# ESCC-RPE: EFFECTIVE SCHEDULING IN CLOUD COMPUTING TO REDUCE PRICE AND ENERGY

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***Abstract***
Cloud computing permits users to request on demand fundamentally unrestricted quantity of computing power. But the computing power is billed as pay per use basis based on the use of computing units called Virtual Machines (VMs). Many real time applications like drug discovery, protein folding, data analysis, climate modelling and energy research etc need more computational power in cloud. Hence these applications ingest huge volume of energy which will result in more price. So in this work, an effective scheduling algorithm that takes into account both energy and price are considered called PPS(Price-proficient Scheduling Algorithm).This algorithm is proficiently implemented to allocate VMs to all the tasks involved in solving large complex applications. CloudSim Toolkit framework is used for this proposed work and it is justified that the demonstrated results provide substantial decrease in financial price and energy during execution of complex as well as simple tasks.

**KEYWORDS**: Effective scheduling, Cloud Computing, Energy efficiency, Price reduction, Virtualization.

## 1. Introduction

Cloud Computing are extensively installed for implementing computationally rigorous parallel applications through proper data centres used worldwide. The miscellaneous complex application's computing needs are satisfied by operative scheduling strategies which takes into account certain eligible factors like price and power of the resources, execution time (makespan) etc. The cloud nodes when coming to satisfying customer requirements and to deliver the end user with more satisfaction, deliver an environment with effective scheduling strategies to attain better mapping of tasks to processors.

Huge number of applications can be solved in cloud environment using hybrid technologies that is by combining many new technologies such as quantum computing etc. Many kinds of industries are getting benefitted from cloud computing such as manufacturing industry, education industry, finance industry, automotive industry as well as healthcare industry. For the implementation of telemedicine, cloud storage with scheduling places a share of attention on client safety, security, and privacy.

In task scheduling, complex tasks are considered to be the collection of a group of sub-tasks which have data dependence relationship among them. But for scheduling to be achieved in a well versed manner accomplishment of a child task will not begin till all its parents complete their implementation and created their yield. Certainly, the outputs are mandatory from the child task so that it can be used as inputs for its further working. These executions in cloud setup need both algorithms support that is proficient algorithms needed to be implemented for scheduling in addition to architectural characteristics of cloud setup to attain a good mapping of tasks with processors. Geetha et al [1] considered that the inappropriate usage of resources present in the cloud show mode for ineffectiveness with environmental hazard.

### *1.1 Cloud Computing*

To make cloud computing, a more reliable, flexible as well as usable technology, many blended technologies are used along with virtualization. This is a variation of distributed computing to supply on-demand system access of data centers to a common group considering configurable computational assets which can endure supplying and releasing of resources with insignificant organization power.

