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Cloud & Distributed

Highlights

Multi Packed Security

Balancing Mechanisms

Cloud Data Storage

Performance Evaluation

Discovering Thoughts, Inventing Future

Volume 13 Issue 1 Version 1.0

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Cloud Data Storage Services Considering Public Audit for Security

By Swathi Sambangi
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Abstract - The cloud computing is a computing technology that allows us to share the pool of configurable sources where the data of individuals or the organisations can be stored remotely those can be accessible on-demand high quality applications. Even though there are many advantages associated with cloud computing still it brings new challenges in terms of security provided for the data storage providers as sensitive information of individuals is stored in these cloud storage providers. The owners of data expect a cloud data storage provider to be ensured with high service-level requirements. To ensure the deployment of cloud data storage service with security levels, some efficient methods has to be designed for the verification of the correctness of data. This paper proposes architecture for cloud computing that has a trusted entity with expertise and capability to assess cloud storage security in assistance of data owner request. The main aim of this paper is to enable public risk auditing protocols with which data owners can gain trust in cloud.

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CLOUD DATA STORAGE SERVICES CONSIDERING PUBLIC AUDIT FOR SECURITY

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Cloud Data Storage Services Considering Public Audit for Security

Swathi Sambangi

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I. Introduction

The cloud computing provides many of the services for IT enterprise like on demand self service, location independent resource pooling, ubiquitous network access, usage-based pricing, rapid resource elasticity and transference of risk. The primary concept of cloud computing is to provide a centralised data base or an outsourcing data from different individuals by using a cloud storage device.

As cloud computing allows individuals to store the data remotely, it has capability of enabling end users to use the resources provided in a rigid way. The advantage of cloud computing is it provides on demand self service methodology that authorizes users to request resources dynamically. Data owners store data on a cloud computing storage provider remotely and they can not directly use traditional cryptographic algorithm to ensure security for data. And downloading data for integrity verification costs high and even large data transmission through network frequently may support customers economically. Once if the data has been stored on cloud computing data storage provider data owner should not worry about security of data. In order to assure security for data and to enable data owner to use data without any worry about security for data, in this paper we propose publicly auditable cloud storage providers where data owners can rely on third party auditor to verify the data integrity of out sourced data to ensure security.

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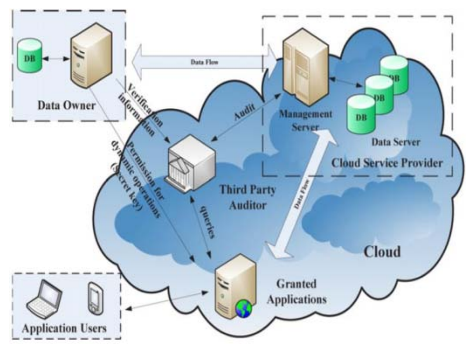


Figure 1 : Audit system architecture for cloud computing

Representative network architecture for cloud data storage is illustrated in Fig. 1. Three different network entities can be identified as follows:

- *Client:* an entity, which has large data files to be stored in the cloud and relies on the cloud for data maintenance and computation, can be either individual consumers or organizations;
- *Cloud Storage Server* (CSS): an entity, which is managed by Cloud Service Provider (CSP), has significant storage space and computation resource to maintain the clients' data;
- *Third Party Auditor* (TPA): an entity, which has expertise and capabilities that clients do not have, is *trusted* to assess and expose risk of cloud storage services on behalf of the clients upon request.

II. Motivation

Cloud data storage can be affected by two different sources. The cloud data storage provider itself is untrusted and possibly malicious.

There are cases in corrupting the data that is stored by users on individual servers. An adversary can compromise an individual server pollute the original data files by modifying or even by introducing its own fraudulent data to prevent the original data from being retrieved by the user.

There is another case where all the servers can be compromised by an attacker so that they can modify the data in files. There are many adversaries to be considered because both malicious outsiders and semi-trusted cloud storage service providers can be interrupted as the malicious outsiders can economically motivate by some others for their own benefit. Even though the cloud service providers can be some times semi trusted and most of the times they does not deviate from the executing a prescribed protocols as far as the security is being concerned, but still they might neglect to keep the files which are accessed frequently, they may cause the data corruption and even they may fail to execute the Byzantine protocols (which are meant to ensure security services.

The data owners could no longer physically possess the storage for their data; They cannot directly adopt cryptographic primitives to ensure the data security because downloading data every time for the purpose of integrity verification is not a feasible solution to be followed by the data owners as it is economically cannot be afforded by them. On the other side, detecting data corruption only when accessing data does not give assurance of the correctness of data, if the data size is too large. To overcome all of these challenges there is a need of third party auditing to ensure data security completely and save data of owners.

III. Third Party Auditing

In Systematic point of view the auditing for cloud data storage should be real and the whole service architecture design should not be not only cryptographically strong. Below are the auditing concepts for Cloud data storage.

a) Support Batch Auditing

The prevalence of large-scale cloud storage service further demands auditing efficiency. When receiving multiple auditing tasks from different owners' delegations, a TPA should still be able to handle them in a fast yet cost-effective fashion. This property could essentially enable the scalability of a public auditing service even under a storage cloud with a large number of data owners.

b) Minimize Auditing Overhead

First and foremost, the overhead imposed on the cloud server by the auditing process just not outweigh its benefits. Such overhead may include both the I/O cost for data access and the bandwidth cost for data transfer. Any extra online burden on a data owner should also be as low as possible. Ideally, after auditing delegation, the data owner should just enjoy the cloud storage service while being worry-free about storage auditing correctness.

c) Support Data Dynamics

As a cloud storage service is not just a data warehouse, owners are subject to dynamically updating their data via various application purposes. The design of auditing protocol should incorporate this important feature of data dynamics in Cloud Computing.

d) Protect Data Privacy

Data privacy protection has always been an important aspect of a service level agreement for cloud storage services. Thus, the implementation of a public auditing protocol should not violate the owner's data privacy. In other words a TPA should be able to efficiently audit the cloud data storage without demanding a local copy of data or even learning the data content.

IV. Implementation

a) Utilizing Homomorphic Authenticators

To significantly reduce the arbitrarily large communication overhead for public auditability without introducing any online burden on the data owner, we resort to the homomorphic authenticator technique. Homomorphic authenticators are unforgettable metadata generated from individual data blocks, which can be securely aggregated in such a way to assure a verifier that a linear combination of data blocks is correctly computed by verifying only the aggregated authenticator.

Using this technique requires additional information encoded along with the data before outsourcing. Specifically, a data file is divided into n blocks mi (i =1, …, n), and each block mi has a corresponding homomorphic authenticator σi computed as its metadata to ensure the integrity. Every time it must be verified that the cloud server is honestly storing the data, the data owner or TPA can submit challenges chal = {(i, νi)} for sampling a set of randomly selected blocks, where {νi} can be arbitrary weights. Due to the nice property of the homomorphic authenticator, server only needs to response a linear combination of the sampled data blocks μ = Σiνi · mi, as well as an aggregated authenticator σ = Πiσi νi, both computed from {mi, σi, νi}i∈chal. Once the response of μ and σ is verified by TPA, then high probabilistic guarantee on large fraction of cloud data correctness can be obtained.1 Because off-the-shelf error-correcting code technique can be adopted before data outsourcing [6, 10], large fraction of current cloud data would be sufficient to recover the whole data. Note that for typical choices of block size mi and file block number n, where mi >> log(n), the response μ and σ are (essentially) about the same size as individual block mi and σi. This means almost constant communication overhead, independent of file size, for each auditing can be achieved. Moreover, since the TPA could regenerate the fresh random sampling challenges, unbounded auditing is achieved too, which means no additional on-line burden would be incurred towards data owner. However, despite the desirable properties, this approach only works well for encrypted data. When directly applied to unencrypted data, it still leaks bits information towards TPA, as discussed next.

b) Protecting Data Privacy

The reason that linear combination of sampled blocks may potentially reveal owner data information is due to the following fact about basic linear algebra theory: if enough linear combinations of the same blocks are collected, the TPA can simply derive the sampled data content by solving a system of linear equations.

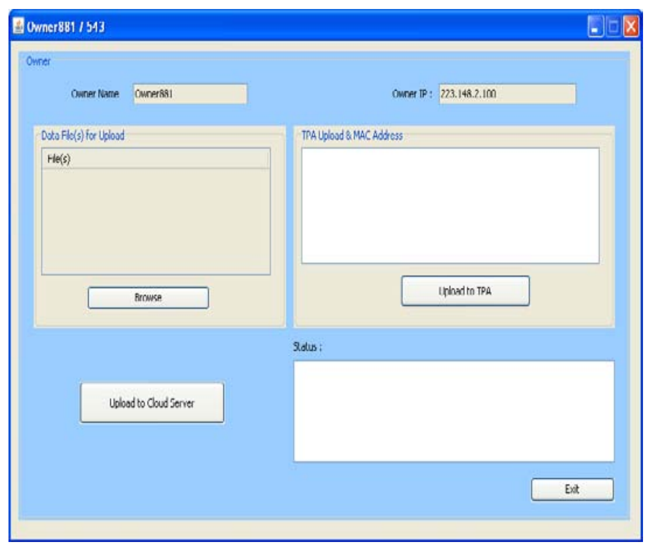
This drawback greatly affects the security of using homomorphic- authenticator-based techniques in a publicly auditable cloud data storage system. From the perspective of protecting data privacy, the owners, who own the data and rely on the TPA just for the storage security of their data, do not want this auditing process introducing new vulnerabilities of unauthorized information leakage into their data security. Moreover, there are legal regulations, such as the U.S. Health Insurance Portability and Accountability Act (HIPAA) [17], further demand the outsourced data not to be leaked to external parties. Exploiting data encryption before outsourcing is one way to mitigate this privacy concern, but it is only complementary to the privacy-preserving public auditing scheme to be deployed in cloud. Without a properly designed auditing protocol, encryption itself cannot prevent data from flowing away toward external parties during the auditing process. Thus, it does not completely solve the problem of protecting data privacy but just reduces it to the one of managing the encryption keys. Unauthorized data leakage still remains a problem due to the potential exposure of encryption keys. To address this concern, a proper approach is to combine the homomorphic authenticator with random masking. This way, the linear combination of sampled blocks in the server's response is masked with randomness generated by the server. With random masking, the TPA no longer has all the necessary information to build up a correct group of linear equations and therefore cannot derive the owner's data content, no matter how many linear combinations of the same set of file blocks can be collected. Meanwhile, due to the algebraic property of the homomorphic authenticator, the correctness validation of the block-authenticator pairs (μ and σ) can still be carried out in a new way, even in the presence of randomness.

