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On

Cloud Computing-Service Level Agreement Requirement Parameter Matching

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Submitted By

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CERTIFICATE

This is to certify that dissertation titled "**Cloud Computing-Service Level Agreement Requirement Parameter Matching**" is a bona fide record of work done at **Delhi Technological University, India** by **Vikas Kumar, Roll No. 2K11/CSE/19** for partial fulfilment of requirements for degree of Master of Technology in Computer Science & Engineering. This project was carried out under my supervision and has not been submitted elsewhere, either in part or full, for the award of any other degree or diploma to the best of our knowledge and belief.

Date: _____

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Abstract

Cloud computing is a technology that has evolved and gained popularity among masses and IT giants with great pace. Basically, Cloud is a large pool of easily available and accessible virtualized resources such as hardware, platform for development and services. It provides on-demand pay-per-use computing resources and acts as a substitute to conventional IT framework. As more and more consumers are going for 'cloud' to accomplish their tasks, Service Level Agreement (SLA) between consumer and provider becomes an important aspect.

SLA is the document of contract between the cloud providers and the cloud consumers and defines some statements of rules and parameters that must be agreed by the both cloud providers and consumers. Since the nature of cloud is dynamic, the matching of SLA templates need to be dynamic. SLA template contains many parameters like cloud's resources (physical memory, main memory, processor speed etc) and properties (availability, response time etc).

This work addresses the issue of matching SLA parameter of application requirements and available clouds. A simple and structural method is presented in this work based on permanent function to identify compatible cloud for particular set of application requirements.

Permanent function is a standard matrix function that is used in combinatorial mathematics. Ryser's equation is used to calculate the permanent of matrices and according to him no polynomial algorithm for permanent computation is known so far.

This work gives suggestion to the consumer in terms of number of matched parameters. A cloud having maximum number of matched parameters with the requirements of an application is a compatible cloud for that application.

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LIST OF ABBREVIATIONS USED

SLA : Service Level Agreement

IaaS : Infrastructure as a Service

PaaS : Platform as a Service

SaaS : Software as a Service

EERM : Economically Enhanced Resource Manager

IT : Information Technology

NIST : National Institute of Standards and Technology

SMB : Small and Medium size Business

VLAN : Virtual Local Area Network

VM : Virtual Machine

SBC : Service Bureau Corporation

BBN : Bolt, Beranek and Newman

VPN : Virtual Private Network

HPC : High Performance Computing

AWS : Amazon Web Service

API : Application Programming Interface

WSDL : Web Services Description Language

SME : Small and Medium Enterprise

AMI : Amazon Machine Image

UCI : Unified Cloud Interface

CCIF : Cloud Computing Interoperability Forum

ERP : Enterprise Resource Planning

CRM : Customer Relationship Management

PMML: Predictive Model Mark-up Language

SDLC : Software Development Life Cycle

DR : Disaster Recovery

WSLA : Web Service Level Agreement Language and Framework

OGF : Open Grid Forum

Chapter One: Introduction

As there is increase in demands for Information Technology (IT) services, there are also increasing requirements to expand IT architecture and infrastructures to provide more services conveniently and easily. As a result, in front of IT service providers there were challenges of expanding the structures and infrastructures with minimum consumption of cost and resources and minimum time in order to fulfill hiking demands from their customers. To enquire these business challenges and commercial interests, development of cloud computing architecture was take place.

The concept of Cloud Computing was introduced by **John McCarthy** in 1960s. The term 'Cloud' came into existence from the world of telecommunications when telecom companies started offering Virtual Private Network (VPN) services for data communications at much lower cost.

The definition of Cloud Computing provided by National Institute of Standards and Technology (NIST) says: "Cloud Computing is a model 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]".

Cloud computing architecture is an environment of IT resources for particular services which is outsourced to customers. In the context of cloud computing the cloud service provider is known as cloud provider which is an organization that provides cloud computing service. On the other hand the organization that receives the cloud computing service is known as cloud consumer [2].

Cloud computing is a kind of computing that relies on share-out computing resources rather than personalized local servers or personal device to compute the applications. Cloud computing is today's one of the enthusiastic technology due to its possessions to decrease the amount of money associated with computing while increasing flexibility and scalability for computer process. Cloud computing is based on network environment that cogitate to utilize computations or resources. This technology allows

anyone connected to the internet to use hardware and software on demand. Actually Clouds are Internet based and it tries to conceal complication for clients. Cloud computing refers to both the applications delivered as service over the internet and the hardware and software in datacenters that provide those services. Cloud providers use virtualization technologies combined with self-service abilities for computing resources via network infrastructure [3].

In cloud computing, the phrase 'Cloud' is used as a figure of speech for "the internet", therefore *cloud computing* is based on Internet where different types of services such as servers computation , hardware storage and applications are delivered to cloud consumers systems through the internet.

Cloud computing is equivalent to grid computing. Grid computing is a case of computing where idle serving cycles of all computer system in a network are reins to work out with problems too motivators for any complete machine.

1.1 Working of Cloud Computing

The main goal of cloud computing is to apply high-performance computing power, or the conventional supercomputing, which is normally used by army technical teams and research oriented organization, to execute hundreds of trillions of data processing per second, in applications that are specially oriented to consumer such as financial portfolios, personalized information delivery, data storage needed, large power, computer games etc.

For this, cloud computing uses networks of servers with large groups specially running with low-cost consumer PC technology with specialized connections to diffuse processing of data load across them. This shared IT framework contains tumid pools of computer systems that are linked together. Often, virtualization techniques are used to amplify the power of cloud computing [4] [5] [6] [7].

1.2 Cloud Computing Standards

There are not fully defined standards at present time for connecting the computer system and the software involved to make Cloud computing works, allowing many companies to specify their own Cloud computing technologies. There is certain Cloud computing systems that are rely on open criteria and open source software which connect together computers used to deliver web capabilities like mobile commerce or mash-ups. Example IBM's "Blue Cloud [8]"

1.3 Small Business Cloud Computing

Cloud computing has started to gain mass address in corporate data axis as it enables the data centers to function like the Internet through the action of altering computing resources to be accessed and shared as virtual resources in a secure manner [9] [10].

For a Small and Medium Size Business (SMB), the profits of Cloud computing is currently dynamic acceptance. In the SMB category there is generally a shortage of time and financial resources to buy, extend and control an infrastructure (e.g. security, software, server and storage).

In Cloud computing, SMB can access these cloud resources and services as the requirements of business modified. The usual pay-as-you-use agreement framework is planned to allow SMBs easily expand or shrink services and the user generally will pay according to his/her usage of cloud services.

1.4 Cloud Services

Cloud computing used to market available services that execute client software on remote location. These services are Software as a Service (SaaS), Infrastructure as a Service (IaaS), and Platform as a Service (PaaS) [7]. End users access cloud based applications using web browser or mobile app while the user's information is stored on data centers at any geographical remote location.

1.4.1 Infrastructure as a Service (IaaS)

In IaaS model clouds offer additional resources such as virtual machines, storage, firewalls, IP addresses, Virtual Local Area Networks (VLAN), and software bundles.
Example of IaaS provider include: Amazon EC2, Azure Services Platform, Google Compute Engine, Oracle IaaS, HP cloud, Joyent, Navisite, AirVM, iLand, RackSpace, ReadySpace Cloud services, Terremark etc.

1.4.2 Platform as a Service (PaaS)

In PaaS model, clouds deliver a platform for computation generally including virtual machines, operating system, database, execution environment for programming language and web server. Software developers can originate and execute their software on a cloud platform without consider the cost and complexity of purchasing and managing the inherent hardware and software. With some offers of PaaS, the inherent computer system and storage resources scale accordingly to match application requirement such that cloud user does not have to worry about allocation of resources manually.
Ex of PaaS include: AWS Elastic Beanstalk, AppScale, Cloud Foundry, Mendix, Heroku, Force.com, Engine Yard, Google App Engine, OpenShift, Windows Azure Cloud Services, OrangeScape, Jelastic, etc.

1.4.3 Software as a Service (SaaS)

In SaaS model, Cloud providers setup and operate application software in available cloud system and cloud users can access and use the software from cloud clients. Cloud users are not responsible for managing the cloud framework and required platform where the application executes. This excludes the need to setup and execute the application on the cloud user's computer system, which simplifies maintenance and support of services. Cloud applications are distinct from other applications in scalability which can be attained by copying undertaking process onto several virtual machines at run-time to

accommodate changing work demand. Payload balancers disperse the required work over the virtual machines sets available. Cloud user sees this process as a single access point because this process is translucent to the cloud user. Enormous number of cloud users, cloud applications can be multithreading, means anytime machine deal with more than one cloud user. It is conventional to associate to special kinds of cloud based application software with an analogous naming pattern: desktop as a service, communication as a service, business process as a service, and test environment as a service. The fee model for SaaS applications is generally a monthly or yearly fix fee per user, so usage price is adjustable and scalable if users are joined or ejected at any point to current cloud.

