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A Survey on Virtual Machine Scheduling Algorithms in Cloud Computing

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***Abstract*—** In present scenario cloud computing is not a new term for scientist, engineers and researchers. It is used by people from varied walks of life ranging from organizations to mobile users. This technology allows many organization and individual users to take services, hardware, storage spaces and software on rent rather than setting up new infrastructure. With advancement in technology, cloud computing faces several challenges like power consumption, reliability, performance, bandwidth cost, security and privacy which needs to be addressed by researchers. This paper presents an overview of cloud computing technology and comparative analysis of virtual machine (VM) scheduling algorithms. VM scheduling algorithms are compared on basis on several parameters such as reliability, scalability, QoS, and environment. The comparison is further fine-tuned with quantified data.

***Keywords*—** *Cloud, Virtual Machine, Scheduling, Quality of Service, Energy, Cost.*

I. INTRODUCTION

Cloud computing has made a significant benchmark in the software industry. The use of virtualization technology together with advancement of internet technology has led to unprecedented growth in cloud computing. The customization in cloud allow the user to use the cloud resources as per their requirements. "Cloud computing is a computing model in which resources are distributed and shared among the users based on pay per view model through that Internet and Virtualization technology led to the rapid development of cloud technology. Its rapid growth will lead to the new trends in cloud like mobile cloud, heterogeneous clouds and green clouds [1].

Cloud models can be categorized in two ways based on their architecture and environment as shown in Fig. 1. The architectural model is a business service model in which hardware, platform level service and various applications are accessed by the users as a service. The environment model based defines the type of cloud model used by cloud vendors to create their data center.

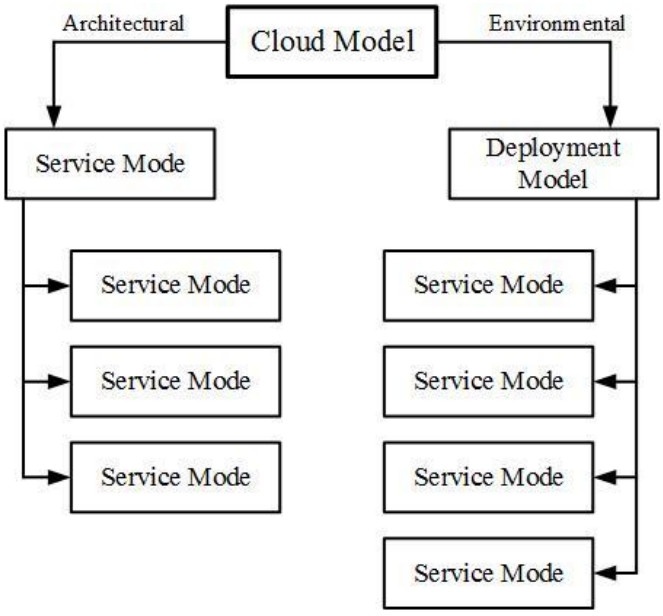

Fig. 1. Classification of Cloud Models

A. *Service Model*

The cloud service models divides the three different layers of the cloud which specify vendor products and services [2] [3]. It consists of various layers of cloud that contains

hardware infrastructure, system software, and different frameworks for development and applications. The various service models which are used in cloud infrastructure are depicted in Fig. 2.

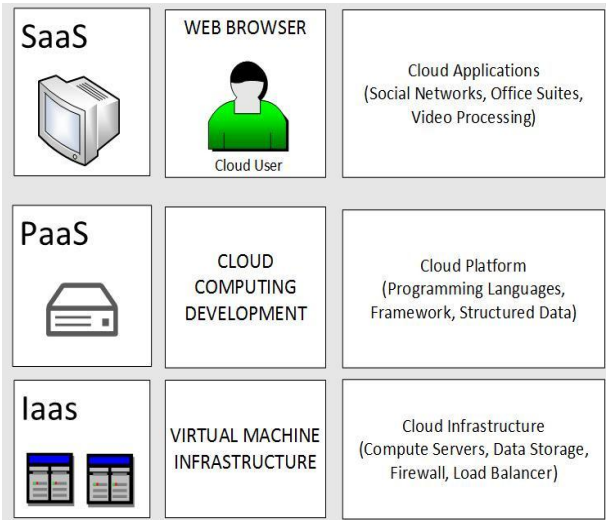

Fig.2. Cloud Computing Service Model [5]

1) Infrastructure as a Service (IaaS)

This service model deals with cloud infrastructure of hardware devices in data center. It contains servers, network devices, switches, routers, data storage devices. The virtual machine manager is installed on the hardware of this layer on which virtual machines are created. Cloud provider provides a virtual hardware for its user in this model.

