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LITERATURE REVIEW ON RESOURCE SCHEDULING & RESOURCE MANAGEMENT SCHEMES IN CLOUD COMPUTING.

Dr.P.Nandhini
No.272, Mullai Nagar, 6th Cross, Near Saibaba temple, Suramangalam,
Salem - 636 005, nandhinirajeshvmkv@gmail.com

K. Karthikeyan
S/o P. M. Krishnasamy, 2/265, trichy high way, Valikandapuram,
Perambalur-621115. Dt.

K.Ayyappan
2/240 east street, pudukadai thirupugalur post nagapattinam Tk and district 609704.
Mail:mtechayyappan@gmail.com

Dr.Saravanan Obuli
Professor, Annapoorna Engineering College, Nh-47, Sankari Main Road,
Periyaseeragapadi,Saem-636308, osaravanan.it@gmail.com

Abstract - Cloud Computing is a promising computing technologies where end user computing tasks are performed in distributed computing environment with redundant infrastructure to support fault tolerance operation. End users are provided with simple user interface with the help of standard or customized browser to get inputs and then those inputs are transferred to remote location with the help of network. Dedicated resource schedulers pass the task to different resources in distributed environment and passes the computed results to end user browser which effectively reduce the total cost of ownership of computer based system to end user. Hardware, Software & Firmware are managed from one centralized atmosphere. Active Directory and other directory helps the organization to manage the distributed infrastructure from one centralized location. Due to this distributed nature of cloud computing resources puts high demand for effective resource scheduling algorithm that utilizes underlying resources effectively which in turn creates way to Green Data centers. To understand existing resource scheduling algorithm, we surveyed different resource management algorithm for different implementation of cloud data centers. After that we showed different problems in existing resource scheduling algorithm which creates ways to propose effective resource scheduling algorithm that enables organization to create green cloud data centers.

Keywords – deep learning based resource scheduling, green cloud computing, green data center, resource management frameworks and virtual cloud computing.

1. Introduction

Cloud Computing is a technique which uses end user minimal computing resource, network and third party data center to perform day to day computing task. In Infrastructure as a service platform cloud provider will give resources directly to the user. The end user can install operating system and required software with the help of web browser or dedicated cloud computing software like amazon work space. All operating system and software are loaded in remote server. In Platform as a service the user will get virtual machines with inbuilt operating system and development platform as a choice. Now end user can use the service offered by client for day to day computing tasks. In Software as a service model the end user get required software with the help of browsers.

End user will use the software and pay based on usage. All this cloud computing provisioning model clearly shows that underlying hardware are managed by cloud service provider who provides service to client. This imposes the great need for modern resource scheduling algorithm that utilizes resources effectively and reducing operational cost of cloud service provider.

The objective of cloud computing is to create low energy consuming and high performance computing environment that meets fault tolerance based service mode.[1]. According to the [1], cloud computing provider should always create high-performance computing resources that always gives quick turnaround time at the same time it should consume low power by utilizing advanced processor and memory technologies. Along with providing high computing infrastructure with low power computing it also need to provide safe service model which enables the infrastructure to be fault tolerant.

In [1], Based on Resource Usage Frequency the optimal voltage is chosen and applied on resources. The optimal power is applied during task processing. The make span optimization is performed by selecting correct resource from the pool which completes the task with lowest computing time including waiting time. Other properties such as optimized scheduling and load estimation makes complexity in cloud computing environment. Loads can increase suddenly and sometimes it will decrease drastically.

Load estimation and optimized scheduling plays vital role in establishing green cloud computing infrastructure. To understand the above mentioned problem, we reviewed works done by other researchers. We found limited number of papers addressing issues of optimized scheduling and multi variable load estimation. Researcher in [2] shows state of art optimized scheduling and multi factor load estimator using two scheduler. One scheduler takes cares of estimated loads that comes to cloud infrastructure. Another scheduler takes care of unpredicted loads that will be scheduled to regular cloud computing resources.

According to the researcher in [2], Collaboration between scheduling algorithm and load estimator helps to bring down power consumption of Data Center. Estimator knows peak time and non-time which scheduler uses to schedule the task to right computing resources. During unpredicted loads, estimator and scheduler makes use of the idle resources in cloud computing environment to complete all the pending tasks.

2. Scope of Resource Monitoring and Management in Cloud Computing

The scope of Resource monitoring presents wide opportunity to do research on monitoring the resources and predict the resource availability for future tasks. Scopes includes resource monitoring against active resource usage by tasks and its completion time. Managing idle resources to bring it up and down based on resource requirement also plays an major role in bringing Data Center Power Consumption. Resource Management plays another important factor to bring down power usage of data center. Once the tasks are allocated to resource then its difficult to switch tasks from one resource to another. So resource must be chosen based on optimal parameters. All this factors gives wide scope in resource monitoring and management in Cloud computing.