Examples of SaaS include: Microsoft Office 365, Google Apps, Onlive, Petrosoft, GT Nexus, Casengo, TradeCard, Marketo, Salesforce and CallidusCloud.

Table 1: Services of Cloud Computing

Cloud Clients
Mobile app, Web Browser, Emulator, Terminal
⇕
(Software as a Service) SaaS
CRM, Email, Virtual Desktop, Online Games, etc.
(Platform as a Service) PaaS
Web server, Execution Runtime, Databases, Development Tools, etc.
(Infrastructure as a Service) IaaS
Servers, Networks, Virtual Machines, Storage, Load Balancers, etc.

1.5 Related Work

Several studies have been conducted in the area of SLA metrics, security metrics and cloud computing. Extensive range of works have been conducted around the SLA for cloud computing. Some models of cloud computing are introduced to maintain the reliability between cloud providers and cloud consumers involved in the negotiation process [11] [12] [13]. Some piece of works concentrate on the gross and Quality of Services (QoS), and then some mechanism were introduced to maximize the revenue of cloud consumers or providers. Monitoring of cloud is also one of the research topic in cloud computing. Some architecture proposed to improve the capacity of cloud monitor [14]**.**

A trust model was introduced to evaluate cloud services, and then a new solution of defining the reliable criteria for the selection process of cloud providers is presented [12]. A mechanism for managing SLAs in a cloud computing environment using the Web Service Level Agreement (WSLA) framework is proposed [12]. In a services oriented architecture, it is developed for SLA monitoring and SLA enforcement.

A conceptual SLA framework was introduced to maintain believe and reliability between cloud providers and consumers tangled in the process of negotiation [11]. Several business rules have introduced for maximizing the provider's revenue and researchers have explored a common entity, called Economically Enhanced Resource Manager (EERM). If cloud providers are not able fulfill all the SLAs that have agreed, the EERM can select some SLAs which are estimated to be less losing according to the next process to be violated or cancelled. However, some rules (such as Selective SLA Violation and Selective SLA Cancellation) may make the providers loss their reputations.

Comuzzi et al. [14] focus on the relationship between establishment and monitoring. The author also proposed architecture for monitoring SLAs. In this architecture, two main requirements introduced by SLA establishment are satisfied: the accessibility of historic information for judging offers of SLA and the judgement of the capability to supervise the terms in a SLA propose.

At present the actual Cloud SLAs are typically plain-text documents, and sometimes an informative document published online. Amazon S3 Service Level Agreement (SLA) and Amazon EC2 Service Level Agreement (SLA) is an example of a document with legal agreement. Consumer needs to manually match application requirements with each and every cloud provider to identify compatible cloud. Proposed algorithm identifies the compatible cloud provider. It gives suggestion to a consumer in terms of number of matched instances.

1.6 Terminologies

Table 2: Basic Terminologies of cloud computing

Terms	**Definitions**
Cloud Computing	A model for soft convenient, on-demand network admittance to a contributed pool of resources.
Cloud Consumer	It is an entity who makes direct use of cloud services.
Cloud Provider	It is an external organization that offers cloud service to its consumers.
Security Vulnerabilities	Flaws in the process of design and implementation for software, hardware and protocol for the system.
Problems	An unknown underlying cause of one or more incidents.
Risk	The level of impact on organization operations from the operation of system.

1.7 Organization of Thesis

Rest of work is organized as follows:

Chapter 2: Literature Review

This chapter deals with the evolution of cloud computing from several years. It also provides the classification and details of various techniques related with cloud computing.

Chapter 3: Service Level Agreement (SLA)

This Chapter deals with the concept of Service Level Agreement. It also provides basic knowledge of various challenges concern with SLA.

Chapter 4: Design and Methodology

This Chapter deals with proposed approach for Service Level Agreement Parameter Matching Problem, parameters used and the algorithm used.

Chapter 5: Experiments and Results

This chapter discuss about the experimental setup used to handle problem and the results obtained using the proposed approach.

Chapter 6: Conclusion and Future Scope

In this chapter the conclusion of dissertation and the future scope of the work are presented.

References: The reference details of the dissertation are included in this chapter.

Chapter Two: Literature Review

This chapter is devoted to the literature review of Cloud computing, its characteristics and services.

The concept of cloud computing came in 1950 when large scale mainframe became available in corporation industry, accessible via clients computers often referred to as incoherent ends, because they were used for information transfer but had no computational capability. To make more effective use of pricey mainframes, a survey developed that granted multiple users to share both the physical access to the computer form multiple systems as well as to share the CPU time [15]. This got rid of periods of inactivity on the mainframe and granted for a heavier return on the investment. The usage of sharing CPU time on a mainframe became popular in the market as time sharing.

John McCarthy conception in 1960 is that "Computation may someday be classified as public tool" [16]. The modern Cloud computing characteristics(provided as a online, service program, false belief of infinite supply, elastic provision), the equivalence to the electricity industry and the use of private, public, government and community forms, were fully researched in *Douglas Parkhill's* 1966 book, The Challenge of the Computer Utility [16] [17] [18], Scientist *Herb Grosch* suggest that the whole world would manage on dull terminals supplied by about 25 big data centers. Due to the disbursal of the powerful computers, many organizations could benefit themselves of computing capability using time sharing and several organizations, such as IBM subsidiary The Service Bureau Corporation (SBC), GE's GEISCO, National CSS, Dial Data, Tymshare, and Bolt, Beranek and Newman (BBN) commercialized time sharing as a commercial hazard.

In the 1990s, telecommunications organizations, which previously mainly provide committed point-to-point data circuits, began with present Virtual Private Network (VPN) services with equivalent quality of service but at a low price. They saw balance of server by switching traffic; they could utilize overall network bandwidth more effectively. They began with the use of cloud symbol to indicate the line of division

between the responsibilities for cloud users and providers. Cloud computing expands this boundary to cover the servers as well as the infrastructure of existing network. As computer became more powerful, researchers and scientists investigate various ways to make large-scale computing power made available to users using time sharing approach, experimenting with algorithms to provide the optimal use of the platform, infrastructure, and applications with prioritized connection to the CPU and efficiency for the end users [19] [20] [21] [22].

Supercomputer is used to carry out high-speed calculations as their processing capacity is very high. High Performance Computing (HPC) is similar to supercomputer, but it has extended advantage of computer clusters. HPC is used to evaluate advanced calculations in the field of science and engineering. All the applications which are evaluated by supercomputers can also be solved by HPC. Engineers, Scientists, and analysts in the leading companies and research stations are depending on HPC to solve challenging problems [23] in the fields like finance, engineering, risk analysis, revenue management, life and earth sciences, manufacturing etc. These problems can be evaluated by HPC and mainly it should have cost control.

Cloud Computing has the ability to effectively reduce cost and complexity. In Cloud Computing large amount of data and computing resources can be accessed remotely over the internet using personal computer or other devices. Cost regulation and several others concerns like speed of execution and remote access leads to HPC development in the cloud.

With the development of Internet technologies and increasing demands of computer applications, Cloud computing came as a multi-service provider that shares software, information, and open resources within the Internet based environment. In October 2007, cloud computing was first introduced to the public through a cooperation between two computing companies, IBM and Google. After the dot-com bubble, Amazon clown a key role in the cloud computing development by modernizing their data centres, like most computer networks, were using as little as 10% of their capacity at any one time, just to leave space for occasional spikes. They found that the new cloud

architectures consequence to significant improvements of internal efficiency. Amazon initiated a new effort of product development to provide cloud computing related services to their users, and launched Amazon Web Service (AWS) on a convenience community in 2006. In early days of 2008, the first open-source was Eucalyptus, API-compatible platform for deploying private clouds. After this, OpenNebula, enhanced in the reservoir European Commission-funded assignment, became the first open-source software for deploying private and hybrid clouds, and for the association of clouds. In the same year, efforts were focused on providing Quality of Service (QoS) guarantees to infrastructure of cloud based, in the European Commission-funded project scheme, resulting to a real-time cloud environment [23]. By mid-2008, Gartner saw an opportunity for cloud computing "to shape the relationship among consumers of IT services, those who make use of IT services and those who sell these services" [24] and observed that "organizations are switching from company-owned hardware and software assets to per-use service-based models" so that the "projected shift to computing will result in dramatic growth in IT products in some areas and significant reductions in other areas". On March 1, 2011, IBM declared the IBM SmartCloud framework to support smarter systems [8]. Among the different components of the Smarter Computing foundation, cloud computing was a critical piece.