This improved technique ensures the privacy of owner data content during the auditing process, regardless of whether or not the data is encrypted, which definitely provides more flexibility for different application scenarios of cloud data storage. Besides, with the homomorphic authenticator, the desirable property of constant communication overhead for the server's response during the audit is still preserved.

c) Handling Multiple Concurrent Tasks

With the establishment of privacy-preserving public auditing in cloud computing, a TPA may concurrently handle auditing delegations on different owners' requests. The individual auditing of these tasks in a sequential way can be tedious and very inefficient for a TPA. Given K auditing delegations on K distinct data files from K different owners, it is more advantageous for a TPA to batch these multiple tasks together and perform the auditing one time, saving computation overhead as well as auditing time cost. Keeping this natural demand in mind, we note that two previous works. Can be directly extended to provide batch auditing functionality by exploring the technique of bilinear aggregate signature. Such a technique supports the aggregation of multiple signatures by distinct signers on distinct messages into a single signature and thus allows efficient verification for the authenticity of all messages. Basically, with batch auditing the K verification equations (for K auditing tasks) corresponding to K responses {μ, σ} from a cloud server can now be aggregated into a single one such that a considerable amount of auditing time is expected to be saved. A very recent work gives the first study of batch auditing and presents mathematical details as well as security reasoning's.

V. Results



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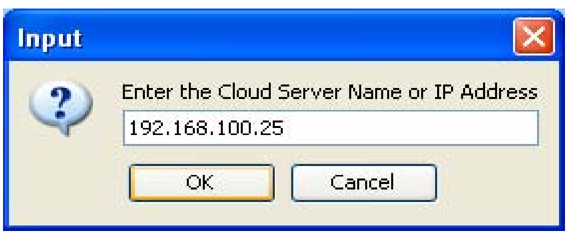

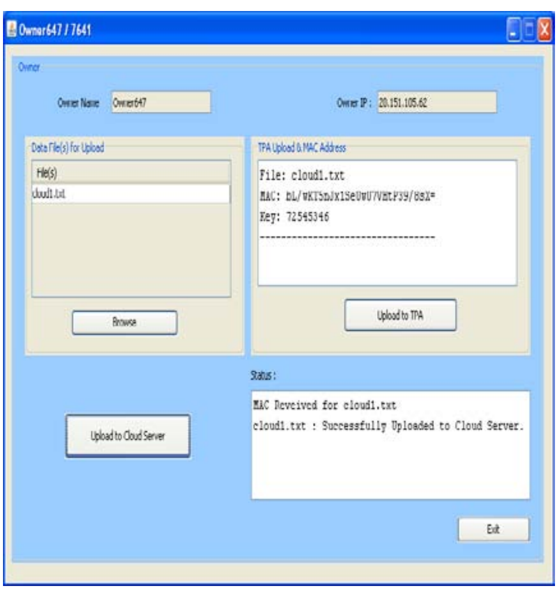

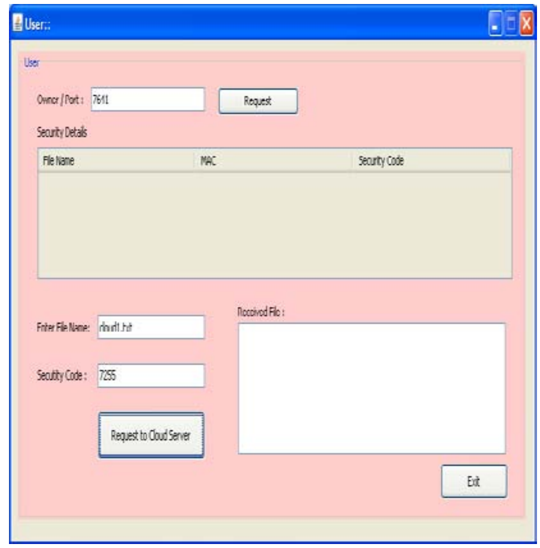

VI. Conclusion

Presently IT Industry depending on Cloud computing. IT services are under proper physical, logical, and personnel controls, cloud computing moves the application software and databases to servers in large data centres on the Internet, where the management of the data and services are not fully trustworthy. So, Data security, recovery, and privacy have become most security challenges in cloud. In this paper we focused on Services for Data Storage on Cloud. We first present network architecture for effectively describing, developing, and evaluating secure data storage problems. We considered public auditing services to suggest a set of systematically and cryptographically as properties. We analyzed pros and cons of existing data storage security building blocks.

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Cloud Computing: Performance Implications and Challenges

By Abhishek Aggarwal & Dr. Sona Malhotra
Kurukshetra University, India

Abstract - Cloud computing is a new paradigm in the field of distributed computing. The objective of cloud computing is to provide various computing resources over the internet in the form of service to number of cloud consumers. Cloud provides the computing environment to organization in a cost effective manner and give flexibility to increase the number of resources as required during peak load time. In this paper we have tried to highlight some of the major challenges like security, availability of cloud services, reliability and auto-provisioning of cloud resources etc. which need to be addressed by researchers. Certainly there are some performance implications which also need to be resolved in order to get maximum output from the cloud so we need to manage the cloud resources in optimized way to increase the performance of cloud and its adaptability among different organization.

Keywords : cloud, services, performance implications, cloud bursting, load balancing.

GJCST-B Classification : C.2.4

CLOUD COMPUTING PERFORMANCE IMPLICATIONS AND CHALLENGES

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Cloud Computing: Performance Implications and Challenges

Abhishek Aggarwal [α] & Dr. Sona Malhotra [σ]

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Keywords : cloud, services, performance implications, cloud bursting, load balancing.

I. Introduction

Cloud computing is treated as a new model for computing which aims to provide reliable, low cost and customizable as per the requirement of user and guaranteed computing dynamic environments for end-users over the internet. It aims for enabling convenient, on demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction [1].The advantages of cloud computing over traditional computing include: agility, lower entry cost, device independency, location independency and scalability. There are lots of characteristics and services offered by cloud computing which makes it different than traditional web services or service oriented architecture. We can understand cloud computing on the basis of its type i.e. how we manage the cloud in order to fulfill the requirement of cloud consumers and type of services provided by the cloud. On the basis of services model there are four types of services offered by a cloud i.e. SaaS (Software as a Service), PaaS (Platform as a Service), IaaS (Infrastructure as a Service), and DaaS (Data as a Service) a kind of IaaS.

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In contrast with the service model, on the basis of deployment model we can categorize cloud into four different type i.e. private cloud, community cloud, public cloud and hybrid cloud. There are a number of challenges which are addressed by researchers and practitioners in the field of cloud computing as briefly presented as Performance, Security & Privacy, Platform Control, Bandwidth Cost, Interoperability, Service availability and Reliability etc. In the cloud computing environment, when we shift ourselves to public cloud there may be several factors affecting the performance of service as listed as 1) Delay in services 2) Availability of services 3) Different standards of cloud vendors 4) Data location and relocation 5) Degree of coupling among computing components etc.

This Paper consists of various sections, In the overview section we explained the cloud computing, its different models and architectures of cloud services. Thereafter, we explained the different performance issues and challenges while migrating to the public cloud and then we find the future research scope in the field of cloud computing model. Finally, conclusion is drawn in last section.

II. Overview of Cloud Computing

Cloud Computing is a branch of computing to provide shared pool of customizable Resources like Application, Platform and infrastructure as a service to different cloud consumers, SME and other cloud vendors. There are two models in the cloud computing, one on the basis of services and other on the basis of deployment. Cloud computing can be viewed as a collection of services, which can be presented as a layered cloud computing architecture, as shown in fig.1

a) Types of Service

SaaS appears on the top of stack in fig. 1 and allow cloud consumers to access the services remotely and on rental basis i.e. "pay-as-you-go". Consumers may access the services depends upon SLA "Service Level Agreement". It save the users from the troubles of software deployment and maintenance, and, software is often shared by the multiple users, automatically updated in cloud and no additional licenses need to be purchased.

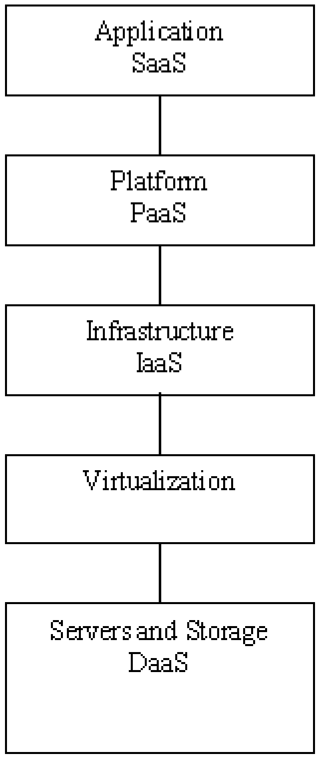

Figure 1 : Layered architecture of cloud computing

Web based mail and Google Docs are best examples of SaaS.

PaaS is a service which enables the users to develop their own applications using the platform of different cloud vendors. It provides complete development environment with a set of services to design, develop, test, deploy and monitor the application on the cloud [4]. End user may not know that on the cloud, which server hosts the application. Storage space of the application may be increased or decreased as per the need of application. Google App Engine and Microsoft Azure are examples of PaaS.

IaaS is a service in the form of infrastructure. So, instead of having high cost data centre maintaining at their own end consumers may use the storage and computing resources like CPU, Hard Disk or other I/O devices from different vendors. Amazon EC2 and Rack space are examples of IaaS. IaaS is virtualized over the set of different servers which may be physically located to different locations so the cloud vendors may setup VM in order to process the user's request uninterruptedly. DaaS is a form of IaaS where logical vs. physical mapping need to takes place using virtualization.

