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A Comparative Study on Resource Allocation Policies in Cloud Computing Environment

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Abstract: Cloud computing is one of the latest models used for sharing pool of resources like CPU, memory, network bandwidth, hard drive etc. over the Internet. These resources are requested by the cloud user and are used on a rented basis just like electricity, water, LPG etc. When requests are made by the cloud user, allocation has to be done by the cloud service provider. With the limited amount of resources available, resource allocation becomes a challenging task for the cloud service provider as the resources are to be virtualized and allocated. These resources can be allocated dynamically or statically based on the type of request made by the cloud user and also depending on the application. In this paper, survey on both Static and Dynamic Allocation techniques are made. Also, comparison of both static and dynamic resource allocation techniques is made.

Keywords: Cloud Computing, Resource Allocation, Static, Dynamic.

I. INTRODUCTION

Cloud Computing is the emerging technology where the services are provided over the Internet. This has become a preferred option for many business contexts. Rather than owning the resources, they are used on a rented basis. This avoids the cloud user the head ache of managing the resources which has to be owned by them instead. For providing the service by the cloud service provider and using the services by the cloud user, an initial agreement called the Service Level Agreement (SLA) has to be made between the cloud users and the cloud service provider. While resource allocation is made to the cloud user, SLA violation should be avoided as much as possible or SLA violation should be minimal without compromising Quality of Service (QoS) parameters like performance, availability, response time, security, reliability, throughput etc. In order to efficiently utilize resources, various resource allocation techniques are to be used. For allocating the resources, virtualization technique has to be used. Since the actual physical resources available are less than the resource demand, virtual resources are to be created, mapped onto the physical resources, and these virtual resources are to be allocated to the requesting cloud user. After utilization of the virtual resources, they have to be destroyed by the cloud service provider. All these have to be made without violating SLA by meeting QoS.

With the limited amount of physical resources available, resource allocation becomes a challenging task for the cloud service provider. Since cloud computing is a multi-tenancy model, multiple users' requests for the cloud resources. So cloud service provider has to decide on how many virtual resources are to be created based on the cloud users' requests. Also which virtual machine (VM) has to be mapped onto which physical machine (PM) has to be taken care. That is, VM-PM mapping techniques have to be considered. At what instance VM migration has to be done is also based on identifying heavily loaded node and lightly loaded node. So the ultimate goal of the cloud service provider is to maximize profit and maximize resource utilization and the goal of cloud user is to minimize payment by renting the resources.

There are various parameters to be considered while allocating resources. While allocating resources to the cloud user, underutilization (wastage) of resources due to over provisioning and overutilization (due to under provisioning) should be avoided. Allocation of resources should consider various parameters like Quality of Service parameters like response time, performance, availability, reliability, security, throughput etc.

Performance: For some application demands, performance is one of the important criteria. The system should perform well to provide service to the cloud user.

Response Time: For interactive applications, response time is an important factor. The system must respond well for these kinds of applications.

Reliability: The system used should be reliable so that the cloud user has no head ache of changing the system.

Availability: Whenever cloud resources are requested the cloud service provider must be able to allocate within short span.

Security: For critical applications like online transaction applications, system used has to be secure. Otherwise it is not safe to use such a kind of system.

Throughput: No. of applications run per unit time should be more.

For efficient resource allocation all the above parameters are to be considered.

The rest of the paper is organized as follows. Section II discusses Static Allocation Techniques, Section III discusses Dynamic Allocation Techniques, Section IV gives a comparative study of resource allocation techniques and Section V gives conclusion.

There are two major types of resource allocation techniques.

Static Allocation: In this case, the cloud user has to make prior request for the resources. By doing so user knows what resources are required and how many instances of the resources are needed ahead of using the system. But the drawback in this case is it leads to underutilization or overutilization of resources depending on the time the application is run.

Dynamic Allocation: Cloud resources are requested by the cloud user on the fly or as and when the

application needs. Here underutilization and overutilization of resources is avoided as much as possible. But the requested resources might not be available when requested on the fly. The service provider has to make allocation from other participating cloud data center.

Resource Allocation Techniques

There are many resource allocation techniques both static and dynamic each having its own advantages and limitations.