2) Platform as a Service (PaaS)

PaaS is platform where all framework of the user applications are created in order to deploy the user applications. Various kinds of compilers, application software, editors, and web applications database applications are provided to access the data and can take any actions on it.

3) Software as a Service (SaaS)

SaaS is an application program which is used by the cloud user through his web browser using an internet connection. The complete list of services are available to user with their cost. The user can select any service from that and pay to cloud broker as pay per use basis [4].

B. *Deployment Model*

Deployment model of cloud defines availability, scalability and usability of the cloud to its user. According to National Institute of Standards and Technology (NIST) the deployment model comprises of four types of cloud. Each type of cloud has its own benefits and drawbacks. Enterprises may select any type of cloud based on their requirement like operational cost and availability, security and privacy.

1) Public cloud

The public cloud belongs to any organization and its services are provided to the customers as their pay per use. The services and resources of this type of cloud are used and accessed by general public. There is no initial investment on infrastructure in public cloud; however, the degree of control over data security and privacy hampers in many business. Various public cloud are available in market like Amazon Elastic Compute Cloud (EC2), IBM's Blue Cloud, Sun Cloud, Google App Engine and Windows Azure Services Platform.

2) Private cloud

The cloud that belongs to any private enterprise is called as private cloud. The users of this type of cloud are employees of a company having control over the cloud. They provide the highest degree of control over performance, availability, security and privacy. The operational cost of investment for this type of cloud is high. Hewlett Packard Enterprise (HPE), VMware, Dell, Oracle provide private cloud infrastructure.

3) Hybrid cloud

As the name specified, it comprised of public, private or community cloud. The ownership may belong to any organization or any third party. These cloud tries to minimize the limitations of both private and public cloud. Infrastructure part of this cloud is executed by the private while remaining part in private cloud. Microsoft Hybrid Cloud, VMware hybrid, Rackspace hybrid are some hybrid cloud providers.

4) Community cloud

The cloud that is designed and used by any community having some specific purposes is called as community cloud. It is shared by many enterprises having some common benefits and interests [6].

The rest of the paper is organized as follows, Section I contains introduction of cloud computing models and their types. Section II contains overview of virtual machine scheduling and its process. Section III presents some exiting virtual machine scheduling algorithm of cloud system. Section IV presents a comparison of exiting VM scheduling algorithms and finally we conclude our work with some future directions for carrying out research in field.

II. Virtual Machine Scheduling

A virtual machine is the fundamental part in the cloud computing. There are many virtual machines that exit in the cloud. These virtual machines allocated to different physical

machines to perform their various tasks [7]. Virtual Machine Scheduling can be defined as allocation of processing elements of virtual machine to the host. It is placed between the users and cloud data centers and consists of SLA managers, VM Manager, pricing and service manager. A simple cloud scheduler is depicted in Fig.3 comprised of various components like VM Manager, pricing and service manager.

A general scheduling algorithm works in three major steps [8] [8].

(a) **Discovery & Filter:** In this step, data center broker will search among list of available resources that are present in the system and pick up all required information which is necessary for allocating virtual machine.

(b) **Selection:** This step is called the deciding state. The resources and virtual machines are selected which fulfill the necessary requirements of the customers.

(c) **Submission:** The selected virtual machines and resources are allocated to physical machines. Each task is now ready to be executed on the virtual machine.

Virtual machine scheduling is very important strategy in cloud computing since it is core fundamental building block of cloud. It is also important to maintain the Quality of Service (QoS) for its customers and Service Level Agreements (SLA) which are maintained between the cloud brokers and cloud users. There are several virtual machine scheduling algorithm that are available in cloud environment and each them perform well in terms of certain parameters. The Quality of Service (QoS) of scheduling algorithm depends upon many factors which can be divided into two types; subjective and objectives [9]. The subjective parameters are mathematical computational ones like packet loss, execution cost, transmission rate, throughput, response time, waiting time, migration time, security, energy, memory, number of migrations. The objective parameters are those which indirectly effect and maintain Quality of Service in cloud like data security, trust, privacy, reliability, availability, user experience, and satisfaction level.

III. SCHEDULING ALGORITHMS IN CLOUD

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

This is the simple algorithm in cloud in which the VMs are scheduled as per their creation. It works on the principle of first come first serve. It is reliable and scalable but throughput of system decreases as VM request increases [10].

B. *Round Robbin Scheduling*

The Round Robbin algorithm based scheduler uses all VMs to distribute task of the user and keep the full utilization of the resources. It placed one task per VM and therefore keep the all Virtual Machine in ON state which causes high power consumption [11] [12].

