Adaptive Threshold Based Dynamic Resource Provisioning in Cloud Environment

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***Abstract*— Cloud computing becomes a widely adopted platform, can be viewed as a single repository contains services, information processing equipment and Storage devices in a very large scale. Cloud services can be accessed anytime from anywhere over the internet. On demand service delivery makes cloud computing most popular, motivating the researchers to focus on it. Dynamic resource management and adaptability with the varying application workload are the major challenges associated with the on- demand allocation of resources in cloud environment. Existing methods for the on-demand resource allocation emphasizes on migration of VM and allocation of physical resource to VMs. Such algorithms results suspension of application due to mandatory shutdown of associated VM and requires an efficient procedure for the allocation of resource under cloud computing environment. Proposed adaptive threshold based dynamic resource allocation policy monitor and predict minimal resource requirement and adjust virtualized resources depending on application's real resource requirement.**

***Keywords*— Cloud Computing, Dynamic resource provisioning, Adaptive Threshold, Virtual machine, Virtualization, VM Migration.**

I. INTRODUCTION

In present computing environment great number of internet services such as e-commerce, social networking and multimedia services etc. are hosted on virtualized cloud system. Internet services are now wrapped on multiple virtual machines hosted on few number of physical servers, consolidates virtualization with cloud computing technology. To handle variable workload without SLA violation is a challenging scheduling problem [1] for cloud providers, requires dynamic resources management.

Conventional computing requires definite amount of computational resources [2] to fulfil application load requirement. Such fixed load based allocation strategies may result underutilization of physical resource. Fixed load based resource allocation strategies [3] having two variants average load based and peak load based. Average load based resource allocation strategies becomes fails to satisfy application peak load requirement while peak load based resource allocation results underutilization of physical resources. Dynamic resource allocation strategies allocates resources according to the real application requirement and enables cloud service provider to satisfy peak load requirement without underutilization of resources. Under the cloud computing environment dynamic resource allocation [4] becomes popular which supports on demand allocation of resources.

The major limitation associated with the dynamic resource allocation is the frequent allocation and re-allocation of resources. Threshold based adaptive resource allocation schemes having calibre to configure virtual resources with respect to load changes, thus it is capable to save up virtual resources reallocation. Thus delivers higher utilization of virtual resources with reduced associated cost.[4]. The proposed algorithm emphasizes optimization of resources at the application level in contrast of allocating physical resources to virtual machine at physical level. The adaptive threshold based resource allocation policy works on multiple intervals in which threshold calculated for any particular interval will be treated as resultant threshold for upcoming intervals. The proposed adaptive threshold based resource allocation strategies restricts frequent allocation of virtual machines as frequent allocation and reallocation causes unnecessary slowdown in application performance.

For the purpose of guaranteed performance at the period of peak load virtual machine processing capacity is often over provisioned. These conditions lead to poor server utilization and restricting cloud providers to exploit the benefits of statistical multiplexing [5]. Cloud computing widely used for internet based application in which pool of sheared resources are available on demand for the purpose of computation. Cloud computing enables users and organizations to process and store data in the data centre installed by the cloud providers [6].

Users can use desired services without the installation of dedicated local server's storage devices. Cloud resources are accessible ubiquitously and accessible on demand basis with economic cost over the Internet. In general cloud services can be broken down into three major components like application processing, network connectivity and storage requirement. Cloud consumer consumes CPU processing cycles, network bandwidth, storage space etc. from cloud and pay accordingly to the cloud providers [7].