II. STATIC RESOURCE ALLOCATION TECHNIQUES

Ruben Van den Bossche et. al. [10] have discussed about online cost-efficient scheduling. For efficient utilization of resources and to minimize cost, a hybrid cloud scheduling algorithm is used for hybrid clouds. The need for hybrid cloud determines which workload type has to be outsourced and to which cloud service provider. These decisions should minimize the cost of running the part of the total workload on one or more multiple cloud providers which must take into account application requirement such as deadline constraint and data requirement. Variety of cost factors, pricing models, and cloud provider offerings further makes use of automated scheduling approach in hybrid clouds. These issues are tackled by a set of algorithms to cost efficiently schedule the deadline constrained set of applications on both public cloud provider and private cloud infrastructure. These algorithms take into account both computational and data transfer costs as well as network bandwidth constraints.

Siva Theja Maguluri et. al. [26] have discussed about Heavy Traffic Optimal Resource Allocation Algorithms. In this paper, a stochastic model of cloud computing is studied, where jobs arrive according to a stochastic process and request resources like CPU, memory and storage space. A model is considered where the resource allocation problem can be separated into a routing or load balancing problem and a scheduling problem. Join-the-shortest-queue routing and power of-two-choices routing algorithms with MaxWeight scheduling algorithm is studied. These algorithms are throughput optimal and it shows that these algorithms are queue length optimal in the heavy traffic limit.

Mohammad Firoj Mithani et. al. [17] have discussed about Resource Allocation in Multi-Tier Cloud Systems. The problem of over provisioning of resources for enterprise-class applications hosted in cloud systems is addressed and ways to minimize over-provisioning of IT resources in multi-tier cloud systems is proposed by adopting an innovative approach of application performance monitoring and resource allocation at individual tier levels, on the basis of criticality of the business services and availability of the resources. To prevent over-provisioning of resources and improve the cloud managed resource allocation processes, an intermediate 'Tier-centric Business Impact and Cost Analysis' (T-BICA) capability to monitor performance of the business application tiers, including infrastructure components at each tier by leveraging existing monitoring layer is introduced.

Ikki Fujiwara et. al. [25] have applied double-sided combinatorial auctions to resource allocation. A market-based resource allocation will be effective in a cloud computing environment where resources are virtualized and delivered to users as services. Such a market mechanism is proposed to allocate services to participants efficiently. The mechanism enables users (1) to order a combination of services for workflows and co allocations and (2) to reserve future/current services in a forward/spot market. The forward market and the spot market run independently to make predictable and flexible allocations at the same time.

Davide Adami et. al. [4] have proposed effective control strategies using openflow in Cloud Data Center. A unified control and management of computing and network resources would be required for assuring proper traffic performances in high volatile virtual machine deployments. This paper introduces a novel resource control platform for virtualized DC environments aimed at optimizing virtual machine placement on physical servers also considering traffic load across links in order to limit oversubscription-related problems. For this purpose Open Flow statistics are elaborated for their distinguished features that well suit virtualized environments. Two novel algorithms have been proposed and the effectiveness of proposed traffic-aware VM placement strategies is evaluated.

Hong Xu et. al. [2] have proposed Anchor, a versatile and efficient framework for Resource management. Anchor is a general resource management architecture that uses the stable matching framework to separate policies from mechanisms when mapping virtual machines to physical servers. In Anchor, clients and operators are able to express a variety of different resource management policies, and these policies are captured as preferences in the stable matching framework. The highlight of Anchor is a new many-to-one stable matching theory that efficiently matches VMs with heterogeneous resource needs to servers, using both offline and online algorithms.

Sheng Di et. al. [5] have discussed about error-tolerant allocation and payment minimization. With virtual machine (VM) technology being increasingly mature, compute resources in cloud systems can be partitioned in fine granularity and allocated on demand. Three contributions in this paper are: 1) Deadline-driven resource allocation problem is formulated based on the cloud environment facilitated with VM resource isolation technology, and also a novel solution with polynomial time is proposed, which could minimize users' payment in terms of their expected deadlines. 2) By analyzing the upper bound of task execution length based on the possibly inaccurate workload prediction, further an error-tolerant method is proposed to guarantee task's completion within its deadline. 3) Its effectiveness over a real VM-facilitated cluster environment under different levels of competition is validated.

Shuo Zhang et. al. [9] have proposed a novel resource allocation algorithm for a Heterogeneous Data Center. The issue concerned about data centers is huge energy consumption, which not only increases operational cost, but also causes environment problems. One way to reduce energy consumption is decreasing the scale of data centers, and another way is using well-designed resource allocation algorithm to achieve the tradeoff between energy consumption and performance. This paper focuses on well-designed resource allocation algorithm. First the resource allocation problem in a heterogeneous data center is discussed, and then a novel resource allocation algorithm is proposed based on fair scheduling policy and energy-aware policy to this problem.

