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Virtual Machine Scheduling Strategies in Cloud Computing- A Review

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ABSTRACT: Virtualization and heterogeneous computing makes cloud computing important in this decade. Task scheduling is very important in load balancing and to achieve high performance in heterogeneous computing. Several studies had conducted to solve the issues related to scheduling the resources in Virtual Machine and proposes the algorithms. These studies try to explore the issues of improving the efficiency of VM and evaluating the performance of scheduling algorithm. Though immediate resource usage plays an important role in scheduling process of virtual machine but system variation and historical data also helps in increasing the optimization efficiency of VMs. Scheduling the Virtual Machines (VMs) may affect the performance of VMs due to computational costs associated with it. Analysis of past utilization of VMs helps in designing the scheduling strategy for the scheduling algorithm. It also helps in reducing the poor performance of scheduling algorithm in resource optimization process. In this paper we have identified some research issues and presented literature findings. We have also discussed VM scheduling techniques and their specifications, advantages. Then VM placement strategy and the process of VM migration is discussed. We have proposed architecture for dynamic resource scheduling and load balancing. Dynamic resource scheduling and load balancing is the primary requirement of a cloud computing environment. Finally the future works also identified with conclusion.

Keywords: Cloud computing, VM, Scheduling, Virtual Machine.

I. INTRODUCTION

Cloud computing has brought a fundamental change in information technology in certain tasks with virtual machine like scheduling, consolidation, migration and other supporting tasks. Cloud computing has changed the network and architecture formation of the system. Cloud computing meant for large scale computation, storage virtualization, and low price service [44]. Scheduling is the allocation of suitable task to the hosts for execution. In cloud environment this task is very important to effective utilization of the resources. Virtual machine is the software employment of computing environment to install or run a program. Allocating resources to the virtual machine and moving applications between virtual machines are important parameters. In the cloud infrastructure virtual machines are scheduled for multiple data centers which may be geographically distributed. In cloud computing environment scheduling policies, resource and infrastructure utilization are defined under scheduling optimization process. Virtual machines are scheduled on the cloud to maximize their utilization. Scheduling helps to increase the quality of service and to achieve maximum benefit for cloud service provider. Companies can reduce the cost by energy saving and obtaining the cloud computing services. Optimization process leads to consume less energy, faster execution of job, and efficient resource allocation. In IaaS (Infrastructure as a Service) model of cloud computing virtualization is an effective solution to manage dynamic resources [1]. Scheduling algorithms aims at the mapping of virtual machine to the physical server. It also focuses on resolving the problem of heterogeneity to achieve the load balance dynamically.

Virtual layers facilitate optimum resource utilization by allocating virtual machines according to the user needs of the resources. Virtual machines allows multiplexing of hardware resources which enables different users to share the physical machine with the isolation from each other. Virtual machines may be of different characteristics in terms of CPU speed, memory size and other physical resources assigned to them. Though virtual machines provide best solution for balancing the load of the system dynamically but the problem of underutilization of resources may arises [2]. Underutilization is due to inefficient distribution of the resources by scheduling algorithms. Underutilization leads to the problem of overloaded servers which further leads to heat generated by overloaded servers and turns to increased cost of cooling system [3]. Appropriate virtual machine scheduling handles two problems simultaneously the mapping of VMs to physical machines and how to select the virtual machines for load balancing. So, in literature two terms are always referred as configuration of virtual machines and placement of virtual machines to physical machines in the cloud computing environment [4, 5]. The theme of the work is to propose the architecture of dynamic scheduling and load balancing to the energy efficient cloud architectures.

II. RESEARCH QUESTIONS FOR THE STUDY

Table 1: Research questions and literature findings.