C. *Shortest Job First Scheduling*

This type of scheduler works on the principle of priority queue. The VMs are allocated to the host server based on the burst time. The VM Scheduler allocates the VMs with least burst time [13]. It is reliable and scalable but may leave small tasks incomplete if scheduler crash.

D. *Genetic Based Scheduling*

Genetic based scheduling is based on the Genetic Algorithm (GA). It is a heuristic technique that select the solution naturally. It uses the first set of solution based on naturally selected data and then uses it to get new solution [14] [15]. Authors [16] have develop heuristic based algorithm which provide a cost based multi QoS scheduling in cloud that optimize the workflow applications with budget and deadline. There exits some security issues with this approach.

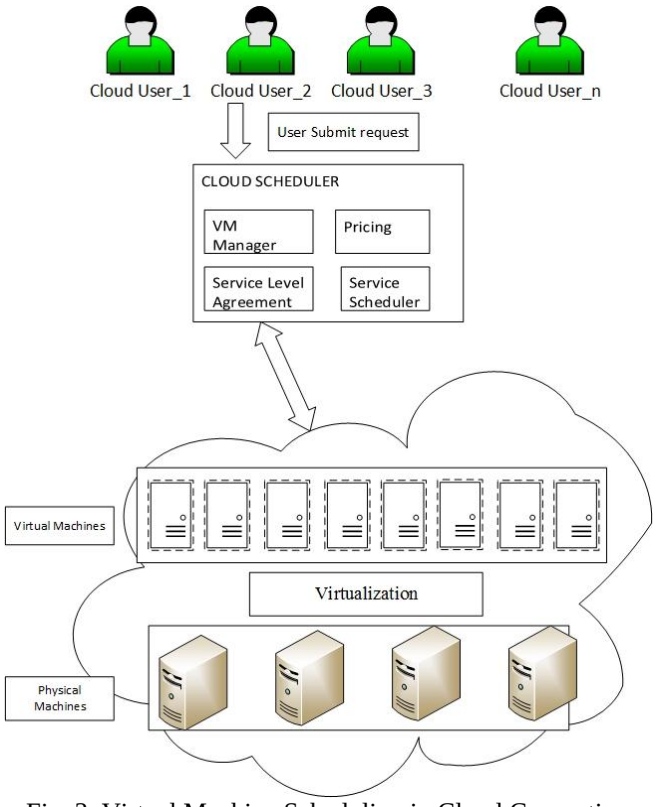

Fig. 3. Virtual Machine Scheduling in Cloud Computing

E. *Generalized Priority Algorithm*

These types of algorithm defines the precedence according to the demands specified by the users. The priority may be depend upon size, memory, bandwidth, MIPS, time etc. The tasks are organised based on their priorities. The Virtual Machines are also ordered and stored in VM list according to their one specific configuration value such that

the one having highest RAM specification has the highest priority. If the two task have same priority then First Come First Serve policy is implemented for scheduling of VMs [17].

The above algorithms are some traditional algorithm that are used for scheduling the VMs in the cloud computing system. These algorithms lags user satisfaction in terms of makespan and cost. Also they are good enough only in one factor but have many deficiencies. In addition to above researchers and scientist have designed many new virtual machine scheduling techniques in recent years which are briefly discussed as:-

F. *Energy Efficient Scheduling*

Many energy virtual machine scheduling had been developed in order to minimize the energy consumption of the data center. Author [20] has proposed a model for minimizing the energy on data center without significant decline of the Quality of Service. The design model estimates the energy consumed by virtual machine and complete system and select the virtual machines from server having high workload and migrate to another server having low workload.

G. *Neuro-Fuzzy Technique*

Author [21] has designed a neuro –fuzzy based PID control mechanism to calculate current QoS and average QoS and then find derivation which helps for scheduling of tasks in different Virtual Machine for next interval. It gives a better load balancing and achieve QoS for customers.

H. *Hyper-heuristic Scheduling*

Author [22] has proposed a novel Hyper Heuristic Scheduling Algorithm for better scheduling solution for cloud computing which tries to reduce the make span of the task so that task can be completed early. It works on the principle of diversity detection and improvement detection operators for balancing in the search scenario. Its performance is good among all exiting heuristic techniques.

I. *Hybrid bio-inspired Scheduling*

Author [23] has developed a novel method for task allocation to VM using modified Particle Swarm Optimization and then manages the resources as per their demand. This technique fully utilize the resources of cloud, improve reliability and also minimize the makespan. Its performance reduces with increase in users dynamically.