Ping Guo et. al. [6] have discussed about hierarchical resource management model. In order to resolve the heavy load and the long waiting time in the centralized resource management, new better model, which is the hierarchical resource management model based on resource tables is proposed. This paper

describes the model of hierarchical management system and the process of the resource allocation; giving the form of the resource table in this model and the access control policy of the resource table.

Li Chunlin et. al. [8] studies multi-layer optimization in service oriented cloud computing to optimize the utility function of cloud computing, subject to resource constraints of an IaaS provider at the resource layer, service provisioning constraints of a SaaS provider at the service layer, and user QoS constraints of cloud users at application layer, respectively. The multi-layer optimization problem can be decomposed into three sub problems: cloud computing resource allocation problem, SaaS service provisioning problem, and user QoS maximization problem. The proposed algorithm decomposes the global optimization problem of cloud computing into three sub-problems via an iterative algorithm.

Saeed Al-Haj et. al. [27] have discussed about security-aware resource allocation in clouds. The problem of resource allocation in IaaS clouds is considered while factoring in reachability and access control requirements of the cloud virtual machines (VMs). A security-aware resource allocation framework is described that allows for effective enforcement of defense-in-depth for cloud VMs by determining (1) the grouping of VMs into security groups based on the similarity of their reachability requirements, and (2) the placement of virtual machines in a manner that reduces residual risks for individual VMs as well as security groups. Security-aware resource allocation as a Constraint Satisfaction Problem (CSP) is formalized, which can be solved using widely available Satisfiability Modulo Theories (SMT) solvers.

Baomin Xu et. al. [21] discusses about job scheduling algorithm based on Berger Model. Job scheduling algorithm based on Berger model is used and in the job scheduling process, the algorithm establishes dual fairness constraint. The first constraint is to classify user tasks by QoS preferences, and establish the general expectation function in accordance with the classification of tasks to retain the fairness of the resources in selection process. The second constraint is to define resource fairness justice function to judge the fairness of the resources allocation.

III. DYNAMIC RESOURCE ALLOCATION TECHNIQUES

Valérie Danielle Justafort et. al. [13] discusses about Performance-Aware Virtual Machine Allocation. Cloud Computing has major challenges among which virtual machine (VM) placement is considered as one of the crucial problems. From the cloud provider's perspective, this process often consists in choosing the best convenient physical hosts with regards to energy efficiency, resource utilization and revenues maximization. However, to secure the loyalty of their clients, cloud providers should also consider the applications performance. In this paper, VM placement approach is proposed tackling the applications performance concern, in an inter cloud environment. VM placement is stated as a mixed integer programming problem which aims to maximize a global utility function considering VM bandwidth requirements and network latencies.

Bo Yin et. al. [22] discusses about multi-dimensional resource allocation. In this paper, study on the resource allocation at the application level is done, instead to map the physical resources to virtual resources for better resource utilization in cloud computing environment. A multi-dimensional resource allocation (MDRA) scheme for cloud computing is proposed that dynamically allocates the virtual resources among the cloud computing applications to reduce cost by using fewer nodes to process applications. In this model, a two-stage algorithm is adopted to solve this multi-constraint integer programming problem. The algorithm can dynamically reconfigure the virtual machines for cloud applications according to the load changes in cloud applications by assigning new applications on the working node instead of opening a new node. Experiment results show that this algorithm can save resources and increase resource utilization as well as centralize working nodes. MDRA provide resource to deal with requirements more steadily. Moreover, the proposed algorithm in the long run can save power efficiently when the demand of user is decreasing.

Amit Nathani et. al. [14] have proposed policy based resource allocation in IaaS cloud. Most of the Infrastructure as a Service Cloud (IaaS) uses simple resource allocation techniques like immediate and best effort. Immediate Resource Allocation Policy allocates the resource if available otherwise the request is rejected. Best effort policy also resources if currently available otherwise the request is placed in the FIFO queue. So it is not possible for the Service provider to satisfy all the requests as there is finite number of resources at a time. So Haizea is a resource lease manager that addresses these issues by using complex resource allocation strategies. Haizea uses resource leases as resource abstraction and implements these leases by allocating Virtual Machines (VMs). Haizea supports four resource allocation policies: Immediate, best effort, advanced reservation and deadline sensitive. Among the four, deadline sensitive leases by Haizea supports minimal rejection of leases and using this policy, maximum resource utilization is possible. Dynamic Planning based scheduling algorithm is implemented in Haizea which can admit leases and prepare a schedule whenever a new lease can be accommodated.