There are lot of risks and advantages associated with different service models e.g. in SaaS user has very limited scope of customization and difficulty may arises in data integration. In contrast to this user does not need to worry about the updates of service.

b) Characteristics of Cloud Computing

There are some essential characteristics of cloud computing services as follow:

i. *Sharing of resources using virtualization*

In a cloud environment, multiple computing resources of different kind may be pooled together and virtualized in order to provide services to different category of users to support multi-tenant model. Resources are dynamically assigned as per the demand of users. Sharing of resources enable the economy of scale and specialization. Specialized resources are pooled to cater the users of one category. Resources are hidden from users and consumers who have no idea about the physical location of resources like CPU, Storage and DBMS etc using virtualization.

ii. *Demand may change very rapidly*

All the resources must be readily available as per the demand of users. Cloud vendors must immediately fulfill the requirement of consumers and release the resources when the task is completed. Vendors must calculate the peak load of all the consumers in order to provide uninterrupted services to them.

iii. *Measuring the services used*

Cloud infrastructure is able to provide some mechanism to measure the services being used by consumer and generate appropriate billing such that no conflict arises. Some monitoring services may be used for the accurate measurement.

iv. *On-demand self service*

Cloud is able to provide set of services automatically without human interaction. User interface may be provided to avail the services and check the usage and billing information with complete transparency.

v. *Support for Different heterogeneous devices*

Computing resources may be used over the internet by broad range of devices and platform using client application (e.g. Web Browser).

c) Deployment Models

On the basis of where cloud services have been deployed clouds are categorized in to different categories like:

i. *Private Cloud*

These are proprietary networks normally resides and most often used by the organizations. All the services are deployed and organized within the organization managed by third party or organization itself. Private cloud doesn't make any sense because a lot of infrastructural and management cost is involved. Only mission critical application should be deployed as a part of private cloud in order to secure them from outside attack. In this type of cloud data and applications are more secure but special management skills are required to maintain it at their own end.

ii. *Public Cloud*

It is the main stream of cloud computing where services are publically deployed. Data and applications are hosted by third party and managed by service providers. Resources are provided free of cost or by charging an amount on pay-as-you-go basis. Cloud vendors shall be fully responsible for availability of service or computing resources but careful supervision is required by the enterprises to check the services of cloud providers.

iii. *Community Cloud*

Where set of computing resources are shared by a particular group of community instead publically. People who have similar and shared backgrounds and requirements may form the community cloud, this way we can reduce the computing cost and increase the security by limiting the access of resources to a particular set of users.

iv. *Hybrid Cloud*

Sometimes it is required to deploy data and applications within the organization (for mission critical processes) and sometimes for an external or outside organization. Hybrid cloud may target very effectively such organizations because of enhanced control and management by the enterprise itself. A clear cut distinction should be made between management responsibilities of the organization and cloud vendors.

v. *Virtual Private Cloud*

It is a secure and seamless bridge between an organization's existing IT infrastructure and the public cloud. It is public because it uses the computing resources of public cloud for users; however it is virtually private because the connection between IT legacy and cloud is secured through a virtual private network. Thereby having a security advantage of private cloud user can still enjoy pay-as-per-use on these public isolated resources.

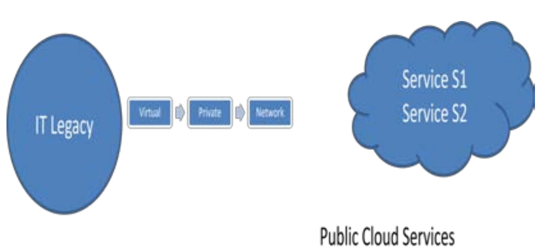

Figure 2 : Virtual Private Cloud

VPC is a perfect balance between the private cloud for control purpose and public cloud as far as the flexibility is concerned.

III. Performance Issues and Challenges

a) *Performance Degradation*

As we know internet is the back bone of cloud computing so performance is limited by the speed of internet. Data intensive or transaction intensive applications are highly effective when migrating to the public cloud. So, for such applications, performance is a major concern. We should provide some mechanism to categorize the applications and decide to migrate it to the public cloud or not.

b) *Security & Privacy*

It is the most important issue in the area of cloud computing. According to M. Kretzschmar [5] for collaborative cloud some cloud security management issues are there. Cloud security management infrastructure has to be managed and integrated with in cloud security management system.

c) *Availability*

Sometimes demand increases very rapidly and resources are not available, resulting delay in the services, so, non availability of services[8] during the peak load is a major concern. It may be overcome by distributing the load to some other resources and balancing the load to various resources within cloud or to other cloud also. some of the issues like non availability of service which lead to lack of reliability, outage and vendor lock-in etc. are highlighted and targeted by proposed 3-tier cloud deployment architecture[11] over two tier deployment architecture. An addition service provide layer which consists of four components outage handling data centre, interface to cloud, value added services and interface to client.

d) *Lack of Support for multi-tenancy*

In the cloud computing, different types of users are using services from the cloud. Sometime a company of repute share resources with notorious user with a criminal mind, so in multi-tenant environment security of data is always a major concern. Security issues has played the most important role in hindering cloud computing as the resources are being shared by multiple users using multi-tenant model.

e) *Interoperability*

Sometime cloud vendors are not able to cater the services to cloud consumers and may seek specialized services to other cloud vendors. Integration of services within a different cloud or with existing legacy system is always a headache for the cloud vendors. Lack of standards being adopted in the industry creates problem of interoperability. Existing legacy IT needs integration with different clouds in order to user services as described in Fig 3.

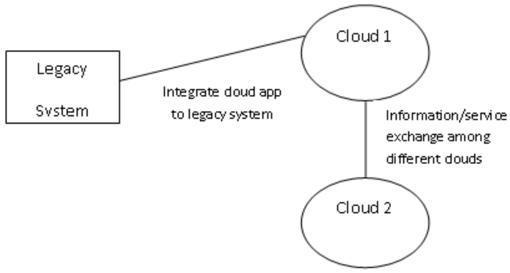

Figure 3 : Integration of services in different clouds

As cloud computing matures, the ability to support interoperability becomes more important [6].

f) Service Level Agreement

SLA is one of the major issues in cloud computing. Lack of well defined SLA by cloud providers lead to a problem for cloud consumers. What is guaranteed uptime? What are the repercussions if the provider fails to meet the standards? What happens to customer data if the company moves to different provider? There are some common questions which arise in the mind of users and there is a need to give sufficient attention to answer these questions. Some standards need to design for setting up SLA in a proper manner. SLA specifications need to be provided in such a way that they can cover most of the consumer expectation and resource allocation mechanism on the cloud.

g) Performance instability and Load balancing

It has been found in various surveys that Amazon, Microsoft and Google suffered from variations in performance and availability due to variations in the load. Specifically, the researchers measured how the cloud vendors scaled up and responded to immediate requirements of 3000 concurrent cloud users resulting sometimes; we can't predict the changes in performance because of the variations in demand. In order to manage the resources efficiently S. Wang et.al. [9] Proposed a two phase load balancing algorithm that combines OLB and LBMM scheduling algorithm in three level cloud computing environment. R.Lee et.al. [10] described two new load balancing policies in dynamic manner. These policies dispatches workload based on the dynamic comparison of the latest resource capacity available in each server. Unfortunately, Server capability varies in practice and is not easy to record in ordered position, which will cause non resource aware load balancing algorithms to distribute workloads evenly.

h) Data Storage and Data Processing

Every Enterprise has some set of sensitive and confidential data which needs to be carefully stored and processed. Each cloud consumer worried about the location of their organizational data so special care shall be given to the location [14] and processing techniques for such private data. Moreover data needs to transfer from one cloud to another, so special attention and preventive measures should be given to the migration and security of data respectively. For Data intensive application performance is purely depends up on high speed internet connection [15].

i) Resource Provisioning Policies

Cloud has a capability to provide resources on demand so an auto provisioning of resources must be supported by cloud in the peak load hours. In order to improve the performance of cloud during peak load a number of resource provisioning policies have been evolved. A.Iosup et.al. [7] analyses provisioning and allocation policies over three IaaS clouds , including Amazon EC2. He has compared various static and dynamic provisioning policies and their performance in different workload pattern over different IaaS clouds. Scheduling of jobs is also a core and challenging issue in cloud computing. L.Li et.al. [12] analyses the different QoS requirements of cloud computing resources. He builds the non-preemptive priority queuing model for the jobs and then build the system cost function. P. Gupta et.al. [13] explained different job scheduling methodologies for web application and web server in cloud computing environment. He has targeted various issues like virtual resources and queuing strategies.

IV. Related Research Scope

In Cloud computing research, both industry and academia have been active and several research activities have been carried out in past few years. Several architectures have been proposed to target the issues and performance implications discussed so far. We can throw some light on the core issues in the field of cloud computing. In order to minimize the cost, multi-tenant architecture has been proposed with minimum interference among cloud consumers. As we know computing components are tightly coupled so we need to minimize the coupling among components within the same cloud so that they may be used in intra-cloud environment and cater the needs of other cloud users also. Secondly we can carry out research on the scheduling of computing resources in order to give maximum resource utilization without making delay in the services to cloud consumers. There is a need to distribute the load of computing resources among different clouds for balancing the load where cloud interoperability remains one of the major concerns. We need to develop some standard techniques or protocols so that services may be frequently used among clouds without any interruption. When we access the services and data from other clouds the data shall migrate from one location to other, so special technique may be find out to secure the data during transmission. Because of widely relocation of data, cloud computing is always be the favorite place for the hackers, so special encryption technique needs to find out so that data shall be fully controlled and monitored by the cloud vendors and consumers. A function 'Cloud Manager' [3] must be available, to at least assign the request to the server. Cloud Manager is like an intermediate between the client side and server side infrastructure. It performs the various functions at the gateway of cloud including monitoring of available capacity of various hosts, load balancing and usage accounting. We need to optimize the functionality of cloud manager in order to improve the efficiency and performance of cloud itself.

V. Conclusion

In this paper, the author discussed the performance implications and challenges in the field of cloud computing. We have discussed the different models of cloud computing as far as services and deployment of clouds are concerned. There is a wide scope of research in the field of cloud computing to target the issues and challenges discussed so far. Several architectures need to be evolved in order to give high quality cloud computing services.

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Multi Packed Security Addressing Challenges in Cloud Computing

By Dr. A. Ravi Prasad, J. Kishore Kumar & N. Jayanthi
Kurukshetra University, India

Abstract - Cloud computing efficiency, flexibility, greater agility, less capital expenditure is to overcome geographic limitations to compete in a global market. Most of the companies are shifting to Cloud based services, but at the same time they are concerned about the security risks. Hopefully after the definitions and illustrations of Cloud computing are given in this paper you will understand it better. This paper identifies security concerns arising in cloud computing environments and outlines methods to maintain compliance integrity and preserve security protection.

Keywords : cloud computing, multi packed security, privacy.