### *1.2 Architecture behind Cloud*

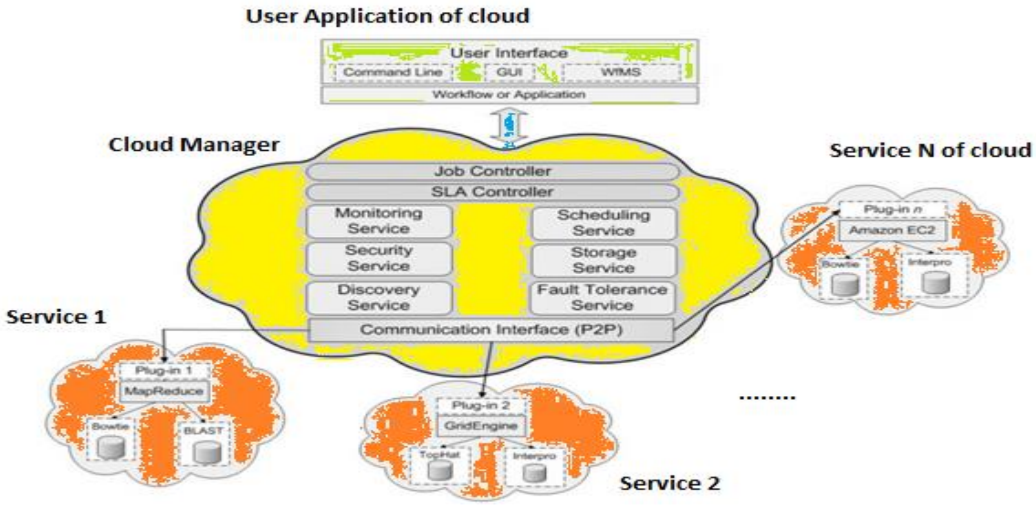


**Figure** 1. Architecture behind Cloud

The Cloud architecture encompasses several cloud modules, which are loosely coupled. There are two broad classifications in architecture parts as shown in figure 1. Here the back end is cloud itself and it is assumed as cloud manager here. The main job of cloud manager is to provide the computing services by supplying the resources efficiently to all cloud service providers. In addition to that the front end is the client part of the system. It has applications as well as interfaces to access the cloud platforms**.** Service modules mentioned in architecture diagram contain modules for using and assigning unusual assets inside the bounds of cloud to satisfy the needs of the cloud application.

### *1.3 Cloud Scheduling*

Scheduling is the distribution of numerous works to the assumed resource in a particular period of time. The scheduler achieves the job of allotting diverse kinds of resources with respect to the constrictions specified by the jobs along with service provider of cloud. Operative scheduling techniques are essential for active enactment in cloud datacenters. The scheduler is particularly used to distribute system resources effectually to accomplish a target quality of service. The allocation by scheduler is concerned with response time, throughput, latency and fairness. The restrictions can remain for deadline stipulated for the given task, the given budget number of users as well as extreme resource utilization of resources from the service providers. So strategize the limits of algorithm used for scheduling formerly while designing the algorithm for the cloud datacenter.

The entire work here is separated into five segments. Segment 1 is the section describing introduction, In Section 2, literature discussed survey is deliberated. Mathematical model formulation is dealt in section 3 along with cloud setup model and then scheduling algorithm using price and power reduction is discussed in section 4 and 5 respectively. Setup of the experiment with evaluation of work involved is deliberated in Segment 6. In final segment, the conclusion part is described.

## 2. Literature Survey

Most of the previous works had concentrated in reducing makespan, price as well as energy consumption individually. But in our work, scheduling is implemented along with the consideration of energy and price. The amount of cloud users remain growing day by day according to current survey about 94 % of users directly use cloud services. Total numbers of cloud users will extent to top and hence it is great time to improve real with efficient scheduling procedures to rise the business values.

Cloud application execution is observed as the implementing numerous tasks enclosed in that program. Cloud tasks can be characterized by a DAG as recommendation shown by Rajak et al [2]. Various categories of task scheduling algorithms are there that were proposed by Nayak et al. [3] , Sarkhel et al. [4] with Arunarani et al. [5]. Round Robin scheduling as well as multilevel scheduling are the common types of cloud scheduling.

Workflow scheduling in cloud is yet another type of scheduling similar to the scheduling in grid as proposed by Aziza & Krichen [6] that improve the makespan desirable to run a group of codependent jobs in cloud so that it decreases the cost of computation although budget constraints with deadline are met. They dealt with a hybrid approach created using optimization algorithm aimed at modelling in cloud. However many previous works and algorithms proposed in scheduling [7] are mainly concentrated on the minimization of make span [8] only. Only few previous works had concentrated on minimizing energy consumption. But this work considers both price and energy while scheduling the tasks to VMs.

In the DVFS-Dynamic Voltage Frequency Scaling Technique [9] used for effective energy consumption highly dependent on the used hardware and it cannot be controlled for the cloud users fluctuating needs. Yang et al. [10] used VM Migration or Resource allocation technique where the requests of users can be relocated permitting to variable requirements and obtainable resources.

Baraglia et al [11] proposed some of the energy efficient techniques such as server consolidation, workload consolidation and the same was also suggested by Homsi, et al.[12]. Using this technique, effectual procedure of computer resources is achieved to decrease overall quantity of servers which an organization necessitates. Increased energy costs along with the increased usage of cloud needs to reduce carbon emissions and therefore the energy efficient technologies [13] are to be developed to sustain cloud datacenters. Therefore this work considers the implementation of scheduling along with energy and cost [14] .