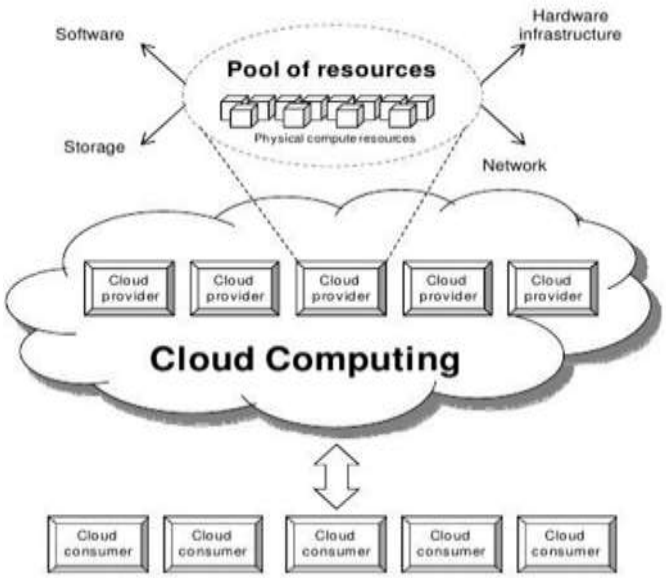

Fig 1: Cloud Computing Architecture

II. RELATED WORK

Recently quite a few schemes have been proposed provides different resource allocation policies based on the prediction of resource requirement in cloud environment. The wide adaptation of the cloud computing causes researchers to focus on it. The various surveys [1,2] on the cloud environments highlights major challenges in the full adaptation of cloud computing. Study of existing resource allocation policies and job scheduling algorithms [2] was performed by Lu Huang and Hai-shan Chen summarizes methods for the improvement in the performance including dynamic resource allocation strategies. On demand resources allocation and rapid elasticity are the major key features of the cloud computing [5]. The major challenge associated with the on demand resource allocation is the resource provisioning and dynamic management of resources [6].

In [6] comparison in static and dynamic resource provisioning techniques was highlighted by B. H. Bhavani and H. S. Guru Prasad. In adaptive resource allocation schemes variation in the workload can be handled adaptively using near-minimum resources. Recently quite a few resource allocation schemes have been proposed provides different approaches for resource allocation in cloud computing environment. Some major approaches for resource allocation are ant colony optimization algorithm for resource allocation, genetic algorithm for dual fitness, threshold based scheduling algorithm for job scheduling.

Most of the existing method focuses on the migration of virtual machines for load balancing[8] and allocation of physical resources to their associated virtual machines for batter resource utilization. Adaptive resource allocation in cloud environment scheme is implemented under the Cloudsim environment [10]. Static and dynamic resource provisioning techniques both having their merits and associated challenges [17]. Resource provisioning techniques have to meet availability, throughput, response time, reliability and other quality of service parameter without violation of service level agreement [18]. As cloud clouting provides elasticity and dynamic allocation of resources having major challenge of resource provisioning that is to determine right amount of resources for execution. The major constraint behind that resource allocation techniques are reduced power consumption, minimal cost and maximum utilization of resources [19].

Approach for the resource allocation in network operator cloud [20] is proposed by J.Soares and J. Carapinha. In this work it is envisioned that for the integration of cloud and networks is possible. As per this approach cloud resources are not limited to the datacentre but they are spread throughout the network, which are owned by the network operator. Such type of resource management is required in both levels (datacentre and network level) by an integrated approach. In [21] multistep time series prediction scheme was used to predict future usage of each type of resources. Then analysis of prediction series was performed to determine server state for next scheduling period. Sadeka Islam, Jackey Keung proposed empirical prediction model for adaptive resource provisioning in the cloud [27] offers more adaptive resource management for the application hosted in cloud environment. With the help of neural network and linear regression prediction for the future resource demand is possible. In both of these method suspensions of cloud computing application is essential to address this problem.

Qingjia Huang , Kai Shuang proposed a prediction-based dynamic resource scheduling for virtualized cloud system. Consolidates virtualization with adaptive resource allocation schemes and minimizes requirement of virtual and physical machine without breach in SLA. The idea behind the prediction based scheduling is to reserve significant amount of resources for network application to guarantee the performance. With prediction based dynamic resource allocation variation in the workload can be handled adaptively with near-minimum resources. Prediction based algorithms [26-28] can consolidates virtualization with adaptive resource allocation schemes and minimizes requirement of virtual and physical resources without breach in SLA[26]. The idea behind the prediction based scheduling is to reserve significant amount of resources for internet based applications to guarantee the optimal performance. One new approach is adopted [29] in which virtual machines are treated as the minimal resource allocation unit. Performance study of the scheme is performed under different scenarios. Finally results are concluded. Results contain multiple future possibilities.

To evaluate the performance of the resource provisioning algorithms a toolkit called Cloudsim is developed which model and simulates cloud environment [31] by . N. Calheiros,

R. Ranjan, A. Beloglazov. Rajkumar Buyya, Rodrigo N. Calheiros, Rajiv Ranjan described the internal architecture and features of the CloudSim: A toolkit for modelling and simulation [32-34] under cloud computing environment and evolution of resource provisioning algorithms.