2.1. Classification of Cloud Computing Resources.

In order to do better load estimation and resource scheduling one must be clear about different classification in cloud computing components. Cloud computing components are classified into three types. Real components, indirect components and logical components.

Real components are used to create data center that caters resources needs of different tasks. Examples of real components are different types of processors based on data center needs, Random Access Memory(RAM) that stores temporary data before processing. Disk Drives like Hard Disk Drive & Solid state drive to store processed data for long time. Different types of Network Interface Controller which enables serves to communicate with one another and also helps to create distributed data centers. Peripheral devices such as Keyboard, mouse and Keyboard Video and mouse Switch(KVM). These devices helps the administrator to interact with server to configure certain roles. Network resources such as switches, routers and other networking components that enables communication between different networks within as well as outside data center.

Indirect components are based on real components of servers. Traditional real components supports execution of one instance of operating system. Virtualization divides the real components into multiple execution environment where multiple instance of operating system and other application can be executed. Some of the popular virtual components are vCPU, vMemory, vSwitch and vStorage which will be present on physical resource but its looks like dedicated resource to user. By using this virtualization technology, multiple components can be assigned as single component and it can be dynamically reassigned. This is also called scaling of components in cloud computing. All this virtualized components are managed with the help of Resource Management Framework. RMF will actively monitor all the tasks executed on components. If any user request for components or submit task then RMF will check the underlying components and match the best fit components. Then it will allocate that components to the user or task will be migrated to component for execution.

2.2 Requirement of Resource Management Framework in Cloud Data Center.

Cloud computing exhibits five properties and their needs are : a la carte self-service, Complete Network Access, Pooled Resources, Instant Elasticity, Metered Service

Table 1: Characteristics and Requirements for Resource Management Framework

	Characteristic	**Requirement**	**Objective**
Cloud Computing	a la carte self-service	Smart & Product-related Resource Management	Better Quality of Service, Energy Optimization
	Complete Network Access	Node to Node Resource Management	
	Pooled Resources	Independent Management and Deployment of Virtual Resources	
	Instant Elasticity	Instant flexible Resource Management	
	Metered Service	Metering of resource at right abstraction	

Green Cloud Computing		Low power High Energy Efficient Resource Management	

2.3 Challenges in Resource Management Framework of Cloud Computing.

Due to Distributed Nature of Cloud Computing Environment, resource management becomes difficult tasks. Next, we reviewed some of the issues present in Management of Resources. Cloud service provider provides service using three different techniques they are Iaas which provides complete computing infrastructure as service, PaaS which provides required service to users & SaaS which provides required Software to end user through hosted environment. If any cloud user access cloud components offered by cloud provider then Resource Management framework available in cloud provider infrastructure should check available resources that execute the given task with low power consumption and fastest execution time. But still some challenges are there in identifying resources with highest efficiency and predicting cloud workloads.

In[3], researcher proposed multi objective genetic algorithm to forecast resource requirement dynamically with the help of past data. This algorithm also forecast the power consumption of resources. Author proposed pre-defined time slots instead of predicting based on random time. Time slots are calculated based on previous history of resource usage by different data center. Resource allocations are carried with the help of CPU & memory utilization of VM as well as PM. VM allocation algorithm allocates the VM in next available time slot based on result from genetic algorithm which predicts resource requirements. Ideal VM's present in upcoming time slots are turned off or its state changed to sleep mode to ensure resources are not consumes unnecessary energy. All the resources that should be available for next slot will be turned on and energy will be supplied based on resource requirement. Dynamic voltage is applied to reduce the energy usage.

To understand different techniques followed by different researchers to predict cloud workloads and optimize resources, we reviewed In[4] , researcher proposed deep learning approach to predict the workload. The main issue present in deep learning approach is to train the different parameters with test data. To reduce this training complexity researcher compressed parameter "by converting weight matrices to the canonical polyadic format". Researcher also proposed self-training algorithm to educate the variables. Usage of deep learning helps to feed real time data into deep learning algorithm which predicts resource usage on real time.

In[5], researcher proposed simulated annealing-based bat algorithm (SBA) which not only focus on resource prediction, optimization and energy consumption. SBA calculates total cost spent by cloud service provider which includes bandwidth charges paid to ISP and energy consumption charges paid to different providers. Cloud data center resources are placed in different geographical location and tasks come from different location. SBA focus on placing tasks to right VM which completes the task in least cost. In each data center SBA algorithm is executed to find the execution cost on predefined time slots. Tasks are placed in different VM based on least cost value achieved through SBA.