The cloud computing has been defined from different prospect since it is still a research stage. The National Institute of Standards and Technology (NIST) have proposed a basic concept of cloud computing that is commonly accepted by the public. They define cloud computing as a model that allows the sharing of many computing resources as services to various clients. In this model, clients can easily change or adjust their service requirements at a very low cost. The availability of high-speed networks, low cost computers and storage devices as well as the universal adoption of virtualization of hardware, utility computing and service-oriented architecture have led to a growth in cloud computing.

The beginning of the term ‘*cloud computing’* was not well defined. The word *cloud* is usually used in science to describe a large collection of objects that visually seem

from a distance as a cloud and identifies any set of things whose details are not scrutinized further in a given context.

- Meteorology: a collection of similar objects-weather cloud.
- Mathematics: a coordinate system with large number of points in mathematics was seen as a point cloud;
- Astronomy: star clouds (star mist) in sky when many stars crowd together e.g. the Milky Way.
- Physics: The fast movement of electrons around an atomic kernel seems like a cloud to a distant observer;
- Video Games: 'The Cloud' follower of Mario characters that permit them to save and access extra tokens.

In analogy to above usage the word Cloud was used as a metaphor for the Internet and a standardized cloud-like shape was used to denote a network on telephony schematics and later to depict the Internet in computer networks diagrams. The cloud symbol was used to represent the Internet as early as 1994. Urban legends claim that usage of the expression is directly derived from the practice of using drawings of stylized clouds to denote networks in diagrams of computing and communications systems. The term became popular through the internet concern Amazon.com that introduced the Elastic Compute Cloud (EC2) in 2006

Miller proposed that cloud computing was user-centric and task-centric, and distributed computing can provide more effectiveness for sharing resources and collaborations in a group. The report of NIST further presents five essential characteristics of cloud computing, which were resource pooling, on-demand self-service, broad network access, rapid elasticity, and measured service [1].

Initially service components of cloud computing has include application as a service, process as a service, database as a service, information as service, storage as a service, platform as a service, and integration as a service. NIST has presented another scope of basic services that were provided by cloud computing includes:

- Software as a Service (SaaS).
- Platform as a Service (PaaS).
- Infrastructure as a Service (IaaS).

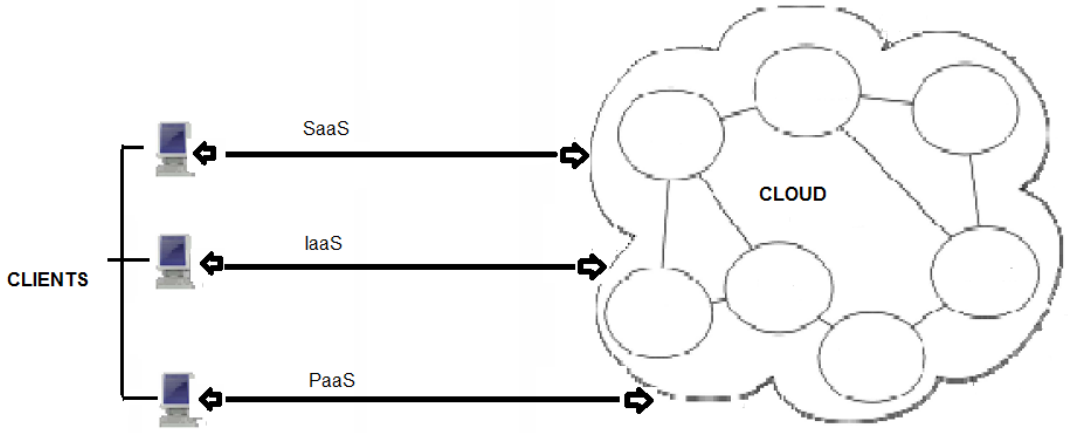

Figure 1: Services of Cloud Computing

2.1 Characteristics

Some of the main characteristics of a Cloud Computing include:

(1) Browser is needed to access the data, applications, or any services and it is independent of the device and user's location.

(2) Less IT Skills required for the implementation of cloud related service [25],

(3) It makes a better use of distributed resources and combines them to achieve the higher throughput and able to solve large scale computation problems.

(4)Virtualization technology allows servers and storage devices to be shared and utilization be increased.

(5) Cloud Computing applications need not to be installed on each user's system thus make the maintenance easy.

(6) Cost reduction since the infrastructure need not to be acquired by each user.

(7) Useful in disaster recovery.

(8) Monitoring of performance is easy and thus it is scalable.

(9) Security is equal to or better than usual system since some dedicated resources are

there for solving security related issues.

(10) Application Programming Interface (API) accessibility to software that enables machines to interact with cloud software in the same way that a traditional user interfaces.

2.2 Cloud Computing Architecture

Cloud Computing System consists of two sections: the front end and the back end, connected via internet [26]. Front end is seen by clients and back end is the Cloud System.

2.2.1 Layers of Cloud computing

Table 3: Different Layers of Cloud Computing

CLIENT
APPLICATION
PLATFORM
INFRASTRUCTURE
SERVER

2.2.2 Services of Cloud Computing [27]

1) Software as a Service (SaaS)

In SaaS model, Cloud providers setup and operate application software in available cloud system and cloud users can access and use the software from cloud clients. Cloud users are not responsible for managing the cloud framework and required platform where the application executes. This excludes the need to setup and execute the application on the cloud user's computer system, which simplifies maintenance and support of services. Cloud applications are distinct from other applications in scalability which can be attained by copying undertaking process onto several virtual machines at run-time to accommodate changing work demand. Payload balancers

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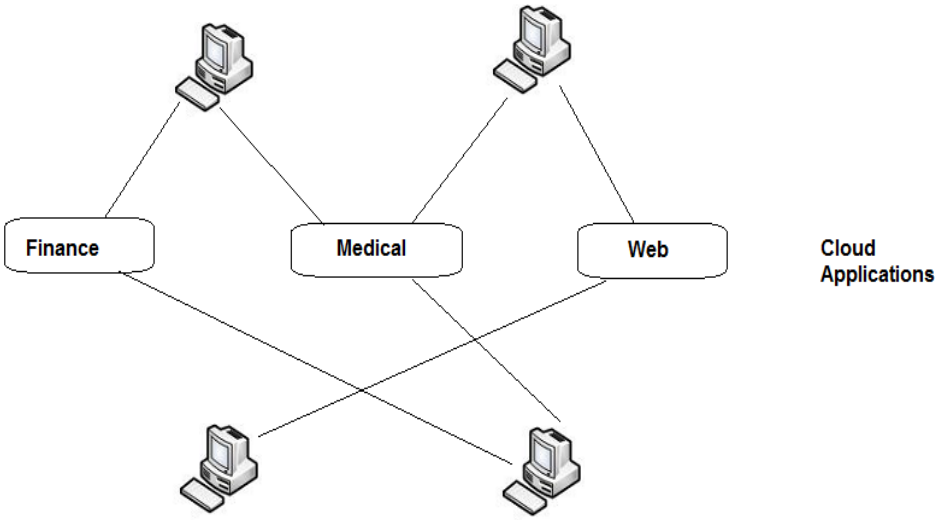

Figure 2: Software as a Service (SaaS)

2) Platform as a Service (PaaS)

In PaaS model, clouds deliver a platform for computation generally including virtual machines, operating system, database, execution environment for programming language and web server. Software developers can originate and execute their software on a cloud platform without consider the cost and complexity of purchasing

and managing the inherent hardware and software. With some offers of PaaS, the inherent computer system and storage resources scale accordingly to match application requirement such that cloud user does not have to worry about allocation of resources manually.

Ex of PaaS include: AWS Elastic Beanstalk, AppScale, Cloud Foundry, Mendix, Heroku, Force.com, Engine Yard, Google App Engine, OpenShift, Windows Azure Cloud Services, OrangeScape, Jelastic, etc.