III. Resource Allocation in Cloud environment : Associated Challenges

Conventional resource allocation policies assigns fixed amount of computational resources to anticipate application resource demand. Such fixed amount based resource allocation policies allocates resources either on the basis of application peak load requirement or on the basis of average load requirement. These two types of fixed resource allocation strategies having their associated shortcomings like underutilization of resources (in average load) and unsatisfied resource request (in peak demand) respectively. As the network application having variable workload during its lifetime, thus to fulfil on demand resource request dynamic resource allocation is essential which results higher resource utilization [8]. The major challenge associated with dynamic on demand resource allocation is creation and destruction of virtual machines which causes extra overhead and slowdown of application. [9]

In ordinary circumstances incoming load of internet applications/web applications is highly dynamic and oscillate during the lifetime of application. If we use a constant load based allocation scheme for providing constant amount of resources to an application, then it is possible due to insufficient resources the execution of that application will take very long time, in contrast it is also possible that superabundant allocation of resources will cause idleness of resources when application is not working with its full load holding capacity. In this way we can improve our resource usage with dynamic resource allocation policies. For implementation of dynamic resource allocation policy based on threshold calculation we have to keep track and foretell need of resources for a cloud application to coordinate VMs according to actual need of application. Adaptive Threshold based resource allocation schemes can be used to enhance performance which dynamically allocate resources according to load changes.

IV. Adaptive-threshold based Resource Allocation

Efficiency of resource allocation policies depend on the fact that when allocation and de-allocation of cloud resources will be performed. Frequent allocation and de-allocation of cloud resources can reduce the efficiency of cloud application, which will cost additional computation time and physical resource. Dynamic resource allocation with adoptive interval calculation policy can be one of the solutions of the above problem. Experimental results show that there is oscillation in applications load during lifetime of an application. Extra overhead can be caused by diverse allocation and de-allocation of cloud resources. We can schedule an allocation policy which is based on present load of application. Then we can avoid overhead due to useless allocation because of oscillation in the application workload. Time of resource allocation can be controlled by threshold based resource allocation.

In adaptive threshold based resource allocation policy reallocation interval between two successive resource requests is set to be adaptive according to load change. When application load change is rapid then we use shorter interval for resource allocation. Applications for which change in load is slow with steady pace then longer interval for resource reallocation is selected. In case large resource allocation interval adopted the resultant system can become unable to handle frequent load changes and will cause inefficient use of virtual resources and reduce the overall performance of the system. On the other hand overhead of resource allocation becomes higher shorter interval between two resource allocations.

Proposed approach limits frequent allocation and de-allocation of virtual machines, aims higher efficiency for cloud application. Virtual machines reallocation take place only if there is sudden change in application workload. The experimental results in CloudSim toolkit shows that proposed scheme can improve resource utilization hence user usage cost can be reduced [31-34]. In the view of the above threshold based dynamic resource allocation having their prime importance.

V. Resource Allocation in Cloud environment : Associated Challenges

A resource reallocation takes place only if the applications load changes (up or down) is over L threshold, where $L_{threshold}$ is defined as-

$$L_{threshold} = R_{threshold} * (1-R_{norm}) * K * L_{max}$$

$L_{threshold}$ = System reserves some virtual Resources to anticipate sudden increase in applications load.

$R_{threshold}$ = threshold rate (between sign 0 to 1)

R_{norm} = normal workload rate (0 to 1) is redefined by system admin according to applications loads.

K = Current number of virtual machines.

L_{max} = maximum workload of a VM

$$L_{norm} = L_{max} * R_{norm}$$

VI. Algorithm for Resource Allocation

Proposed resource allocation based on adaptive threshold calculation combines two main procedures- Broker and Datacentre procedure. The broker procedure runs on user's machine with the application. The datacentre procedure, which works as the manager of the cloud computing resources, runs on the datacentre's central computer.

