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Resource Scheduling Techniques in Cloud Computing Environment : A Survey

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ABSTRACT

Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, applications and services) that can be rapidly provisioned and released. Resource Provisioning means the selection, deployment, and run-time management of software (e.g., database server management systems, load balancers) and hardware resources (e.g., CPU, storage, and network) for ensuring guaranteed performance for applications. Resource Provisioning is an important and challenging problem in the large-scale distributed systems such as Cloud computing environments. There are many resource provisioning techniques, both static and dynamic each one having its own advantages and also some challenges. These resource provisioning techniques used must meet Quality of Service (QoS) parameters like availability, throughput, response time, security, reliability etc., and thereby avoiding Service Level Agreement (SLA) violation. In this paper, survey on Static and Dynamic Resource Provisioning Techniques is made.

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

I. INTRODUCTION

Cloud Computing is the common buzzword in today's Information Technology. Cloud computing platforms are rapidly emerging as the preferred option for hosting applications in many business contexts [5]. An important feature of the cloud that differentiates it from traditional services is its apparently infinite amount of resource capacity (e.g. CPU, storage, Network) offered at a competitive rate. It eliminates the need for setting up infrastructure which takes several months. Start-up Companies need not invest on the infrastructure because the resources are available in the cloud [6]. Cloud Computing enables users to acquire resources dynamically and elastically. A major challenge in resource provisioning technique is to determine the right amount of resources required for the execution of work in order to minimize the financial cost from the perspective of users and to maximize the resource utilization from the perspective of service providers [4]. So, Cloud computing is one of the preferred options in today's enterprise.

Resource provisioning means the selection, deployment, and run-time management of software (e.g., database management servers, load balancers) and hardware resources (e.g., CPU, storage, and network) for ensuring guaranteed performance for applications. This resource provisioning takes Service Level Agreement (SLA) into consideration for providing service to the cloud users. This is an initial agreement between the cloud users and cloud service providers which ensures Quality of Service (QoS) parameters like performance, availability, reliability, response time etc. Based on the application needs

Static Provisioning/Dynamic Provisioning and Static/Dynamic Allocation of resources have to be made in order to efficiently make use of the resources without violating SLA and meeting these QoS parameters. Over provisioning and under provisioning of resources must be avoided. Another important constraint is power consumption. Care should be taken to reduce power consumption, power dissipation and also on VM placement. There should be techniques to avoid excess power consumption.

So the ultimate goal of the cloud user is to minimize cost by renting the resources and from the cloud service provider's perspective to maximize profit by efficiently allocating the resources. In order to achieve the goal the cloud user has to request cloud service provider to make a provision for the resources either statically or dynamically so that the cloud service provider will know how many instances of the resources and what resources are required for a particular application. By provisioning the resources, the QoS parameters like availability, throughput, security, response time, reliability, performance etc must be achieved without violating SLA.

The organization of the paper is as follows. Section II discusses about resource provisioning types. Section III discusses about parameters for resource provisioning. Section IV discusses various Resource Provisioning strategies. Section IV compares different resource provisioning techniques. Section V gives conclusion & future research directions.

II. METHODS AND MATERIAL

A. Resource Provisioning Types

Based on the application needs they are classified as

1) **Static Provisioning**: For applications that have predictable and generally unchanging demands/workloads, it is possible to use "static provisioning" effectively. With advance provisioning, the customer contracts with the provider for services and the provider prepares the appropriate resources in advance of start of service. The customer is charged a flat fee or is billed on a monthly basis.
2) **Dynamic Provisioning:** In cases where demand by applications may change or vary, "dynamic provisioning" techniques have been suggested whereby VMs may be migrated on-the-fly to new compute nodes within the cloud. With dynamic provisioning, the provider allocates more resources as they are needed and removes them when they are not. The customer is billed on a pay-per-use basis. When dynamic provisioning is used to create a hybrid cloud, it is sometimes referred to as cloud bursting.
3) **User Self-provisioning:** With user self-provisioning (also known as cloud self- service), the customer purchases resources from the cloud provider through a web form, creating a customer account and paying for resources with a credit card. The provider's resources are available for customer use within hours, if not minutes.

B. Parameters for Resource Provisioning

i) **Response time:** The resource provisioning algorithm designed must take minimal time to respond when executing the task.
ii) **Minimize Cost:** From the Cloud user point of view cost should be minimized.
iii) **Revenue Maximization:** This is to be achieved from the Cloud Service Provider's view.
iv) **Fault tolerant:** The algorithm should continue to provide service in spite of failure of nodes.
v) **Reduced SLA Violation:** The algorithm designed must be able to reduce SLA violation.
vi) **Reduced Power Consumption:** VM placement & migration techniques must lower power consumption.