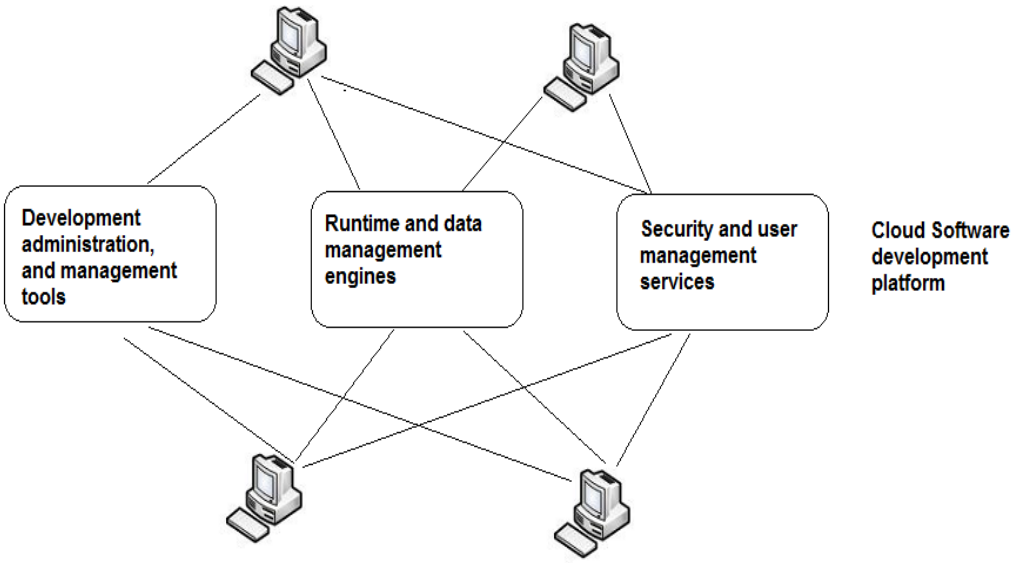

Figure 3: Platform as a Service (PaaS)

3) Infrastructure as a Service (IaaS)

In IaaS model clouds offer additional resources such as virtual machines, storage, firewalls, IP addresses, Virtual Local Area Networks (VLAN), and software bundles.

Example of IaaS provider include: Amazon EC2, Azure Services Platform, Google Compute Engine, Oracle IaaS, HP cloud, Joyent, Navisite, AirVM, iLand, RackSpace, ReadySpace Cloud services, Terremark etc.

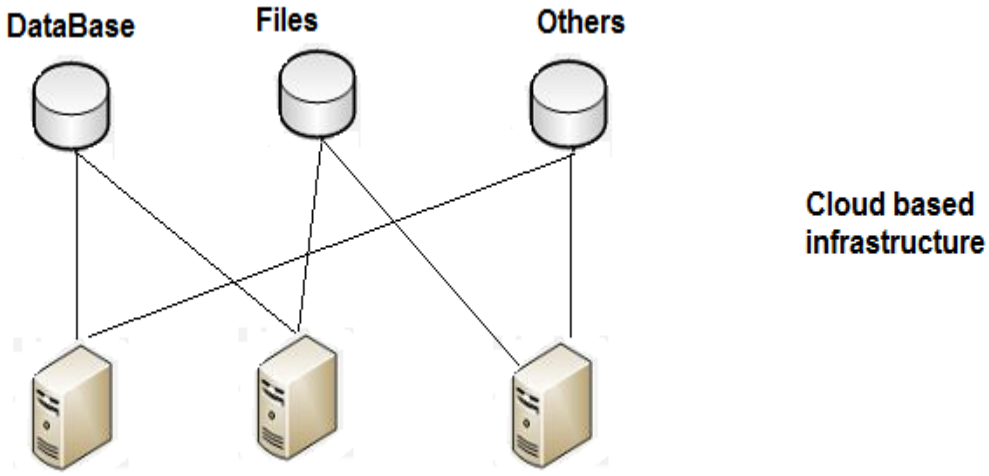

Figure 4: Infrastructure as a Service (IaaS)

Servers consist of all the Software / Hardware required for the clients. Some details of cloud services are provide below

Table 4: Details of Cloud Services

Software as a Service (SaaS)	**Platform as a Service (PaaS)**	**Infrastructure as a Service (IaaS)**
Email	Application Development	Servers
Social Networking	Security Services	Storage
ERP	Database Management	Network
Examples:	Examples:	Examples:
IBM	GAE	GoGrid
Google APPS	Microsoft Azure	Amazon S3
Oracle	Amazon EC2	Joyent

Basic Diagram of Cloud computing is shown below:

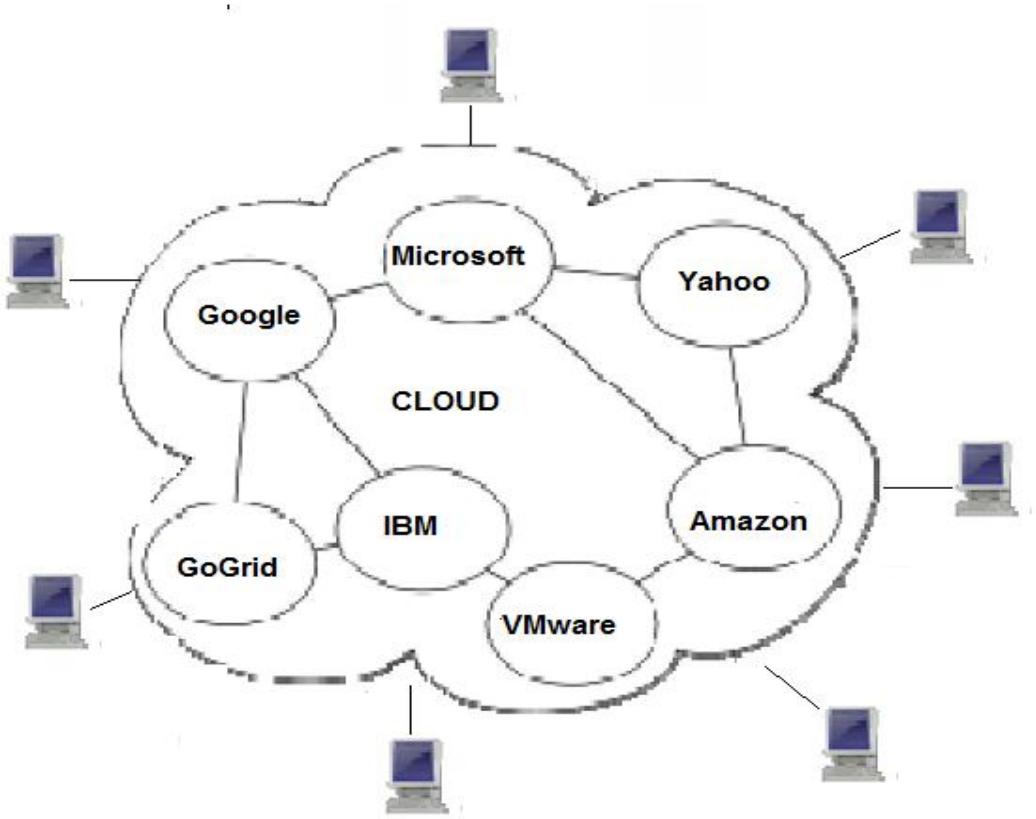

Figure 5: Cloud computing logical view

2.3 Relationship between Cloud Computing, Service-Oriented Computing (SOC), and Grid Computing

2.3.1 Cloud Computing and Service Oriented Computing

The encapsulation, decentralization, componentization, and integration capability provided by SOC are substantial: they provide both software specifications and architectural principles to connect computers and other devices using standardized protocols over the internet.

Benefits of SOC can help Cloud Computing in various ways.

Service Description for Cloud Services: Web Services Description Language (WSDL) and the REST protocol are two commonly used interface languages to explain the web services. These are used to describe Cloud API specification.

Composition for Cloud Services: Since various Web Services are made to compose business applications, a great deal of research in this area can influence for cloud services integration, collaboration, and composition.

Discovery for Cloud Services: Various Web services discovery models can be leveraged for cloud resource discovery, selection and Service Level Agreement (SLA) verification.

Management for Cloud Service: Several research and practices in SOC governance and service management can be adapted and reused in the cloud infrastructure management.SOC represents a very high level of abstraction from the integration and business process perspective. SOC does not provide real time models of computational for running services. For example, how to get minimum cost on my running services? How to scale my applications that are built on top of Service-Oriented Architecture? These computational details have to be dealt with in a specific project and ad-hoc manner, which burdens the workload for SOC developers. Cloud Computing can benefit Service-Oriented Computing research in several important ways.