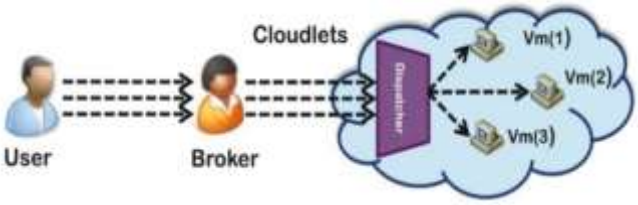

Fig 2: Cloud Computing Architecture

```
do
{
    //Wait for next reallocation cycle
    cal threshold(); // method to calculate new threshold;
    init broker();      // method to initialize broker;

    if(currentCpuLoad()>normalCpuLoad()+CpuThreshold)
    {
        calculate the amount of new virtual machine needed;
        request Datacenter for more virtual machine;

        //wait for response from datacenter

        add new virtual machine to local virtual machine list;
    }//end if

    if(currentRamRequirment()>normalRamRequirment()+RamThreshold
    {
        calculate the amount of new virtual machine needed;
        request Datacenter for more virtual machine;

        //wait for response from datacenter

        add new virtual machine to local virtual machine list;
    }//end if

    if(currentCpuLoad()<normalCpuLoad()-CpuThreshold)
    {
        calculate the amount of virtual machines to be released;
        send a request to datacenter to revoke virtual machines;
        remove released  virtual machines from local virtual machine list;
    }//end if

    if(currentRamRequirment()<normalRamRequirment()-RamThreshold
    {
        calculate the amount of virtual machines to be released;
        send a request to datacenter to revoke virtual machines;
        remove released  virtual machines from local virtual machine list;
    }//end if

}while(system is running)
```

Figure 3: broker pseudo code

These two procedures interact with each other to dynamically manage the virtual resources for cloud applications. In this scheme, the Datacentre procedure, which manages the physical resources such as CPU and RAM, waits for requests from brokers, and provides additional virtual resources (VMs) or revoke excessive virtual resources (VMs) based on the requests from brokers. The broker procedure determines whether an application needs more virtual resources or excessive virtual resources owned by an application need to be revoked based on applications load changes. The pseudo code of these two procedures is depicted as follows-

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```
do
{
    //Wait for broker to submit requests
    if(broker  requests new virtual machines)
    {
        Allocate virtual machine to broker ;
        start application on new virtual machine ;
    }//end if

    if(broker releases virtual machine)
    {
        Revoke virtual machine released by broker ;
    }//end if