S. No.	Research Questions	Literature findings
1.	What are the current techniques for VM scheduling	Major techniques for VM are static, dynamic, heuristic, real time, workflow scheduling. [8, 12, 13-20]. Table 1 represents current techniques for VM scheduling with their advantages and specific feature.
2.	What is the Scheduling process of Virtual Machine and how it can be implemented in multi-user cloud computing environment.	Scheduling algorithms for VM scheduling aims to optimize the resources and focused to minimize the execution cost and time [21], [27], [28].
3.	How the existing resource scheduling algorithm involves in effective VM placement strategy.	A placement strategy can be developed to optimize resources based on current resource requirement. But fluctuation of workloads over the time is a big challenge for predicting the virtual machine placement strategy [22].
4.	Why resource scheduling plays an important role in cloud environment	VM scheduling policy is important for the process and working of the cloud surroundings. The scheduling algorithms which designed for handling resource fluctuations dynamically, performance variation of resources are used as fault tolerant mechanism in cloud environment [30].
5.	What are the research gaps still existing in resource scheduling.	Still numerous gaps exists in VM scheduling techniques viz. no provision for effective resource utilization in case of clients are increased, algorithms developed in specific languages like java may not be compatible in cloud environment. Optimum load balancing i.e. the execution of task in minimum time should be performed [36]. Excessive traffic between host and VM is an overload so there is a need to reduce this traffic as well [35, 36].
6.	What are the parameters for evaluation of effective VM migration	The task like sever consolidation, downtime resources maintenance etc. are supported by VM migration. For evaluation of VM migration process different performance metrics can be used like migration time from one server to another, and the downtime in case if non-live VM migration, and network consumption for data transferring [25, 26].

III. WHY VM SCHEDULING IN CLOUD ENVIRONMENT

In cloud environment VM scheduling plays an important role. It is used for load balancing in cloud infrastructure and allocate VM resources efficiently. Cloud environment based on virtual file sharing and to achieve optimal file sharing VM scheduling is used. Recently Traffic load balancing, energy consumption etc. Managed by cloud data centers. So resource allocation in cloud environment is a challenging task. VM scheduling algorithms designed in such a way that they can effectively handle these issues of resource allocation. This algorithm can allocate VM resources in static as well as dynamic environment. Thus helps in effective utilization of resources [29, 31].

Scheduling algorithm aims to do multiple tasks ranging from allocating resource utilization to monitor energy consumption, execution cost, execution time in the specified conditions and constraints [29]. Cloud environment meant for handling several users with diverse applications so faults are expected in this kind of infrastructure. The scheduling algorithms which designed for handling resource fluctuations dynamically, performance variation of resources are used as fault tolerant mechanism in cloud environment. If a certain task is requiring more than projected resources dynamically then task failures may occur and the task will not be executed on schedule hence affects resource scheduling. To avoid such instances fault tolerant mechanism in the form of dynamic resource scheduling are necessary in cloud computing environment [30, 32].

Cloud service providers have to focus on fulfilling Quality of services parameters specified by the users which also includes security constraint, and maintaining trust levels during the scheduling process [33].

IV. WAYS OF VIRTUAL MACHINE SCHEDULING

The objective of scheduling virtual machines is to minimize the task execution time and maximize the resources utilization through load balancing in the dynamic environment [6]. The task of scheduling the virtual machine is done by scheduling algorithms which allocates the virtual machine in proper sequence to the jobs executing under constraints and within a time slot to maximize the resource utilization. Scheduling algorithms can be broadly categorize in two ways as static scheduling algorithm and dynamic scheduling algorithm [7]. Apart from these two category heuristic scheduling, real time scheduling and workflow scheduling also used.

Static scheduling is used when job or task information is known to prior and the resources are allocated systematically with optimum utilization. While in dynamic scheduling the allocation of task to the virtual machine is done on fly when it is executing. Dynamic scheduling impose runtime overhead more in comparison to static scheduling. Scheduling algorithms are aims for optimization of resources. The optimization problems are hard. These problems can be better solved with heuristics method. When optimization solutions are available heuristics method finds reasonably good solution which is reasonably fast [9].

Table 2: Virtual machine scheduling techniques.