## 3. Formulation of Mathematical Model

### *3.1 Mathematical Model*

Let Graph = (X, Y) remain a directed acyclic graph, whereas X represents group of total tasks implemented, Y characterizes group containing edges signifying preference restrictions among cloud tasks. Let us take that Graph has an entry task, $X_{entry}$ in addition an exit task $X_{exit}$. The lengthiest path of the graph DAG is known as critical path (CriPa). The load of a node $x_i$, denoted by $dtx_i$ signifies the computation load for task $x_i$. The Cloud setup environment comprises of a group of v entirely linked mixed virtual machines, represented by V. Assume $ca_{vj}$ mean the CPU cycles distributed to VM $v_j$. Every task can be implemented on a varied virtual machine, and so denoted by $t(x_i,v_j)$ the makespan of the task $x_i$ executed on a virtual machine $v_j$.

$$t\left(x_i,v_j\right)=\frac{dt_{x_i}}{ca_{v_j}} \quad (1)$$

Then calculation of time used for execution and its average of a task $x_i$ is

$$ET_{x_i}=\sum_{j=1}^{v}\frac{t\left(x_i,v_j\right)}{v} \quad (2)$$

The priority of task $x_i$ is figured by navigating the DAG rising, opening since the exit task, and is well-defined by,

$$\Pr io_{x_i}=T_{x_i}+\max_{x_k\in succ(x_i)}(Pt_{x_i,vx}+\Pr io_{x_k}) \quad (3)$$

### *3.2 Cloud Setup model*

Different brands in service delivery models are already available in Cloud. All categories of virtual machines uses various processing capacity for diverse kinds of tasks. Cloud providers used different metrics aimed at calculating the price. This work follows a model practiced for pricing grounded on the real sharing out of virtual machines cycles of CPU.

Assume that $CPU_{slow}$ signify cycles for CPU for the slowest machine $v_{slow}$. If $Cp_{base}$ is the base price charged to $v_{slow}$, The price earned to perform task $x_i$ on virtual machine $_{vj}$ can be designed as,

$$p\left(x_i,v_j\right)=\theta\times t\left(x_i,v_j\right)\times Cp_{base}\times\frac{CPUslow_{v_j}}{CPU_{v_{slow}}} \quad (4)$$

$\theta$ is a arbitrary variable that is used to produce dissimilar mixtures of virtual machine capacity and cost combinations.

Price for total computation can be estimated by

$$P=\sum_{j\in sel}p\left(x_i,v_j\right) \quad (5)$$

*3.3 Model for Energy Calculation*

Cloud nodes are consuming energy consumption which can be defined using memory, CPU, network interfaces with the help of disk storage. Within the needed things, main part of energy is taken by CPU and henceforth the primary need of the hour considered can be on handling consumption of power as proposed by Juarez (2018). Furthermore utilization of CPU is usually relative to the total system load.

$$p\left(x_i, v_j\right) = \theta\left(x_i, v_j\right) \times t\left(x_i, v_j\right) \times z \quad (6)$$

Whenever there is a need to calculate energy with respect to power, it can be recalculated as an integral of the power (Mohammadhosseini et al. [15]) consumption function.

$$E = \int_{t_o}^{t_1} P(z(t))dt \quad (7)$$

## 4. Price- Proficient Scheduling Algorithm

In order to minimize the energy, makespan and price [16] ,objective function is defined for each virtual machine node $VM_i$ ε M.

Minimalize: A × ET(x,y)+B×P(x,y)+C×E(x,y) (8)
for every $VM_i$ ε M.

$$ET(x,y) = \frac{et(x_i, v_j) - et_{\min}}{et_{\max} - et_{\min}} \quad (9) \qquad E(x,y) = \frac{e(x_i, v_j) - e_{\min}}{e_{\max} - e_{\min}} \quad (11)$$

$$P(x,y) = \frac{p(x_i, v_j) - p_{\min}}{p_{\max} - p_{\min}} \quad (10) \qquad A + B + C = 1 \quad (12)$$

$et_{min}$ ($et_{max}$),$P_{min}$($P_{max}$),$e_{min}$($e_{max}$) can be the smallest (extreme) makespan time, price, energy consumption measured for each job in a setting up strategy.