}while(system is running)
```

Figure 4: Broker Pseudo Code

VII. EXPERIMENTAL RESULT

This section contains the experimental results obtained after applying adaptive threshold based resource allocation scheme. The proposed work is simulated under the modelling and simulation toolkit called Cloud sim and Java language. The application workload is modelled by the various cloudlets contains distinct CPU and RAM requirement. Some snapshots depict the proposed work as under. Each cloudlet contains application workload will require some amount of computational resources.

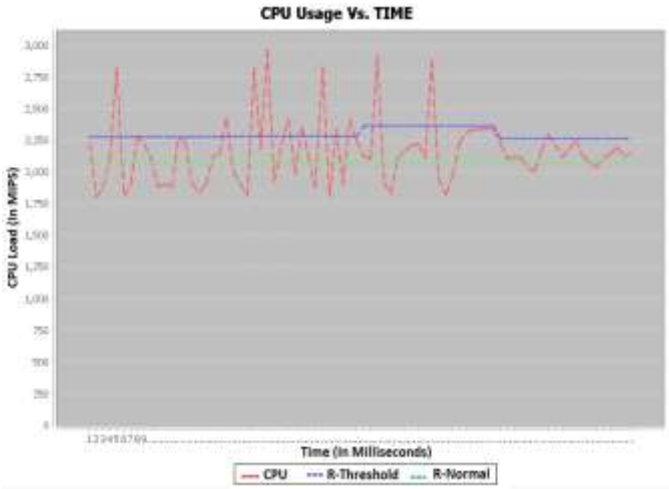

Fig 5: Graphical Representation of CPU Utilization

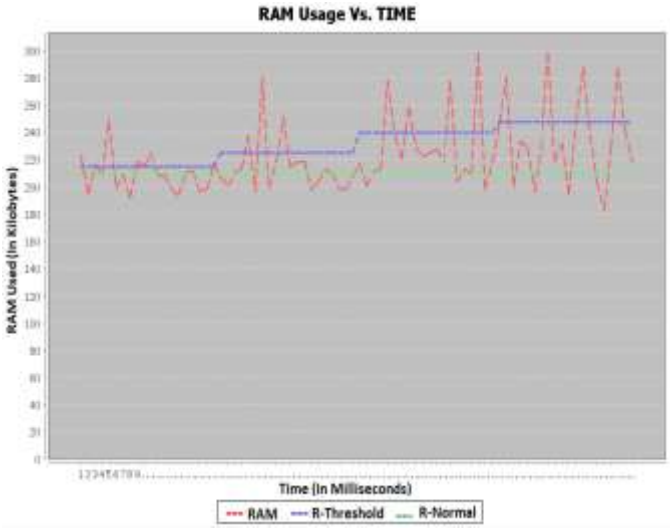

Fig 6: Graphical View of RAM utilization

The amount of CPU and RAM required by cloud application in any stage of time is depicted in Fig 5 and Fig 6. The oscillating workload to the cloud application is represented by the red line. The horizontal green line depicts the normal workload rate to cloud infrastructure. The amount of reserved resources to anticipate the sudden increase in application load is depicted with blue coloured line.

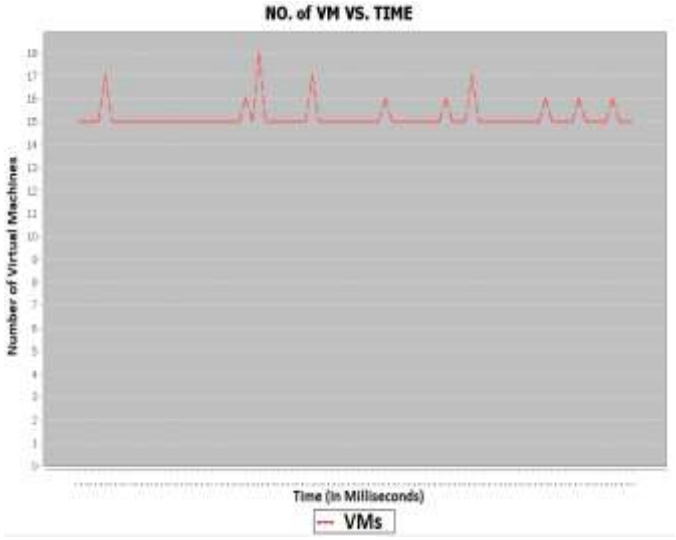

Fig 7: Graphical Representation VM.

Fig 7 shows the number of virtual machines required at any stage of time using adaptive threshold based resource allocation scheme. The comparison of CPU utilization percentage is shown in fig 8.

VIII. CONCLUSION AND FUTURE WORK

Internet can be viewed as a huge pool of resources; these resources are available for each user as a service. Network is on the next stage of revolution, now resources are available in an omnibus manner and can be readily shared. Cloud computing be-comes a fundamental ingredient in this scenario, having calibre to reduce associated cost with greater flexibility and ability to scale. Resource allocation in cloud computing having supreme importance which is related to the efficiency of the whole computing environment. Resource should be allocated in such manner that operative cost and computation time can be minimized.

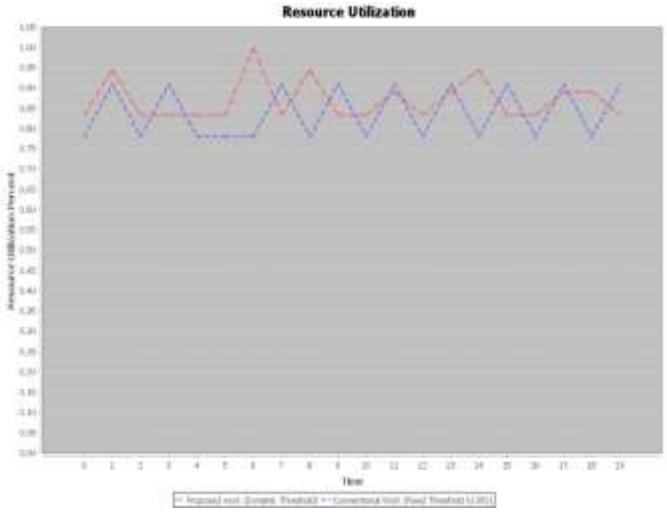

Fig 8: Comparison of Resource utilization

The conventional resource allocation scheme used for allocating resource to an application is based on fixed allocation to satisfy application's peak load request. Such fixed peak load based allocation schemes may lead to underutilization of computing resources. To address this problem threshold based dynamic resource allocation scheme can become milestone, which can monitor and predict actual resource need and adjust virtualized resources based on applications real needs.

Resource allocation techniques with their performance analysis are discussed in literature survey. Experimental results show oscillation in applications load during lifetime of an application. Extra overhead can be caused by diverse allocation and re-allocation of cloud resources. Threshold-based dynamic resource allocation policies having dynamic threshold calculation in fixed interval can address such allocation and re-allocation problem.

To make threshold based resource allocation more effective when we choose large resource allocation interval then the resultant system become unable to handle frequent load changes. On the other hand overhead of resource allocation becomes much higher when we choose shorter interval between two resource allocations. We can use dynamic resource allocation interval to address this problems. This will help us to obtain higher resource utilization hence associated cost can be reduced.

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