Title of the paper & Authors	Type of techniques	Algorithm /Method	Features Used	Disadvantage/ Advantage	Future Directions
[8]	Static Scheduling	PSO based algorithm	Inertia weight and mutation operator included to PSO algorithm	Balancing the workload of Virtual machines between independent tasks	Had restrictions from bandwidth and energy cost
[12]		Min-Min algorithm	The task which are not assigned to VM yet should be considered, the short task preferred first,	Long tasks cannot be executed, unbalanced load	Priority constraint needs to be applied
[13]	Dynamic Scheduling	Dynamic Round-Robin	While physical machine is in its retirement state on finishing a VM but more VMs are waiting for it provisions the physical machine to retire and migrate VM's on another physical machine	When a physical machine is in retirement state for a long time avoids adding extra virtual machines so it can be shut down	Power consumption can be reduced more
[14]		Predictive virtual server scheduling	This scheduling method aims to predictive server scheduling for dynamic consumable resources which works on priority based workload performance	Cloud consumer can provision for on demand computing capabilities	Scalability issues in large clouds
[15]	Heuristic Scheduling	Genetic Algorithm (GA) with Meta Heuristics	Scheduling tasks to the resources with adaptable time in a proper sequence so all the tasks can be executed	Flexible approach for time minimization	Needs to focus on runtime scheduling
[16]		Hyper-heuristic scheduling algorithm for cloud	Diversity detection and improvement detection operators are used to dynamically determine better candidate solutions.	Execution timespan is reduced significantly	Needs to focus on more effective detection operators and perturbation method to enhance the performance
[17]	Real Time Scheduling	Smart energy-aware task scheduling	Provides optimal utilization of host to execute certain tasks in real time and minimize the energy	Reduces Energy consumption significantly	Needs to focus on optimizing the placements of VMs
[18]		Green Scheduling Algorithm for Energy Savings in Cloud Computing	Integrates neural network predictor for optimizing host power consumption for cloud environment	Future load demand can be predicted better, unused servers turns off and leads to reduce power consumption	Needs to focus on more diverse applications
[19]	Workflow Scheduling	Compromised-Time-Cost Scheduling Algorithm	Based on instance cost constrained workflows but compromise execution time and cost	Providing time-cost relationship graph to choose scheduling deadline	Needs to focus on feasibility in rapidly evolving cloud computing environment
[20]		Multi-objective workflow scheduling	based on task's completion time and security requirements of cloud environment	Enhance the overall security of the system under a wide range of workload characteristics	Needs to focus on dynamic workflow scheduling which predicts workflow behavior in the cloud environment

Approximation algorithms use this heuristics method. This method works on deploying cost efficiently schedule for multi cloud environment. Real time tasks scheduling which are also considered as event triggered scheduling increase the total utility of the resources and also increase the through put reduce the average response time, power consumption and SLA violation [10,45]. Presently many applications requires QoS aware scheduling techniques which ensures quality of service in real time. Signal data processing highly needs this kind of scheduling resources. Workflow scheduling works on structuring the application and these applications are inter task dependent. A workflow may be collection of several tasks which are communicating and interdependent. Workflow scheduling algorithm aims to execute the workflow according to directed cyclic graph [11]. It is highly recommended in the cloud computing environment. Various algorithms are proposed for virtual machine scheduling which are based on above techniques. Table 2 represents these algorithms with their advantages and specific feature.

V. IMPLICATION OF EXISTING METHODS

Existing scheduling algorithm may be preemptive or non-preemptive. These algorithms are currently prevalent in cloud environments in which task scheduling emphasized. The existing techniques based on static, dynamic, heuristic, real time and workflow scheduling. Static scheduling techniques has the problem of unbalanced load. These techniques also had the restrictions from bandwidth and energy consumption cost. Dynamic scheduling includes round robin and other algorithms which aims to predictive scheduling for dynamic consumable resources on priority basis. Through these methods when resources are not required VM can be shut down and power consumption can be reduced more. Heuristic scheduling methods executes jobs with closest deadline time delay using dynamic time quantum. These methods needs to focus on more effective detection operators. Real time scheduling techniques based on future load demand prediction and needs a software for monitoring the cloud clusters. Workflow scheduling methods predicts the workflow behavior in the cloud environment and these should be focused on time utility scheduling.

VI. VIRTUAL MACHINE SCHEDULING PROCESS

Virtual machine scheduling within an infrastructure can have several data centers spread geographically is referred as single cloud environment. In this cloud environment scheduling algorithm aims towards scheduling optimization process and take advantage of all information available. When one cloud infrastructure share its workload to another infrastructure, scheduling algorithm deploys virtual machine for cloud infrastructure. In cloud environment the decision making of selection of Host for VM allocation is an important task [21]. Fig. 1 shows virtual machine scheduling process in cloud environment. It shows the mapping between physical machines (hosts) and virtual machines. Physical machines arranges under hosts.