GJCST-B Classification : C.2.2

MULTI PACKED SECURITY ADDRESSING CHALLENGES IN CLOUD COMPUTING

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Multi Packed Security Addressing Challenges in Cloud Computing

Dr. A. Ravi Prasad [α], J. Kishore Kumar [σ] & N. Jayanthi [ρ]

Abstract - Cloud computing efficiency, flexibility, greater agility, less capital expenditure is to overcome geographic limitations to compete in a global market. Most of the companies are shifting to Cloud based services, but at the same time they are concerned about the security risks. Hopefully after the definitions and illustrations of Cloud computing are given in this paper you will understand it better.

This paper identifies security concerns arising in cloud computing environments and outlines methods to maintain compliance integrity and preserve security protection.

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I. Introduction

Cloud computing use advanced computational power and improved storage capabilities. The main focus of cloud computing from the provider's view is extraneous hardware should be connected which can support downtime on any device in the network, without a change in the users' perspective. Also, the users' software image should be easily transferable from one cloud to another.

There are two characteristics of cloud model. They are Multi-tenancy and elasticity. Multi-Tenancy enables sharing the same service instance among different tenants. Elasticity enables scaling up and down resources allocated to a service based on the current service demands. Both characteristics helps in improving resource utilization, cost and service availability.

The Essential Cloud Characteristics are:

- Elasticity - this is useful for large and small organizations as it is pay-per-use basics and it will scale ITinfrastructure requirements.
- Pay-as-you-go versus install-and-own - capital requirements from the user to the service provider is equally attractive - again, to large and small organizations alike
- Savings - t is useful in terms of cost as one of the surveys reported that government agencies can save 25% to 50% of their IT costs and increase their business agility by migrating IT infrastructure to cloud services.
- Reduction in Market barrier - cloud computing services reduce IT barriers and lower infrastructure costs.
- Utilization of Infrastructure - because of its virtualizing hardware and software resources, which are provided as service work can happen between multiple users simultaneously. Because of good infrastructure this has better network efficiency which results in lower power consumption and smaller carbon footprints.
- Investment of Public - governments worldwide are investing to create economic regions of cloud technology development(e.g., China, Japan), are supporting cloud-related standards development (e.g., EU, US) or are migrating their own IT infrastructures to cloud services in an effort to lead by example (e.g., US, UK, Japan)
- Market research view - research points to ongoing rapid adoption of both public and private cloud services are assumed to be future prediction trend.
- Security - providing "security as a service" should be taken care yet.
- Standardization - improved standards are required to reduce or eliminate risk from many current problems which make difficult for cloud adoption
- Cloud Middleman - emerging cloud services brokers not only helps organization's that shift to the cloud to overcome specific security, privacy and compliance issues but also helps in achieve interoperability across multiple clouds and in-house IT infrastructure.
- Missing out - if organizations do not adopt cloud computing along with their competitors risk they are going to miss benefits such as the flexibility, agility and access to the latest versions of technologies.

II. The Cloud Computing Architecture

There are certain characteristics of cloud computing. There are several definitions that stem from the three main categories of Cloud computing which are Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS).

– Infrastructure-as-a-service (IaaS): providers deliver computation resources, storage and network as an internet-based services. This service model is based on the virtualization technology. Amazon EC2 is the most IaaS provider.

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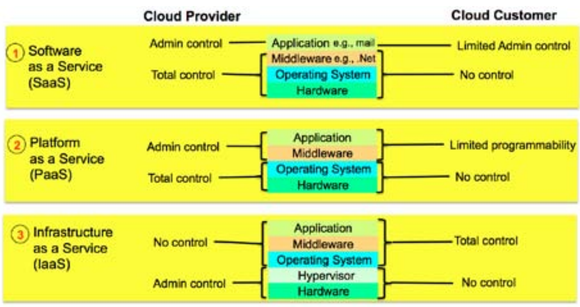
– **Platform-as-a-service (PaaS):** providers deliver platforms, tools and other business services that enable customers to develop, deploy, and manage their own applications, without installing any of these platforms or support tools on their local be hosted on top of IaaS model or on top of the cloud infrastructures directly. Google Apps and Microsoft Windows Azure are the most known.

– **Software-as-a-service (SaaS):** Applications hosted on the cloud infrastructure as internet based service for end users, applications on the customer's computers be hosted on top of PaaS, IaaS or directly hosted on cloud infrastructure. Sales Force CRM is an example of the provider.



III. Deployment Models

There are four deployment models, each with specific characteristics that support the needs of the services and users of the clouds in particular ways.

- **Private Cloud** - The cloud infrastructure has been deployed, and is maintained and operated for a specific organization. The operation may be in-house or with a third party on the premises.
- **Community Cloud** - The cloud infrastructure is shared among a number of organizations with similar interests and requirements. This may help limit the capital expenditure costs for its establishment as the costs are shared among the organizations. The operation may be in-house or with a third party on the premises.
- **Public Cloud** - The cloud infrastructure is available to the public on a commercial basis by a cloud service provider. This enables a consumer to develop and deploy a service in the cloud with very little financial outlay compared to the capital expenditure requirements normally associated with other deployment options.
- **Hybrid Cloud** - The cloud infrastructure consists of a number of clouds of any type, but the clouds have the ability through their interfaces to allow data and/or applications to be moved from one cloud to another. This can be a combination of private and public clouds that support the requirement to retain some data in an organization, and also the need to offer services in the cloud.

a) Benefits

The following are some of the possible benefits for those who offer cloud computing-based services and applications:

- **Cost Savings** - Companies can reduce their capital expenditures and use operational expenditures for increasing their computing capabilities.
- **Scalability/Flexibility** - Companies can start with a small deployment and grow to a large deployment fairly rapidly, and then scale back if necessary. Companies to use extra resources at peak times, enabling them to satisfy consumer demands.
- **Reliability** - since there are services which use multiple redundant sites so user is supported with business continuity and disaster recovery.
- **Maintenance** - Cloud service providers reduces maintenance requirements as accessing is through APIs that do not require application installations onto PCs.
- **Mobile Accessible** - Mobile workers have increased productivity due to systems accessible in an infrastructure available from anywhere.

b) Cloud Security Challenges

The following are some of the notable challenges associated with cloud computing they can be reduced with advanced services by planning.

- **Privacy and Security** -Two important issues that surround cloud computing relate to storing and securing data, and monitoring the use of the cloud by the service providers.
- **Standards Improvement** - Clouds have documented interfaces; however, no standards are associated with these, and thus it is unlikely that most clouds will be operated in conjunction. Working is going on cloud computing standards and practices.
- **Continuously Evolving** - since cloud does not remain static as user requirements are continuously evolving, the requirements for interfaces, networking, and storage should also continuously evolve.

IV. Administrative Access to Servers and Applications

Cloud computing offers "self-service" access to computing power, most likely via internet. This increases exposure and risk. It is extremely important to restrict administrative access and monitor this access to maintain visibility of changes in the system control.

V. Dynamic Virtual Machines: VM State and Sprawl

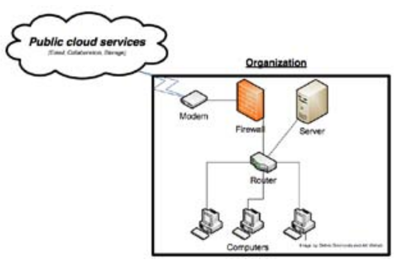
Virtual machines are dynamic. They can quickly be reverted to previous instances, paused and restarted, relatively easily which makes difficult to achieve and maintain consistent security. In the cloud computing environments, it will be necessary to be able to prove the security state of a system, regardless of its location or proximity to other, potentially insecure virtual machines.

a) Security, Privacy

Cloud computing present's specific challenges to privacy and security. When using cloud-based services, one is entrusting their data to a third-party for storage and security. Cloud-sourcing involves the use of many services, and many cloud based services provide services to each other, and thus cloud-based products may have to share your information with third parties if they are involved in processing or transferring of your information. They may share your information with advertisers as well, as many do to help cover the costs.

b) Public Cloud Computing

Public Cloud computing means relying on third parties to offer efficient IT services over the Internet as needed. The National Institute of Standards and Technology defines a public Cloud as a Cloud infrastructure that is made available to the general public or a large industry group. Public Clouds are owned by the organization(s) selling Cloud services



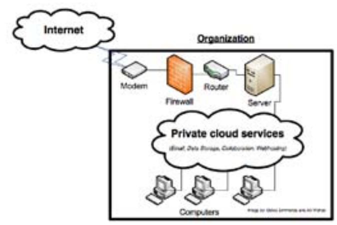
c) Public Cloud Security Issues

Public Clouds are hardened through continual hacking attempts. The NIST definition of public Clouds states that they are made available to the general public or a large industry group. Therefore, public Cloud providers are much larger targets for hackers than private Clouds. Public Clouds also attract the best security people available; the biggest and best Cloud service providers have millions of customers relying on them. They definitely would be meticulous about who they hire. Also public Cloud providers, especially larger companies like Google, Amazon, and Face book would get the latest security gear much easier than a small to midsize private company.

- Assessment of the CSP
- Security of the communication channels
- Transparency of security processes
    - Compliance with Regulations
    - Potentials of a single security breach
    - Access control mechanisms
    - Data Loss

d) Private Cloud Computing

According to the National Institute of Standards and Technology (NIST) a private Cloud is a Cloud infrastructure that is operated solely for an organization. The organization or a third party can manage it. Private Clouds can exist on-site or off-site (Grance, T., Mell, P., 2009). Typically private Clouds are used when sensitive data is involved.



e) Private Cloud Security Issues

Private Clouds have the same security concerns as public Clouds do, but typically on a smaller scale since private Clouds are operated solely for an organization.

- Security Architecture
- Perimeter Security and insider attacks
- Hypervisor vulnerabilities and network level authentication (IPSec, IPS/IDS)
- Security Zones

Solution approaches:

- Firewall
- Intrusion Detection and Prevention (IDS/IPS)
- Integrity Monitoring
- Log Inspection

f) Packed Security

This concept first concentrates on a agreement between customer, cloud provider and third party.

1. Customer training:

- This indicates that first there should be a understanding between customer and service provider. So that a provider must train his/her customer about storing, updating and retrieving data.
- If service provider is taking help of third party for services then there should be an understanding between provider and third party. So that third party train provider first then provider must train customer.