**Algorithm 1: Price - Proficient Scheduling Algorithm (PPS Algorithm)**

Input: CreateDAG(N, E); created DAG task graph
M: the set(dynamic set or static) of Virtual Machines
1. Calculate priority on behalf of all nodes $VM_i$ ε M via passing through graph rising
2. Category $vm_i$ in reducing order by its significance (priority) value;
3. **for** every $v_i$ € VM **do**
4. **for** every $vm_i$ € v **do**
5. Calculate P(r,s) by means of PRS Algorithm
6. Calculate A × ET(x,y)+B×P(x,y)+C×E(x,y)
7. **end**
8. **end**
9. **for** each task in ready queue **do**
10. Assign task $v_i$ to the VM $m_j$ that minimizes the objective function of task $v_i$
11. **end**

## 5. Power Reduction Implemented Scheduling Algorithm

To offer reduction in consumption of power, this algorithm categorizes all virtual machines in reducing order of their current CPU consumptions to assign every VM to a host. Actually PPS algorithm used for scheduling considers both cost and energy while executing the tasks along with execution time. PPS algorithm incorporates PRS Algorithm for implementing energy consumption. Power-aware scheduling allocates all cloud components to complex applications that reduces power consumption under the conditions detailed in SLAs (Service Level agreements).It allocates the VMs to hosts with does not produce any increase in the energy.

Algorithm 2: Power Reduction Implemented Scheduling Algorithm(PRS)

**Input**: Total amount of Host (AmountHost),Total amount of VM (AmountVMs)

**Output**: Apportionment of Virtual Machines

1. TotalVMs.arrangeReducingUtilization ().
2. **for** every virtualmachine in TotalVMs **do**
3. minPower← LARGE
4. allocatedHost ← EMPTY
5. **for** every hostNo in AmountHost **do**
6. **if** any host with sufficient resources for Virtual Machine **then**

7 Energy←estimatePower (host,virtual machine).
8 if Energy < manpower then
9 allocatedHost ←hostNo
10.if allocatedHost ≠NULL
11.Allocate VirtualMachine to allocatedHost
12.End

## 6. Experimental Results and Evaluation

### *6.1 Algorithm Evaluation*

Most of the scheduling algorithms are intended to reduce the makespan. But hybrid scheduling considers two factors for scheduling that is, both execution time and price. But PPS algorithm extends hybrid scheduling by considering certain extra factors. Hybrid scheduling only considers about price but PPS scheduling consider both price and energy while executing the tasks along with execution time. From the experiments it is clear that PPS can reduce total energy consumption than Hybrid scheduling without much increase in total price.

### *6.2. Implementation Setup and CloudSim Usage*

The cloud setup is done in CloudSim [17] with the help of netbeans. Cloud computing services and implementation's simulation and modeling is done by this CloudSim toolkit framework. This module creates cloud users with the needed datacenters as well as cloud virtual machines as per our requirement. The detailed environment setup beside execution of the proposed algorithm and the working of it in CloudSim framework is shown here.

