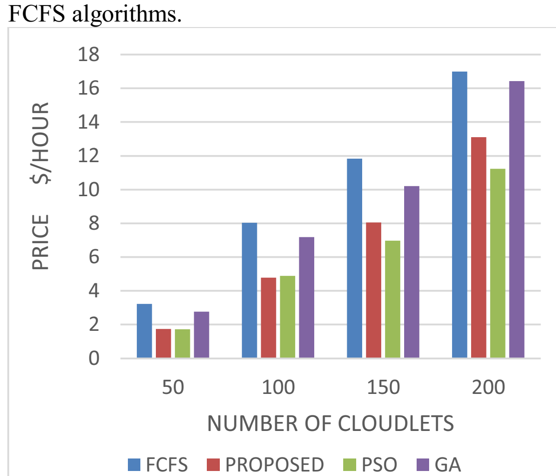

Fig 7: price by considering 5 VMs (EC2)

According to the experimental results in Fig 8 with considering 8 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total price($/hour) by 56.9%, 61.91%, and 65.71 % respectively. The overall performance of the enhancement algorithm (i.e., average improvement) is 61.5% relative to the PSO, GA, and FCFS algorithms.

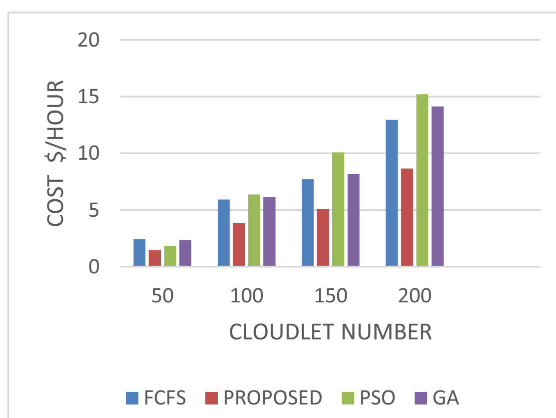

Fig 8: price by considering 8 VMs (EC2)

According to the experimental results in Fig 9 with considering 10 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total price($/hour) by 56%, 61.15%, and 57.41 % respectively. The overall performance of the enhancement algorithm (i.e., average improvement) is 58.18 % relative to the PSO, GA, and FCFS algorithms.

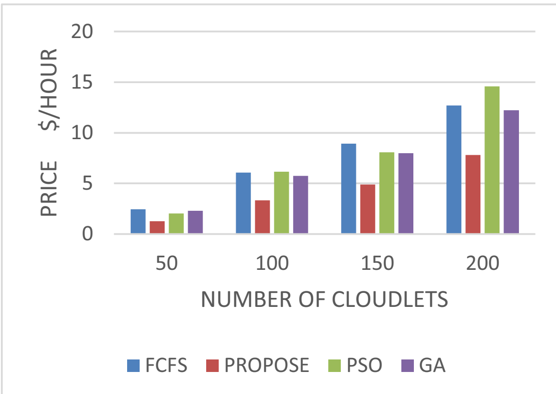

Fig 9: price by considering 10 VMs (EC2)

Using Google Price Model [11]:

According to the experimental results in Fig 10 with considering 5 VMs, it is found that the performance of the proposed algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total price($/hour) by 116.85 %, 68.14 %, and 48.44 % respectively. The overall performance of the proposed algorithm (i.e., average improvement) is 77.81 % relative to the PSO, GA, and FCFS algorithms.

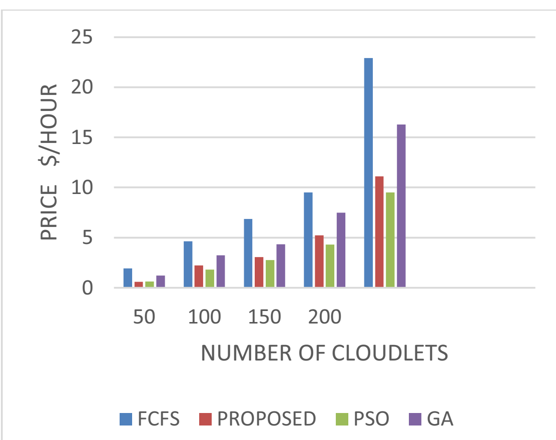

Fig 10: price by considering 5 VMs (Google)

According to the experimental results in Fig 11 with considering 8 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total price($/hour) by 66.15 %, 78.89 %, and 81.25 % respectively. The overall performance of the enhancement algorithm (i.e., average improvement) is 75.43 % relative to the PSO, GA, and FCFS algorithms.