2. Double Jamming Algorithm:

a) Store data in encrypted form
b) Lock data
c) Encrypt the lock
d) Lock the lock
e) If data needed to be accessed or updated
f) First break all locks
g) Access/update data within specified attempts
h) Access/update data within specified time
i) If locks are not broken or

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j) If locks are broken but not accessed/updated data with in particular attempts or
k) If locks are broken, accessed/updated data with in particular attempts but not with in particular time
l) Then it indicates threat to data.
m) Otherwise no problem

Advantages:

1. Very Secured

Disadvantage:

1. Proper choice of number of attempts
2. Proper choice of time interval

VI. Conclusion

In this paper we have provided a definition of Cloud computing and highlighted the security issues/concerns related to Clouds. As more businesses today utilize Cloud services and architectures, more threats and concerns arise. Both public and private Cloud models have their own advantages and challenges; therefore security will always be an issue.

Cloud computing is a v was ery wide subject area. Even though the scope scaled down to the security issues in Cloud computing it is still quite a challenge getting details on certain areas.

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Performance Evaluation of Dynamic Scheduling for Grid Systems

By Radha.B & Dr.V.Sumathy
Sri Ramakrishna Engineering College, Coimbatore

Abstract - Schedulers are applications responsible for job management including resource allocation for a specific job, splitting them to ensure parallel task execution, data management, event correlation, and service-level management capabilities. When Grids allotted a number of jobs, such applications have to consider the overhead time, cost regarding to and from Grid resources, job transmission and at job processing, Grid resources for allocation of the jobs. In this paper, it is proposed to investigate the performance of dynamic scheduling algorithm of schedulers for executing different number of tasks is evaluated.

Keywords : grid computing, resource management, grid schedulers, dynamic scheduling.

GJCST-B Classification : C.2.5

PERFORMANCE EVALUATION OF DYNAMIC SCHEDULING FOR GRID SYSTEMS

Strictly as per the compliance and regulations of:

Performance Evaluation of Dynamic Scheduling for Grid Systems

Radha.B [α] & Dr.V.Sumathy [σ]

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I. Introduction

Grid portals ensure access to Grid resources the same as web portals. Grid portals provision of capabilities include grid computing authentication of resources, remote resource access, scheduling capabilities, and status information monitoring [1]. Such portals reduce task management complexity through customized/personalized user's graphical interfaces which alleviates users need for additional domain knowledge and not on specific grid resource management details [2].

Integrated solutions combine current advanced middleware and application functionalities, to ensure coherence and high performance results on a Grid Computing environment. Integrated Grid Computing solutions should include updated features to aid complex grids utilization like coordinated/optimized resource sharing, enhanced security management, cost optimizations, and other yet to be explored areas. Such integrated solutions sustain high values and provide significant cost reduction in commercial and non-commercial worlds. Various flexibility levels using infrastructures provided by application and middleware frameworks [3] can be achieved by Grid applications.

Employment of Grid technologies leads to better exploitation of a company's IT resources. Administrative overheads can also be lowered. As resources do not belong to various providers they are not part administrative domains. This scenario has a centralized scheduling architecture; i.e. a central broker, forming a single access point to the entire infrastructure, managing resource manager interfaces interacting directly with local resource managers. All users submit jobs to this centralized entity.

Different computing sites, like scientific research labs collaborate for research, a scenario which is represented by high performing computing grids, where compute- and/or data-intensive applications are used on participating HPC computing resources which are generally parallel computers/cluster systems. Resources form part of several administrative domains in such cases, with own policies and rules. Jobs are submitted by users to the institute broker or VO level with brokers splitting a scheduling problem into many sub issues. Otherwise the same is forwarded to many brokers in the same VO.

Global Grids include various resources types from a single desktop machine to large-scale HPC machines all linked through a global Grid network where every peer-to-peer broker can accept jobs yet to be scheduled [4].

A job is a computational activity in a grid and consists of many tasks needing varied processing capabilities with different resource requirements. Tasks, jobs and applications are scheduled, allocated and processed as they are basic computational entities and resources. Resources have self-characteristics like CPU characteristics, memory and software. Many parameters like processing speed and workload which change over time are associated with a resource. Resources can also belong to different administrative domains due to different usage and access [5] policies.

Software components form part of Grid schedulers which take of computing/mapping tasks to Grid resources under multiple criteria/Grid environment configurations. There are varying levels in a Grid scheduler as stated in Grid computing literature. They include super-schedulers, meta-schedulers, local/cluster schedulers and enterprise schedulers. As a main component of any Grid system, The Grid scheduler interacts with the grid system's other components of the Grid system as it is the system's main component. Other grid system components include Grid information system, local resource management systems and network management systems. All such schedulers must coexist in Grid environments, even though they

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might have conflicting goals; this implies that interaction and coordination between various schedulers is a must if tasks are to be executed.

Grid scheduler follows many steps to perform scheduling which are categorized into 5 blocks (1) Preparation/information gathering on grid submitted tasks; (2) Resource selection; (3) Planning tasks computation to selected resources; (4) Planning based task (job/application) allocation (task mapping to selected resources); and (5) Task completion monitoring [6, 7].

Schedulers are responsible for jobs management of jobs including resources allocation for specific jobs, splitting jobs to ensure parallel task execution, data management, event correlation, and service-level management capabilities [7]. Schedulers are hierarchically structured with meta-schedulers, the root and other lower level schedulers, simultaneously providing specific scheduling capabilities which then morph into leaves. Schedulers could be built with local scheduler implementation approach for a particular job execution, or another meta-scheduler/cluster scheduler for parallel executions.

Grid service provider's performance is proportional to collective workload undertaken by many processors scattered globally on participating grid sites. It is challenging to predict time required for workload completion [8, 9]. When grids are presented many jobs, applications take overall processing including high overhead time and cost regarding to and from Grid resources, job transmission and job processing at Grid resources. This paper proposes to investigate dynamic scheduling algorithm performance to execute different tasks. The rest of the paper is organized as follows: Section II reviews related works in the literature, Section III describes the experimental setup; section IV discusses results and Section V conclude the paper.

II. Related Works

Typical scheduling structures that occur in computational grids were investigated by Volker Hamscher et al., [10]. Scheduling algorithms and selection strategies are presented and classified to these structures. Discrete-event simulation was performed to estimate features regarding various job combinations and Machine Models. The obtained results are discussed quantitatively and qualitatively. Simulation proves the importance of Backfill, for hierarchical scheduling. Unexpected results were obtained as FCFS confirms better performance than Backfill under a central job pool.

A complete investigation of a wide range of dynamic workflow scheduling policies performance in multi-cluster grids was presented by Sonmez et al [11]. Based on dynamic information amount used in the scheduling process, taxonomy of grid work flow scheduling policies was presented with the taxonomy of seven such policies being mapped across the information use's full spectrum. Then scheduling policies performance was analyzed through simula-tions/ experiments in a real multi-cluster grid. The results revealed no single grid work flow scheduling policy had a good performance across investigated scenarios.

A novel grid-scheduling heuristic adaptively/ dynamically scheduling task without incoming tasks workload prior information was proposed by Bansal et al., [12]. The grid system is modelled in the form of a state-transition diagram, using a prioritized round-robin algorithm. This undertook task replication to optimally schedule tasks through the use of prediction information on individual nodes processor utilization. Simulations which compared the proposed approach with round robin heuristic revealed the latter to be better than the former in task scheduling.

The scheduling length minimization problem of a batch of jobs having varied arrival times was addressed by Barbosa et al [13]. Direct Acyclic Graph (DAG) of parallel tasks describes a job. A dynamic scheduling method is proposed by this paper which adapts the schedule on submission of new jobs and which change processors assigned during its execution. The scheduling method is split into scheduling Strategy and scheduling algorithm. An adaptation of Heterogeneous Earliest-Finish-Time (HEFT) algorithm, called P-HEFT is proposed to handle heterogeneous clusters parallel tasks with efficiently without a makespan compromise. When this algorithm was compared with another DAG scheduler through several machine configuration simulations and job types it revealed that P-HEFT ensures a shorter make span for single DAG. Bur scores are worse for multiple DAGs. In the end, results of dynamic scheduling of a jobs batch using the proposed scheduler showed significant improvements in heavily loaded machines when compared with an alternative resource reservation approach.

The problem of workflow applications scheduling in a grid environment was suggested by Mika et al [14]. Computational resources and network resources were the two divisions of grid resources. Computational workflow tasks and transmission tasks were distinguished. The problem was further divided into two sub problems: (i) how to find a distributed grid resources feasible resource for workflow task allocation so that all tasks resource demands (both computational, and transmission) were satisfied, and (ii) how to schedule local grid schedulers managed local resources computational tasks. The aim is to lessen total workflow (makespan) completion time. Computa-tional experiments justified resource allocation stage importance and to examine local scheduling policy influence. Experiments revealed that even minor resource allocation improvement compared to random allocation lead to greatly improved schedules. SJF algorithm produced slightly improved results compared to LJF algorithm as regards local scheduling policies. But the second experiment's main aim was to prove local scheduling policy influence with regard to the resource allocation stage.

a) Methodology

Processes are executed by the CPU scheduler when scheduled. When many ready processes are in the ready queue the scheduling algorithm decides the execution order of execution of these processes. Different CPU scheduling algorithms are First Come First Serve (FCFS), Shortest Job First (SJF) and Priority scheduling [15], all of which are by nature not pre emptive and hence unsuitable for time sharing systems. Shortest Remaining Time First (SRTF) and Round Robin (RR) are pre emptive in nature.

The Dynamic Level Scheduling (DLS) algorithm [16] uses the dynamic level (DL) attribute, the difference between a node's static level and its earliest execution start time. At every scheduling step, a pair of node processor providing the highest DL value is selected; a process which is similar to that used by Earliest Time First (ETF) algorithm. But, there is a subtle difference between ETF and DLS: ETF algorithm schedules the node with minimum early execution start time with the static level being used to break ties. But the DLS algorithm in contrast, schedules nodes in their static levels descending order when the process first starts, but schedules nodes in EEST ascending order of EEST when the process nears the end .

b) Experimental Setup and Results

Simulations were carried out in Sim grid framework. The simulations were conducted using 8 clusters of resources. The resources are located at different locations connected using switches. The resources are scheduled using Random and Dynamic scheduling algorithm. The number of jobs of uniform size is varied from 1 to 1000. The DLS algorithm is as follows:

1. Compute the *SL* (static level) of each node in the graph
2. Initially, the ready nodes list includes only the entrynode
3. **while**the ready list is not empty **do**
   - compute the earliest execution start time forevery ready node on each processor
   - compute the *DL* of every node-processor pair bysubtracting the earliest execution start time fromthe node's static level (*SL*)
   - select the node-processor pair that gives thelargest *DL*
   - schedule the node to the corresponding selectedprocessor
   - add the newly ready nodes to the ready list

Table 1 : Grid Parameters

Number of node clusters	8
Number of jobs used in the simulation	200,400,600,800,100 jobs of uniform size.
Job workload	Uniform size
Job failure probability- ρ	0.15
Scheduling schemes used	Random, Dynamic

Table 2 : Tabulates the parameters used in the simulation

Table 2 tabulates part of the simulation results of the time taken to execute the varying number of tasks for Random and Dynamic scheduling. Figure 1 shows the same.