J. *Cost & Energy Aware Scheduling*

The author [24] has taken two scheduling factors in his algorithm. It is designed for workflow scheduling that meets the deadline constraints. The cost of execution of workflow is minimized as previously leased idle VMs are allocated for new workflow rather than creating a new virtual machine. The execution cost and energy of system is minimized in this technique however actual cost of electricity is not analyzed.

K. *Hybrid Haizea and Condor Scheduler (HHCS) approach*

Hybrid Haizea Condor Scheduler is a combination of Haizea and Condor that combines the advantages of both schedulers and minimize their limitations. The scheduler is based on the match-making policy and uses the additional attributes of job with their resource requirements. The resource utilization of HHCS scheduler increases along with the performance in terms of response time and turn-around time [25].

L. *Customer Facilitated Cost-based Scheduling*

Customer Facilitated Cost-based Scheduler proposed to favour the Cloud customers with economic cost. It is the modified version of Heterogeneous Earliest Finish Time HEFT algorithm which calculates the cost of execution of each task using priorities and tries to minimize the cost and balance the load [26].

IV. Comparative Analysis of VM Scheduling algorithms

A comparative study of exiting algorithm have been made which is presented in Table 1. The studied techniques are compared on the basis of various parameters like scheduling factor, design objective, application environment and performance parameters (scalability, reliability, and QoS).

V. Conclusion and Future Work

In this paper, an overview of cloud computing architecture, cloud models and virtual machine scheduling algorithms has been presented. Each algorithm has its own merits and demerits and hence suitability in different applications scenarios. The energy efficient algorithms are good enough for minimizing the energy consumed by the system but they are not cost effective. On the other hand, cost effective algorithm minimize the total execution cost but they are not reliable. Some heuristic, meta-heuristic and hybrid techniques had been proposed to enhance. There is enough space available to improve the performance of existing algorithms by using more hybrid optimization techniques. Also there is need of designing new algorithms that can enhance the Quality of Service in terms of scalability, reliability, availability, makespan and execution cost.

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Table 1. Comparative Analysis of some existing techniques for Virtual Machine Scheduling.

Algorithm/technique	Scheduling factor	Objective	Scalable	Reliable	Environment	Whether QoS oriented	Remarks
First come first serve[7]	Time	Minimize energy	Yes	Yes	Homogeneous	No	More time for short jobs
Shortest Job First[10]	Time	Maximize Throughput	Yes	Yes	Homogeneous	No	Required advanced knowledge about the burst time of each VM
Round Robin Algorithm[8][9]	Time	Minimum Response Time	Yes	Yes	Any	Yes	Power Consumption is high
Memory Aware [18]	Memory	Minimize Memory Contention	Yes	Yes	Any	No	No. of VM Migration is more
Match Making Algorithm[19]	Time	Maximize Resource Utilization	Yes	No	Homogeneous	No	44 % improvement in response time
Energy Efficient Scheduling Algorithm[17]	Energy	Minimize Energy	No	No	Homogeneous	Yes	Bad Performance on low loads
Neuro –Fuzzy Technique[21]	Quality of Service	Load Balancing	No	No	Any	Yes	--
Genetic Algorithm[27]	Cost	Quality of Service	Yes	Yes	Homogeneous	Yes	Migration Cost is Very High
Optimal Scheduling[28]	Time	Efficient Resource Utilization	Yes	Yes	Homogeneous	No	Did not considered Migration Time
Trusted Aware Distributed and Collaborative scheduling Algorithm[29]	Security (neighbouring nodes)	Load Balancing and Resource Balancing	Yes	Yes	Any	No	Provide Fault Tolerance
Weighted Active Monitoring Algorithm[30]	Time	Load Balancing	Yes	Yes	Homogeneous	No	Power consumption is high
Hyper-heuristic Scheduling[22]	Makespan	Work flow scheduling	Yes	Yes	Homogeneous	No	Not for Heterogeneous Clouds
Hybrid bio-inspired algorithm [23]	Time	Efficient Resource Utilization	Yes	Yes	Any	No	Dynamic Resources not Taken for consideration
Cost & Energy Aware Scheduling(CEAS)[24]	Cost and Energy	Cost and Energy Minimization	Yes	Yes	Homogeneous	Yes	Actual Electricity Cost is not considered
Hybrid Haizea Condor Scheduler (HHCS) [25]	Time	Resource Utilization	Yes	Yes	Homogeneous	Yes	Inter-arrival time of jobs is more
Customer Facilitated Cost based Scheduling [26]	Monetary Cost	Load balancing and makespan	Yes	Yes	Heterogeneous	No	Other cost function like storage, Input-Output not considered.

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