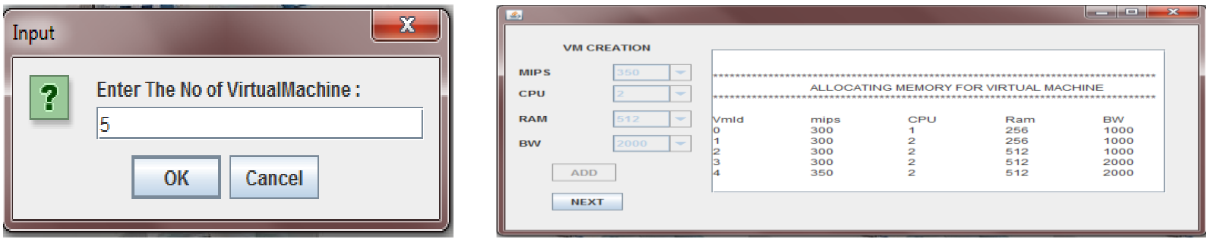


**Figure 2.**Creation of VM

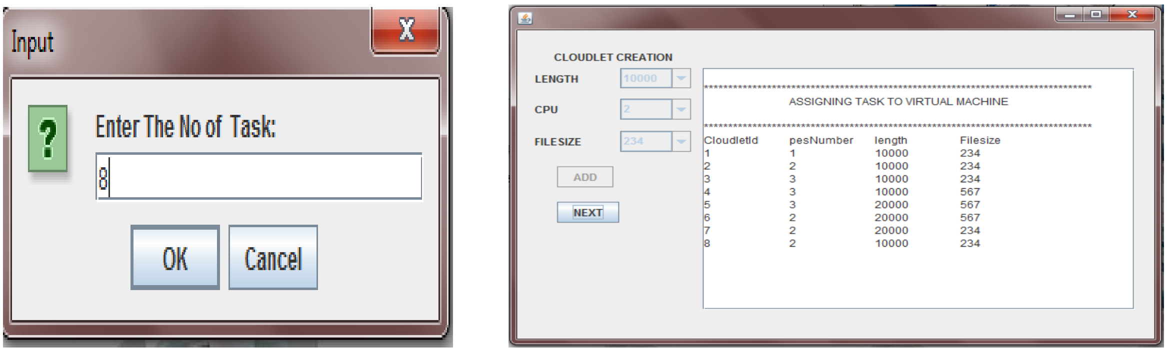


**Figure 3.**Cloudlet Creation

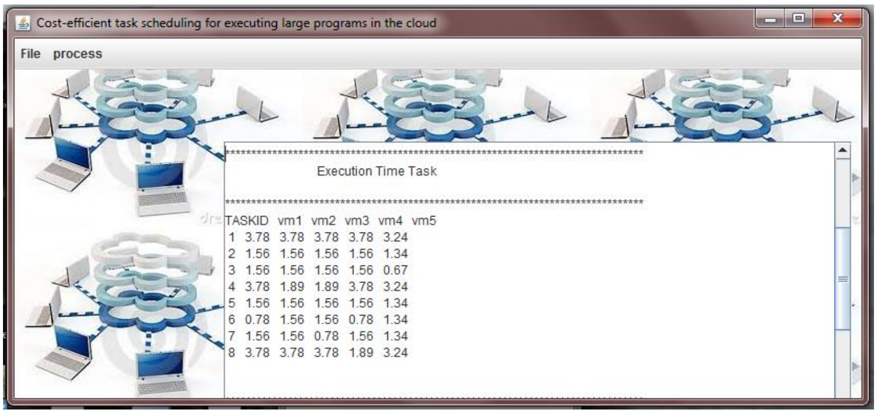


**Figure 4** Execution time of each task for each VM

After completing the cloud setup, Average execution time and communication time for each task is calculated in order to find priority of each task [drawn in figure 2 is implemented using equation (3)].