Table 3 : Simulation Results for time taken to execute varying number of tasks

No of tasks	Dynamic system	Random scheduling
1	0.194475	1.78215
50	17.1837	18.4649
100	33.4314	37.0473
150	51.7019	56.4195
200	68.2239	75.3997
250	87.6894	95.5514
300	101.95	114.922
350	131.146	139.513
400	141.48	151.381
450	166.75	189.209
500	185.042	188.58
550	201.204	217.56

600	217.87	227.713
650	235.683	247.082
700	255.054	266.066
750	269.141	284.296
800	290.652	301.764
850	317.501	320.741
900	314.168	339.721
950	337.405	359.483
1000	358.63	378.852

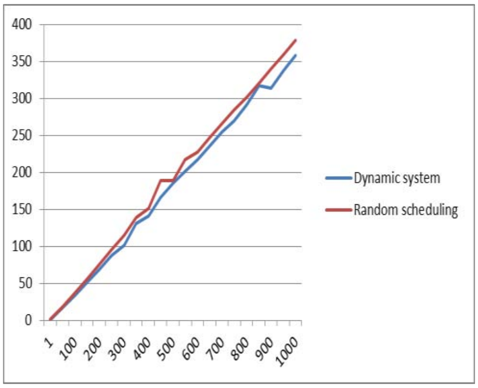

Figure 2 : Time Taken to execute varying Number of Tasks

It is observed from Figure 1, the time required to carry out the scheduled tasks is comparatively lower for the dynamic scheduling.

III. Conclusion

Software components make up Grid schedulers to compute task mapping to Grid resources through multiple criteria and Grid environment configurations. Scheduling's goals include achieving high performance computing and high throughput. The former is through execution time reduction for each job. It is usually utilized for parallel processing. In this paper, the performance of dynamic scheduling algorithm of schedulers for executing different number of tasks is evaluated. Simulation results demonstrate that the dynamic scheduling does improve the performance of the grid.

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Application Deployment Models with Load Balancing Mechanisms using Service Level Agreement Scheduling in Cloud Computing

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Keywords : *qos, SaaS, SLA, lom2his, cloudsim, vm, iaas, PaaS.*

GJCST-B Classification : *C.2.5*

APPLICATION DEPLOYMENT MODELS WITH LOAD BALANCING MECHANISMS USING SERVICE LEVEL AGREEMENT SCHEDULING IN CLOUD COMPUTING

Strictly as per the compliance and regulations of:

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I. Introduction

Cloud Computing is a computing paradigm [2, 6] that refers to variety of services available on internet which delivers computing functionality on the service provider's infrastructure. Cloud is a pool of virtualized computer resources and may be hosted on grid or utility computing environments [1, 7]. Its potential feature which includes the ability to scale, to meet changing users demand, separation of infrastructure maintenance duties from users, location of infrastructure areas with electricity, sharing of peak load capacity and so on. In this modern technical ear, the recent popularity of cloud computing on the scenario of data and computation and investigation of intensive scientific workflow applications like, climate modeling, earthquake modeling, weather forecasting, disaster recovery simulation, Astrophysics and high energy physics [5, 8, 9]. These scientific processes can be modeled or redesigned as scientific cloud workflow specifications at build-time modeling stage [5]. These specifications contain number of data computation activities and their non-functional requirements such as Quos constraints on time and cost basis [10]. At runtime execution stage, with the support of cloud workflow execution functionalities such as workflow scheduling [11], load balancing [3] and temporal verification [4], cloud workflow instances are executed by employing the time and cost basis [10]. At runtime execution stage, with the support of cloud workflow execution functionalities such as workflow scheduling [11], load balancing [3] and temporal verification [4], cloud workflow instances are executed by employing the supercomputing and data sharing ability computing infrastructures with satisfactory Quos.

Scientific applications are time constrained which required to be completed by satisfying a set of temporal constraints and global temporal constraints. The task execution time is the basic measurements for system performance, which need to be monitored and controlled by specific system management mechanisms. To ensure satisfactory temporal correctness and on time completion of workflow application is a critical issue for enhancing the overall performance. Cloud customers are interested in cost effective deployment of single applications in clouds, which is common in the Software as a Service (SaaS) delivery model. Commercial cloud providers such as sales force [24] are offering the provision for single applications based on agreed SLA terms. Commercial providers use custom techniques, which are not open to the general public. To foster competitive cloud market and reduce cost, the need for open solutions is must.

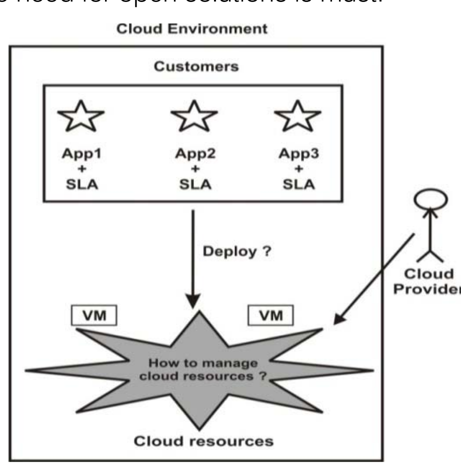

Figure 1 : Scheduling Motivation Scenario

In Figure – 1, a motivating scenario for the development of scheduling and deployment heuristic is represented. The use case scenario shows a Cloud provider and pools of customers who wish to deploy

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their applications on the Cloud resources based on the pre agreed SLA objectives. The application of how to deploy the available virtual machines in the Cloud to ensure their performance and enforce the agreed SLA objectives including the challenge to manage resources to achieve high utilizations and maximum deployments by grid scientific computing [17]. A novel scheduling heuristic considering multiple SLA parameter objectives, such as amount of required CPU, network bandwidth, and storage in deploying applications on Clouds is mentioned. The heuristic includes a load-balancing mechanism for efficient distribution of the applications' execution on the Cloud resources. We also present a flexible on-demand resource allocation strategy included in the heuristic for automatically starting new virtual machines (VM) when a non-appropriate VM is available for application deployment. The concept and detailed design of the heuristic including its implementation in the Clouds simulation tool [15, 16]. The scheduling strategy proposed in this section is integrated into the LoM2HiS framework as shown in Figure - 2.

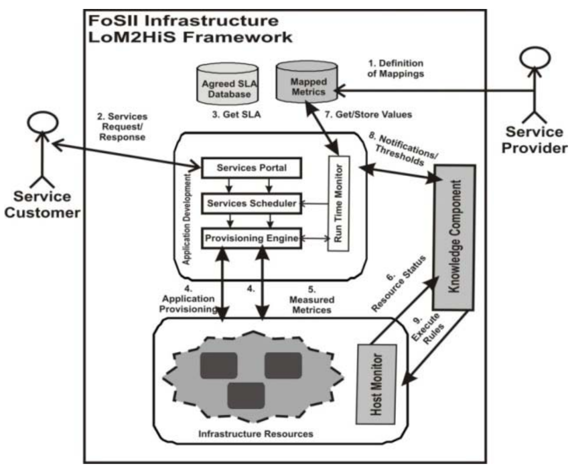

Figure 2 : LoM2HiS with Scheduling Strategy

II. Resource Provisioning

The idea of Cloud computing is to provide resources as a service in a flexible and scalable manner [14]. There are three well known types of resource provisioning [21, 23] in Cloud:

i. Infrastructure as a Service (IaaS) that offers bare hardwires such as the physical machines, storage devices, and network infrastructures as a service. Amazon EC2 [12] is an example of IaaS offering;
ii. Platform as a Service (PaaS), which delivers platform for application development and deployment as a service [20]. It typically utilizes virtualized resources in form of virtual machines that are capable of provisioning resources to applications. A typical example of PaaS service is the Google App Engine [20];
iii. Software as a Service (SaaS) offering resources for the provisioning of single Applications in a Cloud environment. Vendors of SaaS include salesforce.com [24].

The Cloud provisioning and deployment model presented in Figure - 3 shows a scenario combining the three different types of resource provisioning to host service requested from customers. The customers place their service deployment requests to the service portal, which passes the requests to the request processing component to validate the requests. If the request is validated, it is then forwarded to the scheduler. The scheduler selects the appropriate VMs through the provisioning engine in PaaS layer for deploying the requested service and the load balancer balances the service provisioning among the running VMs. The provision engine manages the VMs on the virtualization layer and the virtualization layer interacts with the physical resources via the provision engine in IaaS layer. The low-level resource metrics of the physical resources at the IaaS layer are monitored by the LoM2HiS framework [19]. The service status and the SLA information are communicated back to the service portal [22]. Although, the scenario described above is a possible way of combining the three types of resource provisioning, there exist other scenarios like provisioning of virtual machines alone and provisioning of physical resources alone, which are possibilities of provisioning at the single layers alone.

However, our approach aims to provide an integrated resource provisioning strategy. The proposed scheduling heuristics considers the three layers. Efficient resource provisioning and application deployments at these layers are not trivial considering their different constraints and requirements. At the IaaS layer the physical resources must be managed to optimize utilizations. At the PaaS layer, the VMs have to be deployed and maintained on the physical host considering the agreed SLAs with the customer.