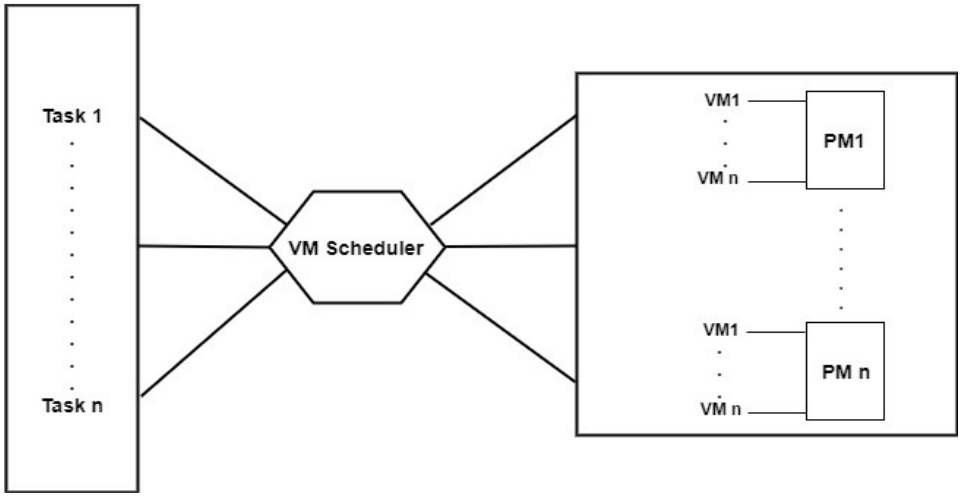

Fig. 1. VM Scheduling in cloud Environment.

Scheduling algorithms used for VM scheduling [27] aims to optimize the usage of resources required by the applications. When a large application needs resources, it's challenging task to schedule VM for the task. In such cases the application can be divide into small sub tasks prior to scheduling the resources [28]. Scheduling algorithms optimize resources by minimizing cost and the processing time. The task came for resource scheduling can be splatted in subtasks. Each subtask is requesting for single VM instance. Suppose a task *T* is submitted for execution then it is divided in the set of subtask {*T1, T2… Tm*} and *VMi* = {*VM1, VM2… VMl*} is the available set of Virtual Machines then the optimization function is

$$\sum_{i=1}^{m} Ti(\alpha.\text{Execution cost} + \beta.\text{processing time})$$

VII. PREDICTION OF VIRTUAL MACHINE SCHEDULING

Presently the solution of virtual machine placement problem is given by allocating a single virtual machine to a server or host at any specified time. This provision ensures that each host has sufficient resources to execute the workload. But it is not effective for efficient

resource utilization. Workload pattern often time varying. By allocating more than one virtual machine according to the aggregate requirement demanded by a host, resource utilization can be improved. It also reduce energy requirement and enhance the service provider's ability. A placement strategy can be developed to optimize resources based on current resource requirement. But fluctuation of workloads over the time is a big challenge for predicting the virtual machine placement strategy [22]. VM placement strategy can be formed by analyzing current and future requirement of VM migration. VM placement algorithms uses fitness functions for checking physical nodes whether they are engaged to run the existing virtual machines or idle. It helps in formulating the VM placement strategy for the new task. If any host is idle it is activated with needed physical resources. Machine learning techniques can be applied to predict the accuracy of predictive algorithm for resource utilization. Artificial neural network can be used for machine learning and the network is to be train for learning the behavior of VM or sequence of CPU utilization [23]. While using neural network for machine learning input vector needs to defined and these values fed to the hidden layers neurons which are specified by weighted connections. Then the network calculates the sum of weighted signals for each neuron as represented by following equation-

$$u_k = \sum_{j=1}^{m} (Wk_j\, x_j)$$

Wk1, wk2 …are the connection weights, x1, x2, xj are the input signals of neuron k. For getting output signal of each neuron an activation function is applied which limits the range of the signal to a finite value between 0 and 1.

VIII. VIRTUAL MACHINE MIGRATION

Data centers have to manage efficiently the increased number of applications hold to their data center. It is a great challenge to manage and scheduling the virtual machine in data center for the numerous applications of different users. Other problems may arise like failing a server due to overloading and VM will also be impacted. All these issues viz. protecting virtual machine from server failure by evenly distributing the resources to the applications can be managed through VM migration. The necessary condition for VM migration are demand for more CPU by VM, demand for more memory resources, and more task allocation. In VM migration a VM is not dedicated to the server where it is formed, but it can be moved from one server to another as well as between the data centers by calculating the fitness function [34]. The task like sever consolidation, downtime resources maintenance etc. is supported by VM migration. It improves overall efficiency of data center by migrating a complete state of VM from one server to another [24].