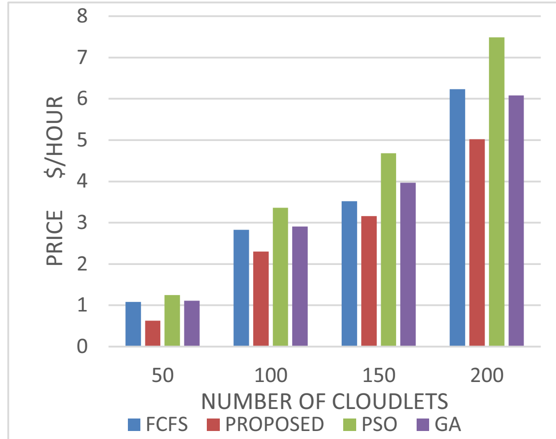

Fig 11: price by considering 8 VMs (Google)

According to the experimental results in Fig 12 with considering 10 VMs, it is found that the performance of the enhancement algorithm outperforms PSO, GA, and FCFS algorithms with respect to the total price ($/hour) by 35.85 %, 54.38 %, and 46.61 % respectively. The overall performance of the enhancement algorithm (i.e., average improvement) is 45.61 % relative to the PSO, GA, and FCFS algorithms.

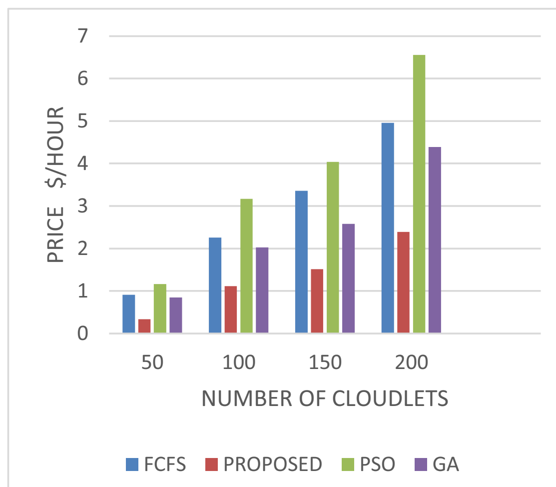

Fig 12: price by considering 10 VMs (Google)

Generally, by calculating the average price of the proposed algorithm , PSO, GA, and FCFS algorithms, it is found that the proposed algorithm outperforms PSO, GA, and FCFS by 74.5 %, 66.68 %, and 61.4 % respectively. And the overall price of the proposed algorithm is 67.52 % relative to PSO, GA, and FCFS algorithms.

V. CONCLUSION AND FUTURE WORK

Task scheduling is one of the main issues in the Cloud Computing. Efficient task scheduling is essential for saving the time and decrease the cost. In this paper, an enhancement task scheduling algorithm has been proposed for the Cloud Computing environment. The main idea of the enhancement algorithm is that allocating the available VMs to the requested tasks by considering the processing power of VMs and tasks. To evaluate the performance of the enhancement algorithm, a comparative study has been done among the enhancement algorithm, PSO, GA, and FCFS algorithms with respect to the execution time (i.e., make-span), and the price of execution using Amazon EC2, and Google pricing models. The experimental results prove the efficiency of the enhancement algorithm by minimizing make-span by 26.06 % ,in addition, decreasing the price by 67.52 %. The proper commentary to this results is that allocating each resource using the ratio of the requested processing power. This ratio is equal to the ratio of each VM power to the total power of all resources. So, the fairness has been satisfied at all levels. The enhancement task scheduling algorithm could be further extended by considering dependent tasks, and also considering dynamic workflow scheduling.

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