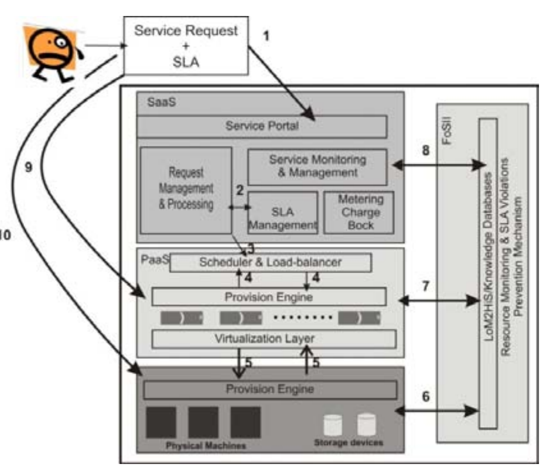

Figure 3 : Cloud Provisioning and Deployment Model

III. Scheduling and Load Balancing Mechanisms

The proposed scheduling heuristic [18] aims at deploying applications on virtual machines based on the agreed SLA objectives. Moreover, the integrated load-balancer in the heuristic ensures high and efficient resource utilization; consequently saving the provider the cost of maintaining unused resources. In this work, we assume that the SLA terms between the customer and the Cloud provider are already established. Thus, the processes of SLA specification, negotiation, and establishment are out of scope for this work, but there is ongoing research work where the Vie SLAF framework [13] is used to address the issues.

Algorithm - 1:
(Scheduling Heuristic)

1. Input: User Service Request
2. Get Global Resources and Available Vm List;
3. // find appropriate VM List
4. If AP(R, AR)! =; then
5. //call the load balancing algorithm
6. deployable VM = load-balance (AP(R, AR))
7. deploy service on deployable Vm;
8. deployed = true;
9. else
10. If global Resource Able to Host Extra VM then
11. Start new VM Instance;
12. Add VM to Available VM List;
13. Deploy service on new Vm;
14. Deployed = true;
15. Else
16. Queue Service Request Until
17. Queue Time > Waiting Time
18. Deployed = False;
19. End if
20. End if
21. If Deployed then
22. Return Successful;
23. Terminate;
24. Else
25. Return Failure;
26. Terminate;
27. End if

By the pseudo code presented in Algorithm - 1, the scheduler receives as input the customers' service requests (R) that are composed of the SLA objectives (S) and the application data (A) to be provisioned (line - 1 in Algorithm - 1). The request can be expressed as R = (S, A). Each SLA agreement has a unique identifier id and a collection of SLA Objectives (SLOs). The SLOs can be defined as predicates of the form:

$$SLO_{id}(x_i, comp, \pi_i) \text{ with comp} \in \{<, \leq, >, \geq, =\} \quad (1)$$

Where x_i € {Bandwidth, Memory, Storage, Availability} represents sample SLA parameters, comp the appropriate comparison operator, and π_i the values of the objectives.

The basis for finding the virtual machine with the appropriate resources for deploying the application, gathers the output of the scheduler and the confirmation about successful deployment or error message in case of failure. In first step, it extracts the SLA objectives information about the total available resources (AR) and the number of running virtual machines in the data center (line - 2). The SLA objectives are used to find a list of appropriate virtual machines (AP) capable of provisioning the requested service (R). This operation can be expressed as:

$$AP(R, AR) = \{VM : \text{VM} \in \text{AR}, \text{capable}(\text{VM}, \text{R})\} \quad (2)$$

Where capable (VM, R) is a predicate that returns true if the virtual machine is capable of provisioning the particular request or false otherwise (lines 3-4). Once the list of VMs is found, the load-balancer decides on which particular VM to deploy the application in order to balance the load in the data center (lines 5-8).

In case no VM, the appropriate resources running in the data center, the scheduler checks if the global resources consisting of physical machines can host new VMs (lines 9-10). If that is the case, it automatically starts new VMs with predefined resource capacities to provision service requests (lines 11-14). When the global resources cannot host extra VMs, the scheduler queues the provisioning of service requests until a VM with appropriate resources is available (lines 15-16). If after a certain period of time, the service requests cannot be scheduled and deployed, the scheduler returns a scheduling failure to the Cloud admin, otherwise it returns success (lines 17-27). The load-balancer shown in Algorithm - 2 is not an extension of Next-Fit algorithm and has two core differences like:

i. It does not fill a box to the full before starting to fill another one and
ii. It goes back to the half filled boxes to add new items.

The similarity lays in each iteration, does not put items in the last filled box unless there is no other appropriate box among all the boxes. In Algorithm - 2, the load balancer receives as input the appropriate VM list (line - 1 in Algorithm - 2). It first gets the number of available running VMs in the data center in order to know how to balance the load among them (line - 2). Then it gets a list of used VMs, i.e., VMs that are already provisioning applications (line - 3). If this list is equal to the number of running VMs, it clears the list because all the VMs are currently provisioning some applications (lines 4-7). The first VM from the appropriate VM list can be selected for the deployment of the new application request. The selected VM is then added to the list of used VMs so that the load -balancer does not select it in the next iteration (lines 8-15).

The load-balancer tries to place one application on each VM running in the data center in the first phase after which it goes back again to place new applications on the VMs. The idea is that VMs executing less number of applications perform better than ones executing many applications while the others are running empty. The load-balancer alone has a total worst-case complexity of $0(n^2)$ in load balancing and selecting the specific VM for application deployment. This worst-case complexity is attributed by two processes:

i. By the processes of selecting the specific VM, which has a worst-case complexity of 0(n) because the load balancer in worst case has to go through the appropriate VM list of n size to select a specific VM
ii. By the processes of balancing the load among the VMs, which has a worse-case complexity of 0(n).

The Algorithm - 2 shows lines 8-14, this process is a sub-process of selecting the specific VM. Thus, the total worst-case complexity is of $0(n^2)$.

Algorithm – 2:

(Load Balancing Strategy)

1. Input: AP(R, AR)
2. Global Variable Available Vm List
3. Global Variable Used Vm List;
4. Deployable Vm = null;
5. If Size (Used VM List) == Size (Available Vm List) then
6. Clear Used Vm List;
7. End if
8. For vm in AP(R, AR) do
9. If vm not in Used Vm List thens
10. Add vm to Used Vm List;
11. Deployable Vm = vm;
12. Break;
13. End if
14. End for
15. Return Deployable Vm;

The scheduling heuristic without the load-balancer has a worst-case complexity of 0(m + n). This complexity is defined by the processes of finding out the resource capacities of the m physical machines and n available virtual machines in the data center. Other operations of the heuristic have constant complexity (0(1)) except the process of checking the available resources on the physical machines in order to start new VMs, which has a worst-case complexity of 0(m).

The total worst-case complexity of the proposed heuristic is a result of the sum of the scheduling heuristic complexity and the load-balancer complexity expressed at run time is:

$$0(m+n)+0(n^2)=0(n^2+m) \qquad (3)$$

IV. Implementation

The proposed scheduling heuristic is implemented as a new scheduling policy in the Clouds simulation tool for the purpose of evaluation offering with unique features are:

i. Support for modeling and simulation of large scale Cloud computing environments including data centers, on a single computing machine
ii. A self-contained platform for modeling Clouds, service brokers, resource provisioning and application allocation policies
iii. Capability of simulating network connections among simulated components
iv. Support for simulation of federated Cloud environment able to network resources from both private and public providers.
v. Availability of virtualization engine that aids in creation and management of multiple, independent, and co-hosted virtualized services on a data center's physical machine
vi. Ability to switch between spaces shared and time-shared allocation of CPU cores to virtualized resources.

Clouds components shown in the custom extensions layer in Figure – 4, has infrastructure level services as modeled by the core layer representing the original Clouds data center, with homogeneous or heterogeneous configuration of their hardware. Each data center instantiates a resource provisioning component that implements a set of policies that allocates resources to computing host and virtual machines. The two groups of Java classes in clouds are:

i) The control policy classes
ii) The simulation specific classes

The control policy classes include the implementations of a new data center broker for interfacing with the data center and our proposed scheduling heuristic. The data center broker is responsible for mediating negotiations between customers and Cloud providers in respect of allocating appropriate resources to customer services to meet their application's Quos needs and to manage the provider resources in the Clouds.

The extended data center broker includes the capability of running dynamic simulations by removing the burden of statically configuring the whole simulation scenario before starting .With this feature one can generate and send in new events (service requests) during the simulation runtime.

The proposed scheduling heuristic provides policies used by the data center broker for allocating resources to applications. The implementations of the heuristic and that of the load balancer are realized with Java methods in a class named SLA Aware Scheduler as shown in Figure - 4. This class is used by the Data center Broker class to schedule, deploy applications, and manage the data center resources.

The simulation specific classes are used in realizing simulation scenarios. This group includes two Java classes named Data center Model and Service Request as shown in Figure - 4. Data center Model class presents methods for flexible instantiation of different data center scenarios for scalable simulations. The Service Request class represents a customer service request. It encapsulates information about the SLA parameter objectives agreed between the customer and the provider and the application data to be provisioned in the Cloud.

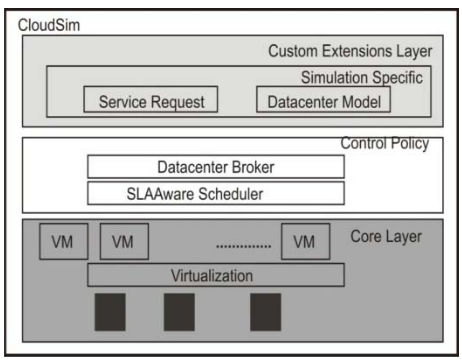

Figure 4 : Cloud Sim Extension Architecture

V. Evaluation

The evaluation of the scheduling heuristic demonstrates the resource utilization by the scheduler. It further shows the higher application performance obtainable while compared to an arbitrary task scheduler. The evaluations presented here are realized using the Clouds simulation tool [16].

Here, we begin with the experimental setup and configuration descriptions and basic experimental configurations. The experimental test bed is setup as described in Figure - 5. It demonstrates the processes of placing service request by customers and how our proposed scheduler deploys the service on appropriate Cloud resources.

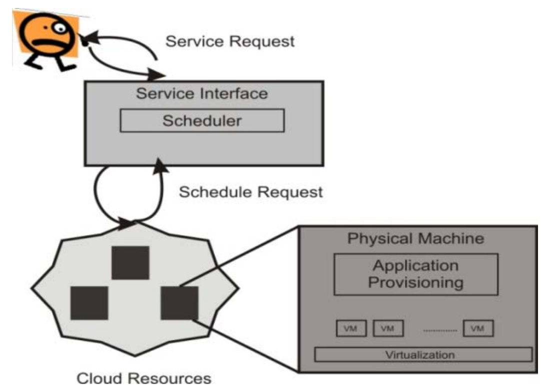

Figure 5 : Scheduling Evaluation Test bed

The Cloud resources comprise physical and virtual machines. Table - 1 shows the resource capacities of the physical machines and the configuration parameters of the virtual machines. Based on the capacities of the physical machine resources and the sizes of the virtual machines, we can start several virtual machines on one physical host in the Clouds simulation engine. To achieve a reasonable application deployment scenario, we use two types of applications each with its own SLA terms to realize heterogeneous workloads. The first workload is extracted from a Web Application (WA) for an online shop and the second workload is a trace of High Performance Computing (HPC) application represented by an image rendering applications such as POV-Ray.