Sharrukh Zaman et. al. [1] discusses online mechanism for dynamic VM provisioning and allocation. Current cloud provider allocates virtual machine instances via fixed price-based or auction based mechanisms. The limitation in these mechanisms is they are all offline mechanism and they need to collect information and invoked periodically. This limitation is addressed by designing an online mechanism by dynamically provisioning and allocating Virtual machine Instances in Clouds. The algorithm called Mechanism for online VM provisioning and allocation (MOVMPA) is invoked as soon as the user makes a request or some VM instances already become available again. When invoked, the mechanism selects users who would be allocated VM instances they requested for and ensures that those users will continue using for the entire period they requested for.

Mayank Mishra et. al. [3] proposed dynamic resource management using Virtual Machine Migrations. Virtual machine related features such as flexible resource provisioning, and isolation and migration of machine state have improved efficiency of resource usage and dynamic resource provisioning capabilities. Live virtual machine migration transfers "state" of a virtual machine from one physical machine to another, and can mitigate overload conditions and enables uninterrupted maintenance activities. This paper focuses on the details of virtual machine migration techniques and their usage toward dynamic resource management in virtualized environments.

Tianyu Wo et. al. [12] have proposed overbooking-based resource allocation in virtualized data center.

Efficient resource management, particularly, economic allocation mechanism is desired to maximize the revenue for commercial cloud providers. This paper uses overbooking from revenue management to avoid resource over-provision according to its runtime demand. An economic model is proposed to control the overbooking policy while provide users probability based performance guarantee using risk estimation. To cooperate with overbooking policy, VM placement is optimized with traffic-aware strategy to satisfy application's QoS requirement. GreedySelePod algorithm is designed to achieve traffic localization in order to reduce network bandwidth consumption, especially the network bottleneck bandwidth, thus to accept more requests and increase the revenue in the future.

Gihun Jung et. al. [23] discusses about agent-based adaptive resource allocation. Since both cloud users and data centers of a cloud service provider can be distributed geographically, the provider needs to allocate each user request to an appropriate data center among the distributed data centers, so that the users can satisfy with the service in terms of fast allocation time and execution response time. In this paper, an adaptive resource allocation model is proposed that allocates the cloud user's job to an appropriate data center. The method to adaptively find a proper data center is based on two evaluations: 1) the geographical distance (network delay) between a cloud user and data centers, and 2) the workload of each data center. The proposed model can successfully allocate cloud users' requests to the data center closest to each consumer. Also, the proposed model shows a better response time for allocation than related resource allocation models.

Xiao-Jun Chen et. al. [16] discusses about resource reconstruction algorithms for on-demand allocation. Resource reconstruction algorithms are used to solve the problem of on-demand resource allocation and can be used to improve the efficiency of resource utilization in virtual computing resource pool. The idea of resource virtualization and on the analysis of resource status transition these algorithms are used. These algorithms are designed to determine the resource reconstruction types and they can achieve the goal of on-demand resource allocation through three methodologies: resource combination, resource split, and resource random adjustment. These algorithms can do the resource adjustment on lower cost and form the logical resources to match the demands of resource users easily.

Jing Xiao et. al. [15] has proposed a priority based scheduling strategy for virtual machine allocation. In the cloud computing environment, the needs from each user do not be kept stable. Instead, they are randomly, for example, the request arriving time is a random factor and the amount of machines requested is still a random one. Therefore, the scheduling algorithm should try to allocate the requests to the resources dynamically rather than generating a static optimizing solution. Scheduling strategy plays an important role in service providing. A priority based algorithm for scheduling virtual machines on physical hosts in cloud computing environment is proposed. The target of this algorithm is to maximize the benefits of the service providers in the case of current resources are not enough to process all the requests in time. In this strategy, the requests are ranked according to the profits they can bring.

Gihun Jung et. al. [24] discusses about location-aware dynamic resource allocation model. In this paper, a dynamic resource allocation model based on the utilization level of PMs in data centers is proposed, and the location of user and data center on cloud computing environments. In addition, this paper also proposes resource management architecture to perform 1) location-aware VM placement and 2) dynamic resource utilization management. The proposed model guarantees to allocate a VM to an appropriate PM that has proper utilization level for the data center, which is not affecting the performance of each allocated VM, and better response time of each VM due to close location to user. The proposed model allows a provider to dynamically place a new VM to an appropriate PM that would achieve the best performance, guarantee the maximized utilization level, and prevent performance degradation, of the data center.