Cloud for Web Service Development: Cloud can present service-oriented development under the PaaS service deploy model. SOC development often requires distributed computing resources that are difficult to obtain for Small and Medium Enterprise (SME). For example, Google's AppEngine provides a full-fledged development platform in which developers can develop and deploy Java Web services to build applications.

Cloud for Web Service Testing: Web services developers could tap into infinite computing number of computing resources in a Public Cloud to simulate the real-world automated machine requests and network flows as a means of load testing and stress testing for services. The cost and ability to simulate network traffic for Web Service testing has been discourage to Web authenticity. The low cost and accessibility of the extremely large computing resources provides the ability to duplicate real world usage of these systems by geographical distributed users, running and testing wide varieties of user scenarios.

Cloud for Web Service Deployment: With the help of IaaS, Web services deployment can be resistance free. For example, under the Amazon EC2 setting, service deplorers can use the Amazon Machine Image (AMI) to distribute their offerings. When requests are made, service deployment image will be loaded into a specified virtual machine to serve the client requests. State full information produced during service interactions can be also kept persistent onto the AMI when Web services are resumed from the suspended mode.

Cloud for Service Process Enactment: The integration and composition of services become frequent problems and their solutions can be packaged as services deployed in the cloud environment. Therefore, a comprehensive approach is to exploit the service users to allow the re-use of solutions that are ready-to-use with minor configuration and composition patterns using various algorithms.

2.3.2 Cloud Computing and Grid Computing

Grid Computing is the federation of computer resources from multiple locations to reach a common goal. The grid can be considered as a distributed system with non-interactive workloads that involve a large number of files [28]. Grid Computing is a hardware and software infrastructure motivated by real problems in advance science research. The Grid is distributed computing 'middleware' that provides 'coordinated cross-organizational resource sharing' to high-end computational applications such as science and engineering. There exist similarities between Cloud Computing and Grid Computing Significant differences between Cloud and Grid Computing are:

- Grid main focus on the "resource sharing" to form a virtual organization. Cloud normally owned by single organization (except the community Cloud which is owned by the community), who allocates resources and provide services to different running cloud users instances.
- Grid aims to provide the maximum computing capacity for a huge task through resource sharing. Cloud aims to meet the needs of as many small-to-medium tasks as possible based on user's real-time requirement. Therefore, multi-tenancy is one of the important concept of Cloud computing.

- Grid makes use of re-usability for high performance computing. Cloud computing is attract by user needs driven by various business requirements.
- Grid makes efforts to achieve maximum computing. Cloud is on-demand computing – Scale up and down, in and out at the same time optimizing the overall computing capacity.

2.3.3 Cloud and High Performance Computing (HPC)

High Performance Computing (HPC) aims to leverage supercomputers and computer clusters to solve scientific computation problems. Initially aim of Cloud computing and High Performance Computing was different, which yield different computing paradigms as well as applications. HPC has been widely used for scientific tasks while Cloud computing was set for serve the needs of business applications. HPC make use of parallelization, the highly complicated state and data depended amongst many business applications have made more difficult to influence parallelization computing techniques for business applications in Cloud computing.

Current Cloud is not leveraged for HPC due to several reasons:

- It is not yet matured enough for HPC
- Unlike Cluster computing, Cloud infrastructure interest on enhancing the overall system performance as a whole.
- HPC aims to enhance the performance of a specific scientific application using resources across multiple organization

Main difference is in elasticity: for cluster Computing, the capacity is often fixed, therefore running an application of HPC requires considerable human interaction.

2.4 Deployment Model of Cloud Computing

Types of Cloud:

1. Public Cloud
2. Private Cloud

3. Hybrid Cloud

4. Community Cloud

2.4.1 Public Cloud:

In public Cloud users access cloud services using web browsers. Pay-per-use policy is there users only pay the time duration they use the service. This can be compared to the internet usage in cyber café. The same concept is there. It helps in cost reduction on IT expenditures. Public Clouds are less secure due to applications and data are liable to harmful attacks.

2.4.2 Private Cloud:

Private Cloud operates within an organization and all needed resources and applications are managed and maintained by the organization itself. It provides same features and availability of public cloud within the organization. The main advantage in private cloud is that it is easier to control over the data, maintenance and upgrades. Since private clouds are implemented within the organization firewall, it ensures security and data loss recovery in natural disaster. Private Cloud is same as intranet.

2.4.3 Hybrid Cloud:

It is an association of public cloud and private cloud. In this cloud model private cloud is connected to various cloud services thus it is more secure way to control the services, data, applications and information access over the internet. It enables the organization to fulfill its requirement in the private cloud and if some extra need occurs then it ask public cloud for the desired services.

2.4.4 Community Cloud:

This model is a jointly construction of many organization where these organizations share cloud infrastructure, their requirements, policies. This model could be managed by third party or by any one of the sharing organization.

2.5 Advantages of Cloud Computing

1. Cost Efficient

   Since all the applications, infrastructure and platform require to run the services all are managed at one place so there is no need to install on each system thus it reduces cost.

2. Easy Management

   Cloud Computing makes the maintenance of infrastructure easier whether it is software or hardware since all things are installed at one place and only require web browser to access them.

3. Green Computing

   Extensive use of systems within an organization leads to harmful emissions and energy consumption this is the main disadvantage of current computing systems. This can be reduces to some level by using cloud computing concept.

4. Disaster Management

   In case of disasters an offsite backup is very helpful. It regularly keeping crucial data backed up using cloud storage services and they also ensures that they have systems in place for recovery from disaster.

5. Easy Information Access

   Once any one becomes a registered user in cloud, he/she can access the information from any geographical location and from any device having Internet connection.

6. Almost Unlimited Storage

   Cloud provides almost unlimited storage for storing our information. So there is no need to worry about running out of storage space.

7. Backup and Recovery

   Since all the data of user is stored in cloud, backing it up and restoring is much easier than storing same on a physical drive. Most cloud providers are able to recover the information. Hence recovery and backup are much easier than any traditional methods.

8. Automatically Integration of Software

In cloud computing software integration occurs automatically. Hence there is no need to customize and integrate our applications as per preferences.

2.6 Challenges of Cloud Computing

Major challenges of Cloud Computing are recognized by organizations are shown as

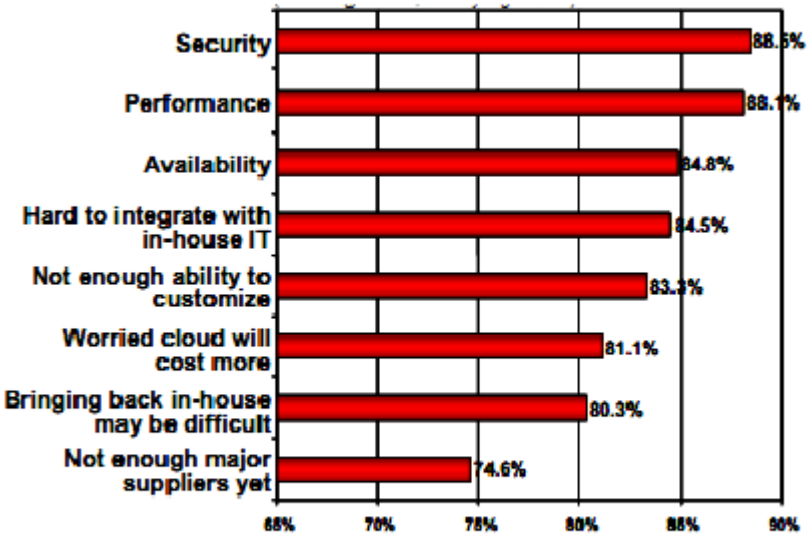

Figure 6: Major challenges of Cloud Computing [29]

1) Security

To make it use difficult to use security issue has played the most important role. Storing data, executing software at other's hard disk using someone else's CPU appears daunting to many [30]. Popular security issues such as phishing, data loss, botnet (running remotely on collection of machines) pretend to be serious threats to organization's data and software.

2) Costing Model

Cloud consumers must consider the adjustment amongst the computation, communication, and integration. During migrating toward Cloud although it can significantly reduce the infrastructure cost but it increase the cost of data communication (the cost of transferring an organization's data to and from the public and community cloud) and the cost per unit time of computing resource used. This problem is particular important if the consumer uses the hybrid model where the organization's data is spread over amongst a number of public/private/community clouds.