C. Resource Provisioning Strategies

For efficiently making use of the Cloud Resources, resource provisioning techniques are to be used. There are many resource provisioning techniques both static and dynamic provisioning each having its own pros and cons. The provisioning techniques are used to improve QoS parameters [1,3,5,13], minimize cost for cloud user and maximize revenue for the Cloud Service Provider [17,25,30,32,38], improve response time [2], deliver services to cloud user even in presence of failures [11,14,15,31], improve performance [26,28,29,33,34,36] reduces SLA violation [27,37], efficiently uses cloud resources [4,6,9,10,16,19,20,22,24,40], reduces power consumption [7,21].

1. Static Resource Provisioning Techniques

Aneka's deadline driven provisioning technique is used for scientific application as scientific applications require large computing power. Aneka is a cloud application platform which is capable of provisioning resources which are obtained from various sources such as public and private clouds, clusters, grids and desktop grids. This technique efficiently allocates resources thereby reducing application execution time [5]. Because resource failures are inevitable it is a good idea to efficiently couple private and public cloud using an architectural framework for realizing the full potential of hybrid clouds. [11] proposes a failure- aware resource provisioning algorithm that is capable of providing cloud users' QoS requirements. This provides resource provisioning policies and proposes a scalable hybrid infrastructure to assure QoS of the users. This improves the deadline violation rate by 32% and 57% improvement in slowdown with a limited cost on a public cloud . Since resources held by single cloud are usually limited it is better to get resources from other participating clouds. But this is difficult to provide right resources from different cloud providers because management policies are different and description about various resources is different in each organization. Also interoperability is hard to achieve. To overcome this, Inter Cloud Resource Provisioning (ICRP) system is proposed in [20] where resources and tasks are described semantically and stored using resource ontology and using a semantic scheduler and a set of inference rules resources are assigned. With the increasing functionality and complexity in Cloud computing, resource failure cannot be avoided. So the proposed strategy in [31] addresses the question of provisioning resources to applications in the presence of failures in a hybrid cloud computing environment. It takes into account the workload model and the failure correlations to redirect requests to appropriate cloud providers. This is done using real failure traces and workload models, and it is found that the deadline violation rate of users' request is reduced by 20% with a limited cost on Amazon Public Cloud. The algorithm proposed in [13] aims to maximize revenue for SaaS users and also guaranteeing QoS requirements of SaaS users. The algorithm includes two sub algorithms at different levels; Interaction between the SaaS user and SaaS provider at the application layer and interaction between the SaaS provider and Cloud Resource Provider at the resource layer.

2. Dynamic Resource provisioning Techniques

The algorithm proposed in [2] is suitable for web applications where response time is one of the important factors. For web applications guaranteeing average response time is difficult because traffic patterns are highly dynamic and difficult to predict accurately and also due to the complex nature of the multi-tier web applications it is difficult to identify bottlenecks and resolving them automatically. This provisioning technique proposes a working prototype system for automatic detection and resolution of bottlenecks in a multi-tier cloud hosted web applications. This improves response time and also identifies over provisioned resources.

VM based resource management is a heavy weight task. So this is less flexible and less resource efficient. To overcome this, a lightweight approach called Elastic Application Container [EAC] is used for provisioning the resources where EAC is a virtual resource unit for providing better resource efficiency and more scalable applications. This EAC–oriented platform and algorithm is to support multi tenant cloud use [19]. Dynamic creation of the tenant is done by integrating cloud based services on the fly. But dynamic creation is by building the required components from the scratch. Even though multi-tenant systems save cost, but incur huge reconfiguration costs. This approach allows clients to specify their requirements which are not supported in previous techniques. This approach proposes a novel user interface-tenant selector (UTC) model which enables cloud based services to be systematically modeled and provisioned as variants of existing service tenants in the cloud. This considers functional, non functional and resource allocation requirements which are explicitly specified by the client via the user interface component of the model. So the cost and time is saved in this approach [15].

The technique proposed in [7] makes use of the provisioner called adaptive power-aware virtual machine provisioner (APA-VMP) where the resources are provisioned dynamically from the resource pool. This is from Infrastructure-as-a-Service provider point of view where the custom Virtual machines (VM) are launched in appropriate server in a data center. The cloud data center considered is heterogeneous and large scale in nature. The proposed meta scheduler maps efficiently a set of VM instances onto a set of servers from a highly dynamic resource pool by fulfilling resource requirements of maximum number of workloads. This technique reduces power consumption without affecting performance.