While migrating VM the data should be moved from one server to another and the continuity of network connection should also be maintained. Data migration involved the memory data and storage data migration for transferring the current state which are running and the virtual storage of migrated VM should also be transferred to the destination. VM migration can be performed in live and non-live state of VM. In live migration memory data and network continuity are two challenges needs to handle to avoid any interruption in providing service. To maintain network continuity and current memory state all the running states should be transferred without suspension of VM. In non-live migration the running states are transferred to the destination and network connection is built after resumption. Fig. 2 indicates VM migration for live state and non-live state which is monitored by local manager through monitoring resource utilization and the need for VM migration.

For evaluation of VM migration process different performance metrics can be used like migration time from one server to another, and the downtime in case if non-live VM migration, and network consumption for data transferring [25, 26].

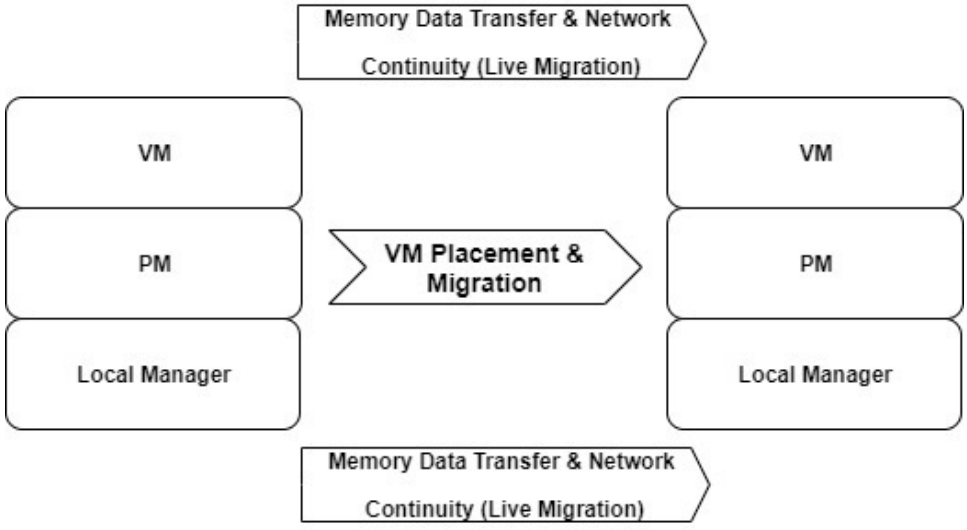

Fig. 2. VM Migration.

IX. PROPOSED ARCHITECTURE

The proposed architecture aims at reducing the traffic for communication between host and virtual machines. Whenever the physical machine is in idle state it also gets involved in all the communication between host and VMs. The best idea to reducing the overhead of involving the idle host in communication is switching off the idle physical machine [37, 38]. VM consolidation is done to effective allocation of VM on physical machine by clustering techniques. VM migration is also based on finding similarities, distance and suitability between PM and VM [38]. The proposed architecture is also taking care of dynamic resource allocation and monitoring. Through dynamic resource allocation and monitoring the quality of service (QoS) which are expected by the customers can be entertained. This system can work in stages viz. first of all it can monitor the available physical resources of cloud service providers like CPU, and memory and network bandwidth. At the same time it should also monitor and analyze the demand for resources from the task. According to the demand and available resources VM placement strategy can be formulated. Lastly the task can be executed by VM scheduling.

In the proposed VM scheduling architecture a section which is job request monitoring obtains the request for resource scheduling from different users of cloud dispersed in distributed geographical area. The users may submit the request in terms of hardware (processor and memory requirements), software or networking resources (bandwidth etc.) [38, 42]. After receiving the job request the job request monitoring section accepts the request and verifies whether it is from valid user or malicious user. If it is found that the request made from the valid user then it is forwarded to controller of VM scheduler otherwise the request is deleted and report generated. Resource scheduling in cloud environment is quiet challenging due to its dynamic environment [39, 40]. The job request from the users may be change at any point of time in their applications. Here the controller plays an important role by matching the job request with the available resources. Only the authenticated requests are further processed by the controller. For the status of available resources controller takes the help of Physical & virtual Resource monitoring section. This section have the status of all available physical and virtual resources as well as the resources which are idle or switched off. The priority of VM scheduling to any job is also checked before allocating any resources [40, 41-44]. Users preference for providing QoS (make span time, optimum resource utilization) also considered. When a task is removed after completion its job the status has been changed of VM and informed to all the sections to allocate a new job to that VM.