3) Charging Model

The flexible resource pool has made the cost analysis a lot more complex than regular data centers, which in many cases calculates their cost based consumptions of static computing. An instantiated virtual machine has become the unit of cost analysis rather than the underlying physical server. A sound charging model needs to embodied all the above as well as VM associated items such as software licenses, virtual network usage, node and hyper vision management and so on.

4) Service Level Agreement

It is necessary for consumers to obtain guarantees from providers on service delivery. These are provided through Service Level Agreements (SLAs) contract between providers and consumers. The important issue is the definition of SLA specifications that has the tradeoffs between extravagant and complexity, so that they can cover most of the consumer expectations and is relatively simple to be verified, weighted, evaluated, and enforced by the resource allocation scheme on the cloud. Different cloud offerings (IaaS, PaaS, and SaaS) will need to define different SLA specifications.

2.7 Issues of Cloud Computing

Some issues related with cloud computing are

1) Intermediary Layer

Number of current works point out the practical issue by providing an intermediary layer between the cloud consumers and the specific cloud resources. For example, Sotomayor proposed the concept of Virtual Infrastructure Management to replace native VM API [29] interactions in order to accommodate multiple clouds private or hybrid for an organization.

2) Standard

Standardization seems to be a good solution to address the interoperability issue. The standardization process will be very hard to progress when big players such as Amazon and Microsoft do not reach consensus since neither Amazon nor Microsoft supports the Unified Cloud Interface (UCI) Project proposed by Cloud Computing Interoperability Forum (CCIF). Eucalyptus project is commonly used cloud API within the community, which reflects the well known Amazon EC2 API for cloud operation. Eucalyptus IaaS cloud consumer can easily connect to the EC2 cloud without re development, it cannot solve the general interoperability issue that requires an open API compiled by different types of Cloud providers.

3) Open API

The Sun Open Cloud Platform recently launched by SUN under the Creative Commons license. It defines a set of clear and easy-to-understand Web services interfaces, using these cloud consumers are able to create and manage cloud resources, comprise of computation, storage, and networking equipments in a unified way. HTTP is used as an application protocol and JSON for resource representation, using these, the open cloud API defines these resource types: Cloud, Virtual Data center, Cluster, Virtual Machine, Private Virtual Network (VPN), Storage Volume, Public Address and Volume Snapshot. These resources share a certain degree of similarity with the internal architectural design of Eucalyptus.

4) SaaS and PaaS Interoperability

SaaS interoperability includes different application domains such as ERP, CRM etc. Progress with great potential in this direction leads to the development of the Predictive Model Mark-up Language (PMML) a gradually undertaken standard that permits users to exchange predictive models among various software tools [31]. Efforts are not yet discovered that should be taken into account in providing PaaS interoperability. Since PaaS involves the Software Development Life Cycle (SDLC) on the cloud, it makes more difficult to reach the uniformity with regards to the way consumers develop and deploy cloud applications.

2.8 Delivery Models of Cloud Computing

Cloud computing can be offered in three delivery models today, depending on the amount of integration. Infrastructure as a service (IaaS) offers virtual machines and other virtualized resources, such as storage and network access. Platform as a service (PaaS) offers a computing platform which typically includes the a database, virtual machine, web server, Operating System (OS), and environment for execution of programming language,. Software as a service (SaaS) offers application software in the cloud, and cloud users access to the software from cloud clients.

In the future, the cloud computing delivery model for business applications will move into a more integrated virtual appliance delivery model to simplify delivery and deployment of complex software systems. A Virtual Appliance is a self contained package with pre-installed software and described by metadata which specify the required computing resources as an ensemble of several virtual machines, storage and network configuration [32]. The delivered appliance is pre-configured and contains a customized and tested software stack, from operating systems and middleware to application software. Metadata describe goals and constraints for the virtual appliance, such as performance and availability goals, placement constraints (e.g., for security isolation and for legal data compliance), and configuration variables. The entire software solution is managed (deployed, updated, etc.) as a unit. As consumer computing is

moving into the post-PC era, the importance of personal computers is diminishing, and most computing interaction is moving towards mobile computing. In this space, there is increasingly separation of user interaction and data storage and processing which occurs transparently to the user. While user interaction and limited processing is performed on mobile devices, persistent storage and processing intensive applications are moving into the cloud.

The first computer system with system virtualization was released in 1972, when IBM released the Virtual Machine Facility/370 (VM/370) for the S/370 mainframes. For the first time, VM/370 provided multiple users with seemingly separate and independent computing systems, partitioning a single mainframe into several virtual machines. This offered the same advantages cloud computing is offering today: multi-tenancy, centralized management, over the network delivery, and better hardware utilization. To this date, mainframes offer the highest level of centralized, virtual system integration in the enterprise based on System virtualization. In the 1990s, POWER systems servers started to offer virtualization with Power VM hypervisors implementing live partition mobility and active memory sharing. Also in the 1990s, the DAISY and BOA research projects at the IBM T.J. Watson Research Center demonstrated how to fully virtualized instruction sets. Virtualization techniques became widely available for Intel x86 systems in late 1990s based on software solutions to overcome the intrinsic limitations in this architecture that had previously prevented virtualization of this architecture by using instruction set virtualization techniques.

2.9 HIGH AVAILABILITY AND DISASTER RECOVERY

The virtualization, standardization, modularity and cross system management capabilities of cloud computing, offer a unique opportunity to provide highly resilient and highly available systems. As virtual machines are becoming first class resilience techniques that can build on a well-defined framework for providing recovery measures for replicating passive services, and recovering failed services to respond to disaster scenarios. Since virtualization allows packaging of workloads-operating system, applications, and data-in

a portable virtual machine image container, it enables easy transfer of workloads from one server to another. High availability features can leave a VM image seamlessly from one physical server to another within the same data center if the original server suffers from any performance loss, failure, or to perform scheduled maintenance. This flexibility and movement of workloads permits implementation of highly available systems, where a customer requires that the most significant workloads are continuously made available. Cloud computing is radically changing the way how a disaster recovery (DR) of a data center can be implemented. In conventional disaster solutions for recovery, a data center must have a disaster recovery site. Classic disaster recovery generally make use of data backup and stores data onto storage records which are then transferred to a recovery data centers, or stored in a vault until they are needed for recovery. For recovery, the failover servers need to be loaded with the operating system images and application software and patched to the last configuration used in production before the data can be restored. This procedure is prolonged and can take hours and days till the workloads are made available again.

Cloud computing and virtualization make recuperation of VM images and their cost effective resuming on some other host in a different data center for calamity recuperation, and enable significantly faster recovery times. The capability to restart VMs from one data center located in some area to another data center located in another area is redefining how disaster recovery can be implemented [33].

Cloud computing is also changing the economics of disaster resilient computing. Traditional disaster recovery solutions of a data center are costly, and rely on recovery data centers, which can be either dedicated as a recovery data center of a single data center, or can be shared between multiple data centers to lower cost. With cloud computing, virtual workloads from a data center affected by a disaster scenario can be restarted and distributed across multiple unaffected data centers by using their available capacity. This significantly lowers the cost and affordability of a disaster recovery solution. In addition to high availability techniques at the hypervisor and control system level of cloud computing, a new class of distributed, stateless applications is emerging.

These applications are designed from ground up to run in a distributed architecture across multiple sites in a cloud environment, being stateless and resilient to failure of any individual server or site. These alterations at the applications, software and system phases capable to move computing from disaster resilient and highly available systems to disaster avoiding, continuously available systems.

Virtualization technology is the key enabling technology for cloud computing, which transcends static view of a system as a piece of hardware, but views systems as dynamic entities. Cloud computing increases flexibility, and opens new ways to think of computing systems by separating computing capabilities and services from the hardware used to provide these functions. Thus, servers are no longer bound to specific racks – instead, systems can migrate from one rack to another or one data center to another. This flexibility allows systems to be more dynamic, and be optimized to be more efficient for any number of metrics, e.g., energy use, capacity, reliability, availability, serviceability in ways not possible before, by focusing on how systems are used and thereby making IT more consumable.

Chapter Three: Service Level Agreement

3.1 Service Level Agreement

A Service Level Agreement is a document that includes a description of the acknowledged services, guarantees, service level parameters, and actions and remedies for all cases [34] [35] [36]. The SLA is basically a contract between consumer and provider. Service Level agreements provide some degree of assurance to both the users and providers of these cloud resources and define the scope of usage and provision of resources. Cloud consumers need an SLA before they transfer their infrastructure to cloud data centers, to provide assurance that the resource provided and the ability to reach the desired level of productivity. Cloud providers need SLA document to define the trust and quality of services they provide to the users as well as an agreed framework for costs and charges.