Server Consolidation is a technique to save on energy costs in virtualized data centers. The instantiation of a given set of Virtual Machines (VMs) to Physical Machines (PMs) can be thought of as a provisioning step where amount of resources to be allocated to a VM is determined and a placement step which decides which VMs can be placed together on physical machines thereby allocating VMs to PMs. Here a provisioning scheme is proposed which takes into account acceptable intensity of violation of provisioned resources. Correlation among aggregated resource demands of VMs is considered when VMs are mapped to PMs. This reduces number of servers (up to 32%) required to host 1000 VMs and thus enables to turn off unnecessary servers [21]. In Cloud Computing federated Cloud Environment is used when the resource requirement of user requests exceeds the resource limits of Cloud Providers' resources. It is desirable to reduce SLA violation which can be achieved through load balancing algorithm that is threshold based. This algorithm allocates VMs in order to balance the load among multiple datacenters in a federated cloud environment by focusing on reducing users' SLA violation [27].

Provisioning of collection of Virtual Machines (VMs) having different placement constraints given a set of Physical Machines (PMs) with known specifications is done by two approaches [38]. The first is based on the formulation of problem of an Integer Linear Programming problem which provides solution for optimal VM placement. The second is a heuristic based on classifying requests into different categories and satisfying the constraint in a particular order using a first fit decreasing (FFD) algorithm. This is to maximize IaaS Cloud Provider's revenue.

III. RESULTS AND DISCUSSION

Comparison of Resource Provisioning Techniques:

Sl. No.	Resource Provisioning Techniques	Merits	Challenges
1	Deadline-driven provisioning of resources for scientific applications in hybrid clouds with Aneka [5]	Able to efficiently allocate resources from different sources in order to reduce application execution times.	Not suitable for HPC-data intensive applications.
2	Dynamic provisioning in multi-tenant service clouds [15]	Matches tenant functionalities with client requirements.	Does not work for testing on real-life cloud–based system and across several domains.
3	Elastic Application Container: A Lightweight Approach for Cloud Resource Provisioning [19]	Outperforms in terms of flexibility and resource efficiency.	Not suitable for web applications and supports only one type of programming language, Java.
4	Hybrid Cloud Resource Provisioning Policy in the Presence of Resource Failures [31]	Able to adopt user the workload model to provide flexibility in the choice of strategy based on the desired level of QoS, the needed performance, and the available budget.	Not suitable to run real experiments.
5	Provisioning of Requests for Virtual Machine Sets with Placement Constraints in IaaS Clouds [38]	Runtime efficient & can provide an effective means of online VM-to-PM mapping and also Maximizes revenue.	Not practical for medium to large problems.
6	Failure-aware resource provisioning for hybrid Cloud infrastructure [11]	Able to improve the users' QoS about 32% in terms of deadline violation rate and 57% in terms of slowdown with a limited cost on a public cloud.	Not able to run real experiments and also not able to move VMs between public and private clouds to deal with resource failures in the local infrastructures.
7	VM Provisioning Method to Improve the Profit and SLA Violation of Cloud Service Providers [27]	Reduces SLA violations & Improves Profit.	Increases the problem of resource allocation and load balancing among the datacenters.
8	Risk Aware Provisioning and Resource Aggregation based Consolidation of Virtual Machines [21]	Significant amount of reduction in the numbers required to host 1000 VMs and enables to turn off unnecessary servers.	Takes into account only CPU requirements of VMs.
9	Semantic based Resource Provisioning and Scheduling in Inter-cloud Environment [20]	Enables the fulfillment of customer requirements to the maximum by providing additional resources to the cloud system participating in a federated cloud environment thereby solving the interoperability problem.	QoS parameters like response time and throughput has to be achieved for interactive applications.
10	Design and implementation of adaptive power-aware virtual machine provisioner (APA-VMP) using swarm intelligence [7]	Efficient VM placement and significant reduction in power.	Not suitable for conserving power in modern data centers.
11	Adaptive resource provisioning for read intensive multi-tier applications in the cloud [2]	Automatic Identification and resolution of bottlenecks in multitier web application hosted on a cloud.	Not suitable for n-tier clustered application hosted on a cloud.
12	Optimal Resource Provisioning for Cloud Computing Environment [13]	Efficiently provisions Cloud Resources for SaaS users with a limited budget and Deadline thereby optimizing QoS.	Applicable only for SaaS users and SaaS providers.

IV. CONCLUSIONS AND FUTURE DIRECTIONS

In Cloud Computing, Resource provisioning means the selection, deployment, and run-time management of software (e.g., database servers, load balancers etc.) and hardware resources (e.g., CPU, storage, network etc.) for ensuring guaranteed performance for applications. These techniques are used to improve response time, performance, save energy, QoS, SLA. The ultimate goal of resource provisioning is to maximize profit from the Cloud Service Provider's Perspective and from the Cloud User's Perspective to reduce cost.

There are many challenges in the existing resource provisioning strategies. A mechanism that overcomes the challenges of the existing techniques has to be used. Architecture has to be proposed so that it works for Data intensive-HPC applications and also for real workload. Mechanisms have to be proposed to efficiently make of cloud resources so that QoS is met and SLA violation in minimized in hybrid clouds when dynamically provisioned. Also these provisioning mechanisms must be used for both SaaS and IaaS users

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