The Proposed scheme of VM scheduling is taking care of dynamic task scheduling and load balancing. Physical and virtual resource monitoring section monitors the state of VM and PM at each and every instance which helps in resource scheduling dynamically [43]. The monitoring may at the happening of a particular event or it can be at a regular time interval.

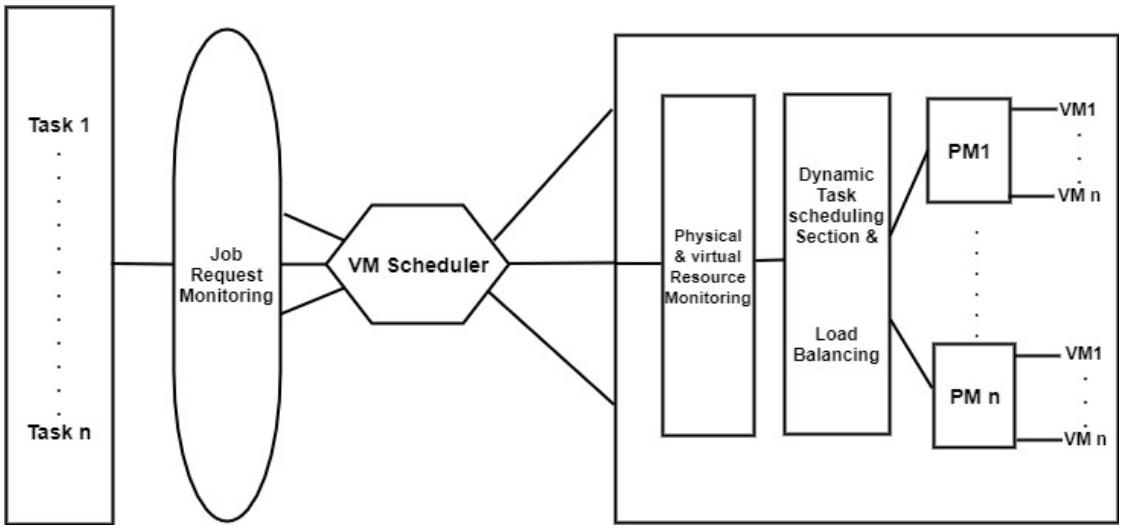

Fig. 3. VM Scheduling Architecture.

X. CONCLUSION AND FUTURE WORK

This paper presents a detailed study of existing VM scheduling techniques and the implications of performance of the methods. Cloud computing environment is heterogeneous in terms of user demand because diverse kinds of application can be executed by customers on cloud platforms. Therefore a VM scheduling approach needed which can handle the load balancing of the machine. The internal management of VM Scheduling mechanism should be strong for optimum utilization of resources. VM scheduling mechanism should be aimed for less energy consumption as well as to achieve QoS parameters expected by the cloud customers. In this paper we have discussed VM scheduling techniques which includes static, dynamic, heuristic, real time and work flow scheduling. Virtual machine scheduling process within the heterogeneous cloud environment is also discussed. For optimum utilization of resources the prediction of virtual machine is also required due to dynamic nature of cloud environment. By predicting the requirement for VM scheduling VM placement strategy can be formed. In the complex cloud environment various data centers

takes the services. All the data centers are equally important and should be treated equally for better performance. VM migration is the crucial techniques in performing the VM scheduling strategy. This is the key factor for effective utilization of resources. The main objective of our proposed architecture is develop the technique for resource allocation efficiently in dynamic cloud environment.

In future we would like to compare our proposed architecture with other existing models with the results. The proposed model can be extended by considering more quality factors like security and more elasticity. It can also enhanced by ensuring the priority execution of the tasks. The feature of switching the allocated resources according to the higher priority between the different tasks can also be inculcated. The VM scheduling is major concern for the data centers. It is directly impacting the cost reducing for data centers as less execution time means lower task and it is achieved by optimized task scheduling. In future the extensive simulations on the real dataset may be conducted for showing the feasibility of our proposed model. The future goal of our research is to formulate and extend the proposed architecture for shared virtualized infrastructure.

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