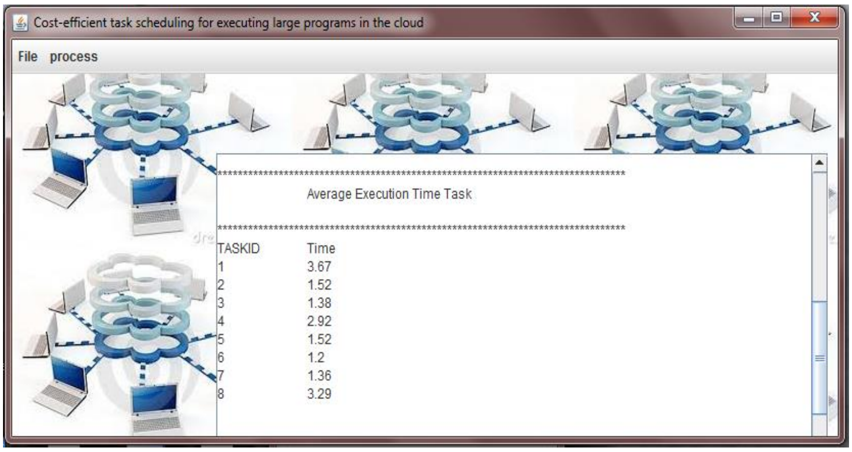


**Figure 5.** Average execution time of each task

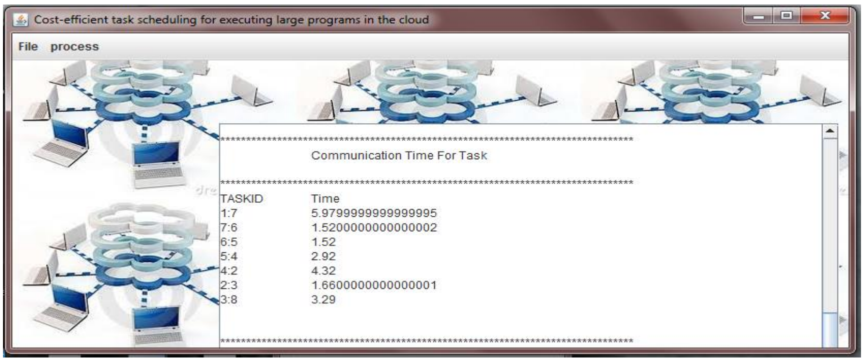


**Figure 6.** Calculating communication time for tasks

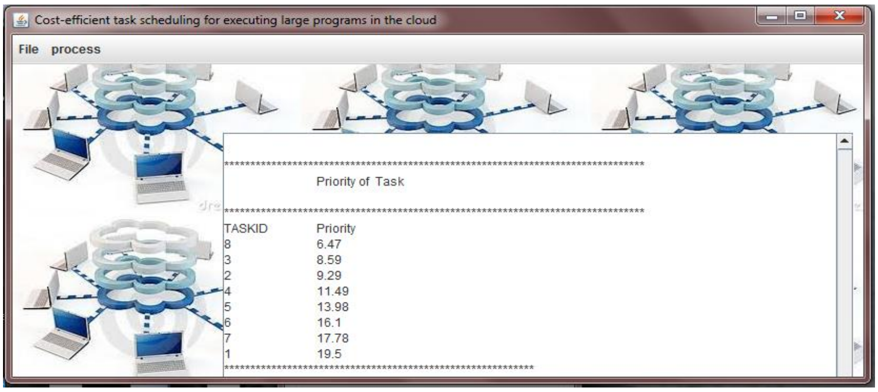


**Figure 7.**Priority Calculation

Task with highest priority is assigned to price efficient VM. After finding the priorities of each task, calculate the value of the objective function for each task and each VM using equation (8).The cloud resource model is presented in figure 8.

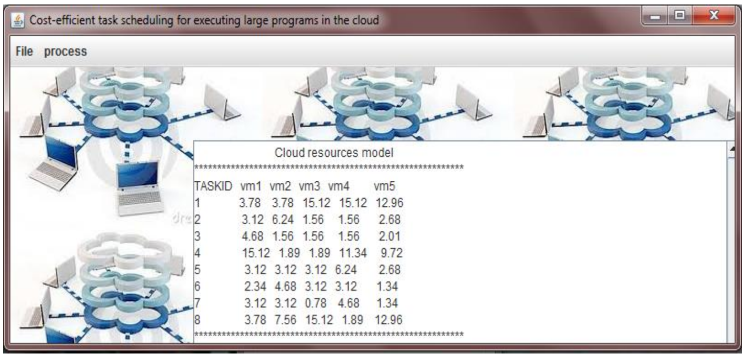


**Figure 8.**Cloud resource model (Price for executing each task in VM)

The Price efficient and Energy effective scheduling(PPS) is shown in Fig 8.It allocates the task to VM that has lower value for the objective function. After that, it reschedules the VM to host according to the CPU utilization of each VM.