3. Different Schemes of Resources Management in Cloud Data Centers

Resource Management schemes are divided into Resource Identification, Resource Scheduling, Resource Provisioning, Real Time Resource Allocation in Infrastructure, Continuous Resource Monitoring, Resource Consolidation & Resource Sharing. We reviewed different schemes developed for Resource Management.

Dynamic Resource Allocation is the common scheme which helps cloud computing service provider to allocate the resources with least cost also decreases responses time.

Network Aware Resource Allocation is another scheme which allocates the resources by considering network parameter such as latency and Round trip time to allocate optimal resource which further decreases congestion in networks.

Resource scheduling scheme takes care of allocating processors and servers based on predicted loads. If there is no load then processors and servers will be turned off to create energy efficient data center.

Resource provisioning scheme provisions the next required resources so that over all execution time will be decreased which further decreases the total cost of execution.

Resource Discovery scheme will help the cloud service provider to identify available resources in distributed cloud computing infrastructure.

Resource monitoring scheme checks all the resources those are executing task as well as those are ideal. If there is any failure in executing resources then it should be safely migrated to different VM.

Resource Consolidation scheme keeps collecting feedback about resources and consolidate the resources based on pre-defined threshold values.

Resource sharing scheme will actively share the resources with different data center spread across the globe.

3.1 Schemes of Resource Management Framework

The global aim of resource management framework mainly to ensure overall reduction in service cost to cloud service provider. It should also improve the performance of cloud infrastructure as well as it should provide secured service and finally it should ensure energy efficiency in all distributed data centers. We analyzed different resource management technique based on variables like response time, cost, execution time, service level agreement, processors needed to execute tasks, scalability and security. Algorithm such as “improved clonal selection algorithm[1]”,”cut-and- solve[2]”, “VM Placement Algorithm[3]”, “net gain-optimal resource allocation (GRA) algorithm[6]”,”simulated annealing-based bat algorithm(SBA)[5]”, “two-layer iterative algorithm[18]”, “resource-utilization-aware energy efficient server consolidation algorithm(RUAEE)[13]”, “Power Migration Expand(PowMigExpand)[28]”, “OBD-based LM adaptation algorithm[11]”, “virtual machine consolidation algorithm with multiple usage prediction (VMCUP-M)[26]” was mentioned as optimization procedures to enhance performance of resources, reducing cost, utilization rate, scalability & security of cloud computing infrastructure.

Table 2 shows comparison of resource management schemes based on common metrics

Table 2: Analysis of Different Resource Management Schemes.

Articles	Schemes	Parameters					
		Quality	Usage	Total Cost	Energy Consumption	Extendibility	Protection
[6]	Resource Discovery	×	×	×	✓	✓	×
[7]		×	✓	×	×	✓	×
[8]		×	×	✓	✓	✓	×
[4]	Resource Scheduling	×	✓	×	×	✓	×
[9]		×	✓	×	×	✓	×
[10]		×	✓	✓	×	×	×
[11]		×	✓	✓	×	×	×
[12]		×	✓	×	✓	×	×
[13]	Resource Provisioning	×	✓	×	✓	×	×
[14]		×	✓	×	×	×	×
[15]		×	✓	✓	✓	×	×
[16] [16]		×	×	×	✓	×	×
[1]	Resource Allocation	✓	✓	✓	✓	×	×
[3]		×	✓	×	✓	×	×
[17]		×	✓	×	✓	×	×
[18]		×	✓	×	✓	×	×
[19]		✓	×	✓	✓	×	×
[20]		×	×	✓	✓	×	×
[21]	Resource Monitoring	×	×	✓	✓	×	×
[22]		×	×	×	✓	×	×
[23]	Resource Consolidation	×	✓	×	×	×	×
[24]		×	✓	✓	×	×	×
[25]		×	✓	×	✓	×	×
[26]		✓	×	×	✓	×	×
[2]	Resource Adaption	×	✓	×	✓	✓	×
[27]		✓	×	✓	×	×	×
[5]		×	×	✓	✓	×	×
[28]		✓	✓	×	✓	×	×

3.2 Virtualization Techniques

The purpose of virtual machine consolidation is to reduce total number of active physical servers in data center so that power consumption can be reduced.[26]. Virtualization is a technique which helps to host multiple guest operating system on top of host operating system. Even its possible to run multiple guest operating system on bare hardware with the help of hypervisors. All these virtualization technique helps to create multiple virtual execution environment on top of physical execution environment. Snap shot is a term used to refer running state of VM. By using snapshot live running VM can be migrated to different physical execution environment which helps to decrease power consumption in data center. If two servers are running with minimal loads then VM's running on one server can be migrated to others with little effort.