An SLA contains several parameters like a set of properties and resources the provider will deliver, a specific definition of each resource, the responsibilities of the provider and the consumer, a resource quantity, an auditing mechanism to monitor the service etc [37].

The SLA is a legal format documenting the way of in which service will be delivered as well as providing a framework for service charges. Service providers use this document to optimize their use of infrastructure to meet signed terms of services. Service consumers use this document to ensure the level of quality of service they need and to maintain acceptable business models for the long term provision of services [34] [38].

Main requirements of SLA format are:

- It should clearly define and describe a service so that the service consumers can easily understand the operation of services.
- Commenced the level of performance of service.

- Define the ways by which the service parameters can be monitored and the format of monitoring reports.
- Impossible penalties when service requirements are not met.
- Commenced the business metrics such as billing stipulate when this service can be terminated without any penalties being incurred.

3.2 Functional and Non Functional Requirement for Cloud Users

Functional and Non Functional Requirements of cloud services must meet with the requirements of cloud users to fulfill the needs of consumers. For each type of cloud service, there are different requirements. Figure shows the categorization of cloud computing services and requirements of each service.

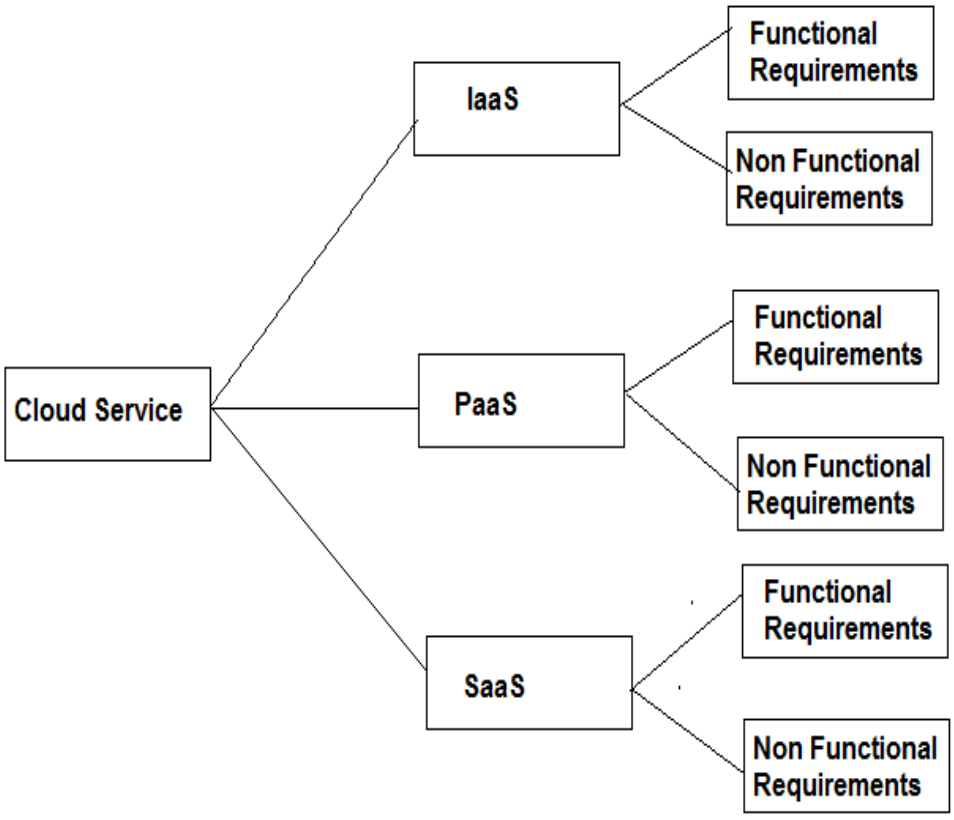

Figure 7: Categorization of requirements for cloud services

3.2.1 Functional Requirements

The functional requirement also known as functional specifications define the capability and the functioning of a system that it must be able to perform successfully. It defines a function of system. A function is described by a set of inputs, the behaviour and outputs. Functional requirements may be calculations, technical details, manipulation of data and processing and other specific functionality that define what a system is supposed to achieve.

Functional Requirements should include:

- Description of data to be entered into the system.
- Description of operations performed by each system.
- Description of work-flows performed by the system.
- Description of system reports or other outputs.
- Who can enter and edit the data into the system.
- How the system satisfied applicable regulatory requirements.

The functional specification is designed to be easily understood by a general assembly. Readers should understand the system, but no particular technical knowledge should be required to understand the document [39].

Examples of Functional Requirements

Interface Requirements

- Field accept numeric data entry
- Field only accepts dates that are before the current date.
- Screen can be able to print on-screen data to the printer

Business Requirements

- Data must be entered before a request can approve.
- Clicking the approve button must moves the request to the approval workflow.

Regulatory Requirements

- The database will have a functional examination trail.
- The system will bound access to authorized users.
- The spreadsheet can protect data with electronic signatures.

Security Requirements

- Data Entry group members can enter requests but not approve or delete requests.
- Manager's group members can enter or approve a request, but not delete requests.
- Administrator's group members cannot enter or approve requests, but can delete requests.

Depending on the system being characterized, different categories of requirements are applicable. System Owners, Developers, Engineers, Key End Users, and Quality Assurance should all participate in the requirement gathering process, as appropriate System Owners, Key End Users, Developers, Engineers and Quality to the system. Requirements outlined in the functional requirements are usually tested in the Operational Qualification.

3.2.2 Non Functional Requirements

- Availability: in cloud computing one of the most important criteria for quality of service is the availability of the service. Availability is the probability that the infrastructure of the cloud or service are running and up in the specific time of utilities of the service provided for in the SLA.
- Scalability: Cloud consumers pay for the service only as per use of it. The cloud provider should facilitate the specific resource for scaling up and down. With Scalability, cloud consumers can maximize the revenue and cloud providers are able to optimize the resources efficiently.
- Cost Calculation: Cloud consumers pay the cost of usage as they use the service, so no annual billing period or even monthly periods are not suitable

for cloud computing. So there should be a clear method for cost calculation which includes the entire factor needed.

- Configuration of Service: For the use of service provided by the service provider user deal with the virtual machines and these VMs should be configured in a flexible manner to permits user to execute business with minimal need for managing the effort of the configuration.
- Security and Privacy: The important data of an organization must be stored with prevention of attacks and transferred via secure channels. If security features are not guaranteed by the cloud providers, then the business organization may spend too much cost on operating their own data centers rather than storing their data to cloud.

The main specifications which are needed to describe the syntax of SLA, these designs are

- Web Service Agreement (WS-Agreement).
- Web Service Level Agreement (WSLA) Language and Framework.

A WS agreement is made by Open Grid Forum (OGF) in order to make official contract between service consumers and service providers. This contract document should specify the guarantees, the obligations and penalties in case of violations and it also includes the functional requirements and other specifications of services. There are three main sections for WS-Agreement: name, context, and terms. A unique id and optional names of services are included in the name section. The information about service consumer and service provider, domain of service, and other specifications of service is presented in the context section. Terms of services and guarantees are described with more details in the terms section.

The WSLA was developed to describe services in these three categories:

1) Parties: In this classification knowledge about service users, service providers, and agents are described.

2) SLA Parameters: In this classification the main parameters which are measurable parameters are presented in two types of metrics.

The first is resource metrics, used to describe service provider's resources as row information. The second one is composite metrics. This metric is used to represent the calculation of the combination of information about service provider's resources. The last and final section of WSAL specification is Service Level Objective (SLO) this section is used to specify the obligations and all actions when service consumers or service providers do not comply with the guarantees of services.

3.3 SLA Framework for Cloud computing

In this Framework the SLA parameters are specified by metrics. These metrics define how the parameters of cloud service can be measured and specify values to the measurable parameters. The SLA metrics for cloud computing considers these cloud services: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS), and Storage as a Service. For each part of the SLA the most important parameters that consumers can use to make a reliable model of negotiation with these service provider.

1) SLA Metrics for IaaS

Amazon Company provides Infrastructure as a Service. The important parameters for consumers who are interested in using cloud as an Infrastructure service.