Makhlouf Hadji [7] discusses about minimum cost maximum flow algorithm for dynamic resource allocation. A minimum cost maximum flow algorithm is proposed for resources (e.g. virtual machines) placement in clouds considering dynamic workloads and flow variations. The algorithm is compared to an exact method generalizing the classical Bin-Packing formulation using a linear integer program. A directed graph is used to model the allocation problem for cloud resources organized in a finite number of resource types which is a common practice in cloud services. Providers can use the minimum cost maximum flow algorithm to opportunistically select the most appropriate physical resources to serve applications or to ensure elastic platform provisioning. The modified Bin-Packing algorithm is used to benchmark the minimum cost maximum flow solution. The latter combined with a prediction mechanism to handle dynamic variations achieves near optimal performance.

Ilhem Fajjari et. al. [11] discusses about optimized dynamic resource allocation algorithm for Cloud's Backbone Network. Because of the unpredictable and varying user's demands, a flexible and intelligent resource allocation scheme is necessary. This paper tackles the fundamental challenge of efficient resource allocation within cloud's backbone network. The ultimate goal is to satisfy the cloud's user requirements while maximizing cloud provider's revenue. The problem consists in embedding virtual networks within substrate infrastructure. A new dynamic adaptive virtual network resource allocation strategy named Backtracking-VNE is investigated to deal with the complexity of resource provisioning within cloud network. The proposal coordinates virtual nodes and virtual links mapping stages to optimize resources usage.

IV. COMPARISON OF RESOURCE ALLOCATION APPROACHES

Table 1 gives comparative study of Static Resource Allocation techniques. Table 2 gives a comparative study of Dynamic Resource Allocation Techniques. Table 3 gives a comparative study of Resource Allocation Techniques based on other parameters:

Table 1. Comparison of Static resource Allocation techniques

Allocation Strategies	Revenue Maximization	Efficient Resource Utilization	Improve Performance	Fair Scheduling	Efficient VM-PM Mapping	Cost Minimization
Hybrid Cloud Scheduling	✓	✓				✓
Tier-Centric Business Impact and Cost Analysis approach		✓		✓		
Anchor Resource Management Framework		✓	✓	✓	✓	
Efficient resource Control Strategies				✓	✓	
Error Tolerant resource Allocation						✓
Hierarchical Resource Management Model		✓				
Novel Resource Allocation				✓		
Multilayer Resource Management		✓	✓			
Berger Model based Job Scheduling				✓		
Heavy Traffic Optimal Resource Allocation			✓	✓		
Double-sided Combinational Auctions	✓			✓		
Security-Aware Resource Allocation				✓		

Table 2.Comparison of Dynamic Resource Allocation Techniques

Allocation Strategies	Revenue Maximization	Efficient Resource Utilization	Improve Performance	Fair Scheduling	Efficient VM-PM Mapping	Cost Minimization
Policy based Resource Allocation		✓				
Online Mechanism for Dynamic VM Provisioning and Allocation		✓				
Resource Reconstruction Algorithm		✓				
Priority-based Scheduling	✓	✓				
Performance Aware VM Allocation			✓			
Minimum cost maximum Flow Resource Allocation	✓	✓	✓			✓
VM migration based Resource Management					✓	
Overbooking based Resource Allocation	✓	✓	✓			
Optimized resource Allocation	✓	✓	✓			✓
Location-Aware Dynamic Resource Allocation		✓	✓			
Agent-based Adaptive Resource Allocation		✓	✓			
Multi-dimensional Resource Allocation		✓				

Table 3: Comparison of Resource Allocation techniques based on other parameters

Allocation Strategies	Fault tolerant	Prevent Over provisioning	Security	Energy Aware Policy
Error Tolerant resource Allocation	✓			
Novel Resource Allocation				✓
Security Aware Resource Allocation			✓	
Overbooking based resource allocation		✓	✓	
Multidimensional resource Allocation				✓
Tier-Centric Business Impact and Cost Analysis approach		✓		

V. CONCLUSION:

In this paper, survey on both static and dynamic resource allocation and management is made. Resource allocation in Cloud Computing Environment is an important and a major challenge as the resources available are less than the requested ones. At any point of time, cloud resources are to be allocated to the cloud user in order to run the application. So it becomes challenging for the cloud service provider to allocate resources considering various parameters like performance, availability, revenue maximization, reliability, security, response time, payment minimization, energy efficiency etc. depending on the application needs. The above algorithms satisfy some of the parameters even though all cannot be satisfied. In future, a framework has to be proposed in order to satisfy user needs without violating Service level Agreement and maximizing revenue.

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