3.2.1 Migration Procedures

Migration is the scheme of pushing one instance of operating system with running application to one physical server to another server. Migration can be performed in different ways. Some common techniques are Live Migration, Cold Migration, Hybrid Migration and Storage Migration. Live migration is the technique which transfers live virtual machine from one server to another server without disconnecting application and operating system. Memory, Storage and network connectivity are transferred from one server to another server by maintaining its same state. Its is also called hot migration. Cold migration is a process of moving virtual machine or application in suspended state to another server or physical environment. VM or application will be in suspended state for the entire duration of migration. It is called offline migration. Hybrid migration uses both hot & cold migration to move VM from physical environment to another physical environment. Storage migration migrates the underlying storage from one physical server to another physical server and utilizes same computing resources. All this migration techniques helps cloud computing provider to create energy efficient & fault tolerance infrastructure.

3.3 Open Research areas in Resource Scheduling and Management of Resources

In our Literature Survey, We discussed different resource management techniques and its issues. Some common advantages of resource management are improved throughput across duty cycle, high availability, better quality of service, Higher utilization rate of all resources, reduced network access time such as latency, reduction in resource overhead which slows down the performance of resource, overall reduction in computational cost, over all reduction in computation time and higher energy efficient cloud infrastructure. Resource Management technique drawbacks are less secured, Lower priority to resources, degradation of system performance due to different types of migration, delay in underlying networks, time spent on balancing workloads across infrastructure. Some of the common unresolved issues are mentioned below which may be useful to carry out further research to establish green cloud computing infrastructure.

3.4 Performance issues in Cloud Computing Resources

Performance is key factor that influences in providing satisfactory services to cloud users. Measuring performance is a continuous process which need to be done regularly to ensure all resources are providing expected service levels which also helps to achieve promised service level agreement to clients. Performance of nodes including secondary nodes such as networking and other supporting nodes to be monitored regularly to achieve energy efficient high computing environment. Some of the achievable techniques to improve the resource performance and underlying application executing in cloud computing infrastructure are given below.

Formulate the performance parameter and evaluation grades: The mentioned grades are used to examine the performance of cloud computing resources: Input Output Operation Per Second, Task Completion Time, Upload & Download Bandwidth, Response time, Instruction Execution time per Second.

Apply Performance Grades in Action : Use the above mentioned grades to measure and capture real time data and apply against agreed upon Service Level Agreement. Calculate total number of SLA violation and its recovery time to bring back resources grades within SLA.
Calculate and Apply Energy efficiency grades : Energy Efficient grades such as input voltage, utilized watts of power per resource and idle time of resource helps to adjust voltages and some times resources can be turned off or on based on demand for resources.
The above mentioned procedure can be implemented to solve some level of performance issues in distributed cloud computing infrastructure which in turns reduces the overall cost of cloud service provider.

4. Security issues in Cloud Computing Resources

Cloud Computing infrastructure spread across multiple location that are connected together with help of networks. End user computing devices such as computer, laptop and other computation devices are connected to Local area network using different networking resources. LAN is connected to Wan using Internet service provider using different ways. Now security issues starts from protecting the data that is transmitted over physical medium to securing higher end data center which stores and process huge data every day. Single security mechanism are not enough to protect the data due to increasing cyber security attacks. Multi-level of protection are required to ensure information security principles such as confidentiality, Integrity and Availability.

5. Conclusion

In our paper we analyzed various resource management technique in cloud computing. By analyzing those techniques we understood resource management can be performed using Resource Identification, Resource Scheduling, Resource Provisioning, Real Time Resource Allocation in Infrastructure, Continuous Resource Monitoring, and Resource Consolidation with Resource Sharing. The global aim of resource management technique mainly to create high computing cloud infrastructure that operates with energy efficient way to achieve higher customer satisfaction. As discussed above all technique bring huge advantages to cloud computing service provider but still lot of open issues are found and if its rectified with proper solution then cloud computing provider will achieve greater customer satisfaction. Some of the open research areas in cloud computing are resource performance issues, security and privacy related issues, different resource scheduling issues. We observed following metrics in existing research work that helps us to focus our research works on below mentioned parameters such as Input Output Operation Per Second, Task Completion Time, Upload & Download Bandwidth, Response time, Instruction Execution time per Second, etc. In our next research we work on deep learning based resource management technique for cloud computing.

Conflicts of Interest

"The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper."

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Author Contribution Statement

Senthil Kumar K and Anandamurugan S collected and reviewed articles from different journals. Senthil Kumar K and Anandamurugan S created literature review table. Senthil Kumar K wrote the manuscript. All authors read and approved the manuscript.

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