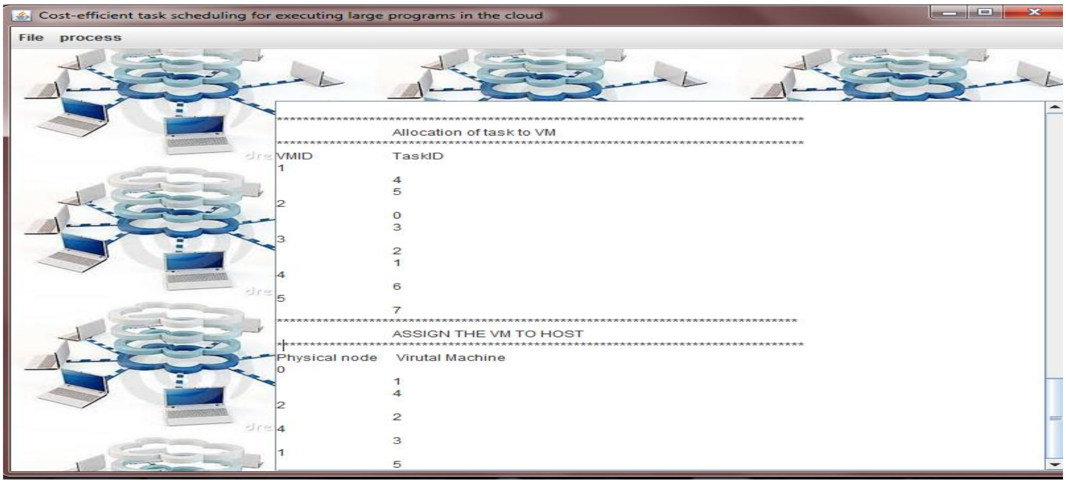


**Figure 9.**PPS (Price efficient & Energy effective scheduling)

The main metrics measured here is total price and energy. While evaluating the performance, price and energy are calculated and compared with Hybrid scheduling. With the help of CloudSim, the improvement significance of PPS algorithm is equated with hybrid scheduling. In a fully connected CloudSim setup framework, 5 different hosts with twelve similar or dissimilar virtual machines. The slowest virtual machine base price is taken as 0.5 dollars/VM.

Hybrid scheduling as well as PPS scheduling are implemented using 10 different tasks. Total price and energy is calculated for both scheduling plans and compared. Energy, price and makespan are considered as vital factors to examine the proposed scheduling algorithm. So these different factors for PPS and Hybrid scheduling plans are compared in figure 10. Three comparison metrics are used to examine this scheduling: makespan, price, energy. Makespan is the total execution time requisite for execution of cloud tasks. Price is defined to be the total monetary price, Energy [18] is the total power consumption of VMs. The total monetary price for the PPS and Hybrid scheduling plans are compared in figure 10.This graph contains no. of VMs on x axis and price on y axis. Price is calculated in dollars. It is clear that the proposed scheduling achieves lower price than the Hybrid scheduling in almost all the cases.

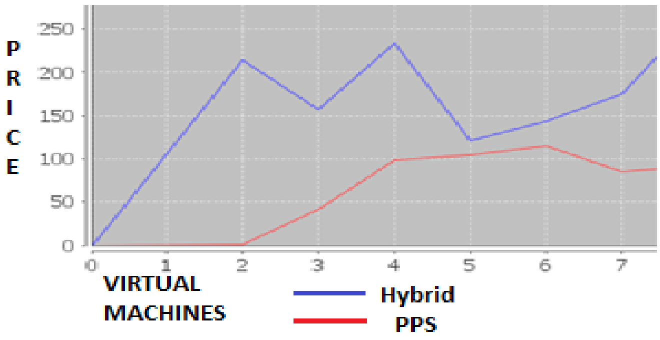


**Figure 10.**Calculation of Price

The figure 11 represents second scheme of scheduling that reflects the energy consumption of each VM. Here no. of machines is represented in x-axis with energy represented in y-axis in WH (Waat hour). Red line represents PPS scheduling and Blue line represents Hybrid scheduling. Lower energy is achieved in almost all the cases in the proposed scheduling algorithm.

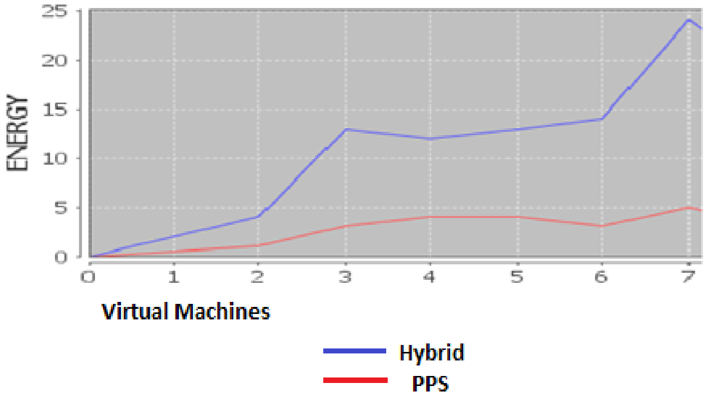


**Figure 11.**Calculation of Energy

Results illustrate that when this algorithm is applied, it reduces the response time of VMs which is clearly a characteristic requiring consideration in cloud computing.

## 7. Conclusion and Future Work

With the intention of satisfying dissimilar requirements of users using cloud an effective as well as proficient algorithm for scheduling in cloud environment is recommended to lessen cloud user price and energy. The demonstrated scheduling algorithm for price and power reduction also reduces the makespan which benefit the users of cloud in various ways. The scheduling algorithm explores the fact that the simulator considered here works well to decrease all the three factors. In future, it is intended to progress this algorithm by bearing in mind further QOS factors also. The future work will develop a framework which will implement self-management policies along with QOS requirements in near futur

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