Table 1 : Cloud Environment Resource Setup

Machine Type = Physical Machine

OS	CPU Core	CPU Speed	Memory	Storage	Bandwidth
Linux	6	6000 MIPS	3.072 GB	30000 GB	3 Gbit/s

Machine Type = Virtual Machine

OS	CPU Core	CPU Speed	Memory	Storage	Bandwidth
Linux	1	1000 MIPS	512 MB	5000 GB	500 Mbit/s

Table - 2 presents the experimental SLA objective terms for the two application types. The web application generally requires less resource while executing and its performance is ensured by the specified SLA objectives. The HPC applications are resource intensive in execution and their performance are safeguarded by the specified SLA objectives.

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Guaranteeing these SLA terms ensures the good performance of the application executions.

Table 2 : Heterogeneous Application SLA Objectives

Application Type	CPU Power	Memory	Storage	Bandwidth
Web	240 MIPS	130 MB	1000 GB	150 Mbit/s
HPC	500 MIPS	250 MB	2000 GB	240 Mbit/s

a) Deployment Efficiency and Resource Utilization

The evaluation of the efficiency of the proposed scheduler for deploying customer service requests and utilizing the available Cloud resources. The test essence of the on-demand resource provisioning feature, simulate a large data center made up of 60 physical machines and 370 virtual machines. The capabilities of the scheduler are evaluated into two groups:

i) Fixed resource
ii) On-demand resource

In the fixed resource group the on-demand resource provisioning feature is deactivated while in the on-demand resource group, it is activated. The essence of these two groups is to demonstrate the advantages of the on-demand resource provisioning feature. Each group runs three scenarios:

i. The first scenario handles the deployment of only web applications' service requests.
ii. The second scenario deals only with HPC applications.
iii. The third scenario deals with a mixture of web and HPC applications.

The three scenarios are intended to cover real world deployment situations in the sense that they handle applications from different categories, which exhibit different behaviors in terms of resource consumption. In the scenarios, the service requests are randomly generated and sent to the scheduler for scheduling and deployment. Next, we describe the achieved results in two groups.

i. *Fixed resource group*

The scheduler schedules and deploys the applications on the available running VM in the data center without the flexibility of starting new VMs when required. The results achieved by the three scenarios of this group are presented in Figure - 6.

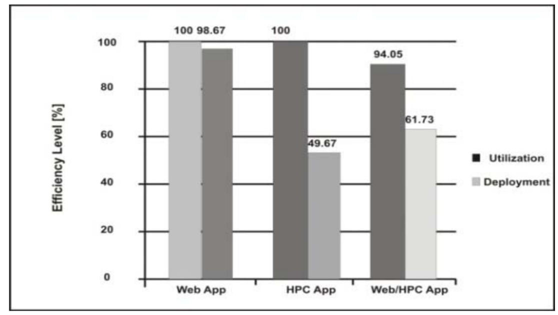

Figure 6 : Scheduling and Deploying With Fixed Resources

In Figure - 6, scenario 1 presents the results of the first evaluation scenario, which handles only web applications. The first bar shows the total resource utilization level achieved among the running VMs in the data center. The resource utilization is measured by checking the number of service applications. The scheduler achieved 100% resource utilization meaning that the resources on each VM were adequately utilized. The second bar shows the total deployment efficiency achieved by the scheduler. The deployment efficiency is calculated by counting the total number of deployed service applications in relation to the total number of requested services. In this scenario a total of 1480 service applications are deployed whereas a total of 1500 service requests were made. This gives a deployment efficiency of 98. 67%. About 20 service requests could not be provisioned due to lack of resources on the available VMs.

The results of the second evaluation scenario dealing with only HPC applications are presented as Scenario - 2 in Figure - 6. The first bar shows the resource utilization achieved by the scheduler, which is in this case 100%.. The second bar represents the deployment efficiency achieved, which is in this scenario 49.67%. The low deployment efficiency is caused by lack of available resources. The results of the third evaluation scenario are presented as Scenario 3 in Figure - 6. This scenario deals with a mixture of web and HPC applications' service requests. The scheduler achieved about 94.05% resource utilization in this scenario as shown by the first bar. The inability to achieve 100% resource utilization is caused by the heterogeneous nature of the workload whereby some

HPC applications cause some resource fragmentation leaving some resource fragments that are not usable by the scheduler. The second bar represents the deployment efficiency of this scenario, which is 61.73%. This is significantly better than the deployment efficiency achieved in the second scenario. This increase in deployment efficiency is attributed by the heterogeneous workload whereby the number of HPC applications' requests is smaller than in the second scenario.

ii. *On-demand resource group*

In this group, it is possible for the scheduler to flexibly start new VMs when necessary as far as there are available resources on the physical machines. This feature allows for higher service request deployment and better usage of the resources at the data center. The results obtained by the three evaluation scenarios of this group are depicted in Figure - 7. The first bar shows that the scheduler achieved 100% utilization in this case. The observation in this scenario as compared to the first scenario of the fixed group is the 100% deployment efficiency achieved, which is shown by the second bar. The scheduler made advantage of the flexible on-demand resource provisioning feature to start extra four virtual machines to fully deploy the whole service requests.

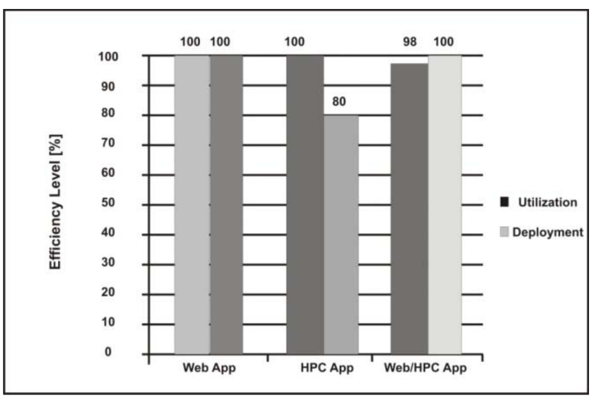

Figure 7 : Scheduling and Deploying with On-demand Resource Provisioning Feature

The second evaluation scenario results are presented as Scenario 2 in Figure - 7. This scenario deals with only HPC applications. The scheduler achieved 100% resource utilization in scheduling and deploying the HPC applications as depicted by the first bar. That means the available resources are fully utilized. Although the resources were fully utilized, the scheduler could only achieve 80% deployment efficiency. This is better result than 49.67% achieved by the equivalent scenario in the fixed group. The scheduler created extra 229 VMs for the applications deployments thereby reaching the limits of the physical machines and could not achieve 100% deployment efficiency due to ultimate lack of resources in the data center. This problem could be addressed with Cloud federation paradigm. Scenario 3 in Figure -7 depicts the results of the third evaluation scenario dealing with a mixture of web and HPC applications. The scheduler achieved 98% resource utilization due to resource fragmentations caused by the heterogeneous workload and resource over provisioning.

The last two VMs started on-demand were under-utilized. 100% deployment efficiency was achieved in this scenario by starting 215 VMs on-demand. Comparing the results achieved by the former group scenarios (Figure - 6) against those of the later group (Figure - 7), it can be clearly seen that the later group obtained much better resource utilization rates and deployment efficiencies. This demonstrates the effectiveness and relevance of our proposed scheduling approach in a Cloud environment.

b) Application Performance Comparison

The performance of applications being provisioned in the Cloud simulation test bed but application performance is evaluated in two aspects using the scenarios of the previous section:

i) Response time for the web applications
ii) Completion time for the HPC applications

The result achieved is compared by the proposed scheduler with that achieved by an arbitrary task scheduler. Table 3 presents the applications performance results. The results show the average response time and completion time of the applications while deployed by the two schedulers. It can be clearly seen that our proposed scheduler is two times better than the task scheduler. The good performance of our scheduler is attributed to the fact that it considers multiple performance objectives before deciding on which resource to deploy an application thereby finding the optimal resource combination for the application best performance, whereas the task scheduler considers mainly single objectives in its deployment, which cannot provide the optimal resources for the application best performance. Note that in Table 3 the on-demand resource provisioning feature applies only to our proposed scheduler.

Without On-demand Resource Provisioning Feature				
SLA-aware Scheduler			Traditional Task Scheduler	
Scenario	Response Time	Completion Time	Response Time	Completion Time
1	8 Sec	-	20 Sec	-
2	-	10 Sec	-	22 Sec
3	10 Sec	14 Sec	25 Sec	30 Sec
With On-demand Resource Provisioning Feature				
Scenario	Response Time	Completion Time	Response Time	Completion Time
1	5 Sec	-	15 Sec	-
2	-	7 Sec	-	18 Sec
3	8 Sec	10 Sec	19 Sec	24 Sec

Table 3 : Scheduler Comparison

VI. Conclusion

Scheduling and deployment strategies are means of achieving resource provisioning in Cloud environments. A further contribution of this thesis is the development of a novel scheduling heuristic considering multiple SLA objectives in deploying applications in Cloud environments. The heuristic includes load-balancing mechanism for efficient distribution of the applications' execution among the Cloud resources. A flexible on-demand resource usage feature included in the heuristic for automatically starting new VMs when non-appropriate VM is available for the application deployments is presented. The design of the heuristic and its implementations with proposed scheduling heuristic using the Clouds simulation tool is discussed.

In order to manage the deployment of multiple applications on a single virtual machine, a proposed application monitoring architecture (CASViD), which monitors and detects SLA violations at the application layer in Cloud environments. The evaluated architecture on a real Cloud test bed using three types of image rendering application workloads with heterogeneous behaviors necessary to investigate different application provisioning scenarios and to automatically determine the optimal measurement intervals to monitor the application provisioning. By experiments, the proposed architecture is efficient in monitoring and detecting individual application SLA violation situations. Further one can automatically find the optimal measurement intervals by sampling different ones and checking their net utility values. With the realization of CASViD, the capabilities of monitoring and detecting SLA violations of single customer applications being provisioned in a shared host, in addition to the previous resource monitoring techniques, a holistic monitoring model capable of monitoring at different layers in Clouds is provided.

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- To the point depiction of the research
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Approach:

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The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

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	A-B	**C-D**	**E-F**
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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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