Table 5: SLA metrics for IaaS [11]

Parameter	Description
CPU Capacity	CPU speed for VM
Memory Size	Cache memory size for VM
Boot Time	Time for VM to be ready for use
Storage	Storage size of data for short or long term of contract
Scale Up	Maximum number of VMs for one user
Scale Down	Minimum number of VMs for one user
Scale Up Time	Time to increase specific number of VMs
Scale Down Time	Time to decrease specific number of VMs
Auto Scaling	Boolean value for auto scaling features
Max Number can be configured on physical Server	Maximum number of VMs that can be run on individual server
Availability	Uptime of service in specific
Response Time	Time to complete and receive the process

2) SLA Metrics for PaaS

Platform as a Service provides all the requirements needed to support application developers in developing, evaluating and delivering applications and software for cloud users. The important parameters for consumers who are interested in using cloud as a Platform service.

Table 6: SLA metric for PaaS [11]

Parameter	Description
Integration	Integration with e-services and other platforms
Scalability	Degree of use with large number of online users
Pay as you go billing	Charging based on resources or time of service
Environments of deployment	Supporting offline and cloud systems
Servers	
Browsers	Firefox, IE…
Number of developers	How many developers can access to the platform

3) SLA Metrics for IaaS

This service is a common example of cloud services. In this service an application is hosted on a particular cloud platform and infrastructure to provide built-in services for cloud users. Examples of SaaS are mail, calendar, and social websites like Facebook, Twitter, Orkut, etc. The important parameters for consumers who are interested in using cloud as a Software service.

Table 7: SLA metric for SaaS [11]

Parameter	Description
Reliability	Ability to keep operating in most cases
Usability	Easy built-in user interfaces
Scalability	Using with individual or large organizations
Availability	Uptime of software for users in specific time
Customizability	Flexible to use with different types of users

4) SLA Metrics for Storage as a Service

Online users access their data from different geographical locations. In the past few years, online storage providers were unable to maintain large size of data because of the lack of huge space in storage disks, network performance, and data management systems. Now, data storage service providers such as S3 by amazon.com configure large numbers of storage hardware and they are able to manage and serve millions of users efficiently with their method of data transfer and ensuring this information are compatible with various types of applications. The criterion for information storage service metrics are basic requirements for negotiation with storage providers. The important parameters for consumers who are interested in using cloud as a Storage service.

Table 8: SLA metric for Storage as a Service [11]

Parameter	Description
Geographic location	Availability zones in which data are stored
Scalability	Ability to increase or decrease storage space
Storage space	Number of units of data storage
Storage billing	How the cost of storage is calculated
Security	Cryptography for storage and transferring of authorization and data authentication.
Privacy	How the data will be stored and transferred
Backup	How and where images of data are stored
Recovery	Ability to recover data in disasters or failures
System throughput	Amount of data that can be retrieved from system in specific unit of time
Transferring bandwidth	The capacity of communication channels
Data life cycle management	Managing data in data centres, and use of network infrastructure

5) SLA General Terms

There are general metrics for SLA with any or all type of cloud users. The important parameters that should be include while creating the basic Sla contract between cloud computing users and providers.

Table 9: SLA General Terms [11]

Term	Description
Monitoring	Who do the monitoring and what method of monitoring
Billing	Cost of service and how can be calculated
Security	Issues like cryptography, authentication, and authorization are main requirement for cloud users
Networking	The number of IPs, throughput, and load balancing
Privacy	How the data will be stored and transferred
Support service	Cloud providers should clearly define the methods of help and support
Local and international policies	The policy standards that providers follow

3.4 SLA Based Trust Model for Cloud Computing

This model recommends the most related and trusted resources from various cloud providers. The related services mean the services which match in high percentage all the main functional requirements of the required service. This model uses the SLA management and trust techniques to provide a reliable model to select the best available provider among various cloud providers to fulfill the desired requirements.

Architecture

The basic components of the proposed architecture including SLA agent, cloud services directory, cloud providers, and cloud consumer entities as shown below:

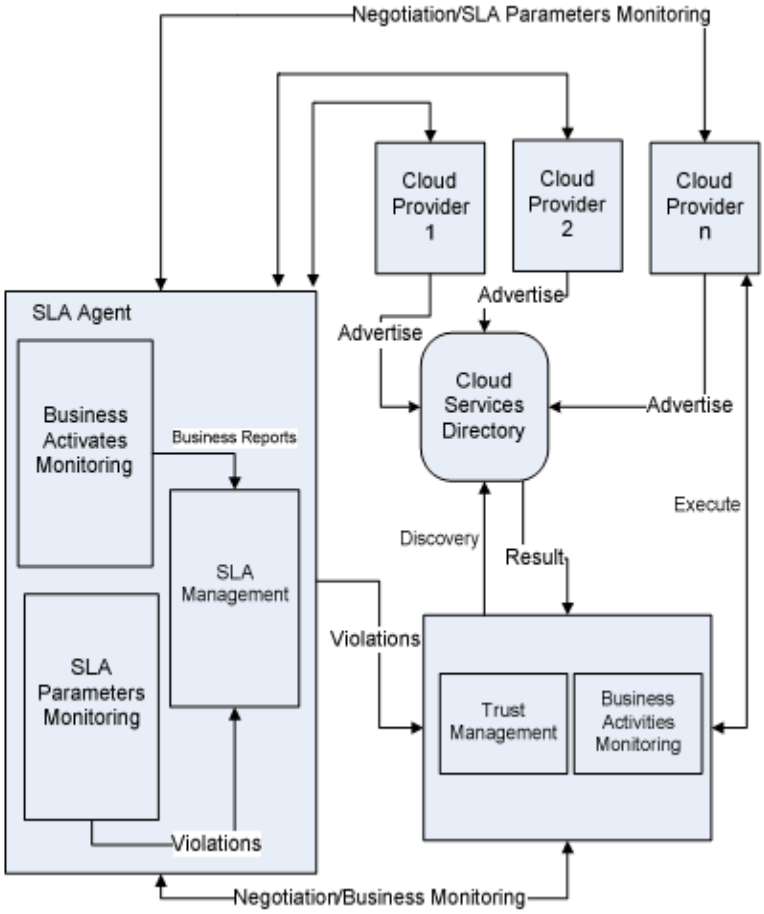

Figure 8: SLA-Based Trust Model for Cloud Computing [12]

SLA agent: These professional can provide services such as designing IT metrics for SLA Agreements, setting values for SLA parameters and examining the policy and legislations for Cloud partners. SLA agents act as an intermediary agent between cloud consumers and cloud providers. SLA agent performs the following tasks:

a) Group the cloud consumers according to different classes based on business needs.
b) Constitute SLA metrics based on the consumer requirements.

c) Negotiating with cloud providers.
d) Selecting cloud providers based on non-functional requirements. The analysis and election processes to obtain the cloud services based on the functional requirements are made by the consumers in the early stage of communication with cloud providers.
e) Check business activities for consumers.
f) Monitoring SLA parameters.

Cloud Consumer Model: Cloud Consumer is one who requests for the execution of one or more services. Cloud consumer is required to pay bill of usage upon completed execution of services based on well-defined model of prices. The SLA agent has the authority to choose the optimal price model for services [40]. The consumer model consists of two parts:

a) **Trust management model**: this model maintains the trust relationships between cloud providers and users of cloud services. Three origin of information are used in the trust management model. The first source is the local experiences with cloud providers and users. The second source is the opinions of external cloud services. The last one is the reports which are provided by SLA agent. The output of the trust management system will be used to rank the list of cloud providers obtained from the cloud services directory. Then, the ranked list will be sent to SLA agent to select the final cloud provider based on non-functional requirements.
b) **Business activities management**: The key feature of this model that distinguishes it from the solution proposed by others who design online services is the use of an indicator of business activities. This approach uses this indicator as one of the main SLA parameters to determine who is responsible for the violation of the revenue or profit parameters.

Cloud Services Directory: Consumers of cloud services will not know about the existing cloud providers if there is no agent or registry to advertise and describe their services. At the present time, there is no public directory for

storing the descriptions about cloud services and details about the cloud providers. In this architecture, a common directory is used in order to help cloud consumers to find the services they require. The directory will store at least the Ids of cloud providers and the functional advertisements of their services. It not considers the processes of discovery and service selection in detail.

Cloud Providers: Cloud providers are the organism who own the cloud infrastructure and provide cloud services for cloud consumers.

Protocol

a) **Advertise Cloud Services:**

The first step of the protocol is that cloud services must present their services in the cloud services directory. So, any consumer can easily find a suitable provider using the functional requirements discovery process.

b) **Discovery of Cloud providers:**

Cloud consumers use the discovery operation to find the related providers who are able to accomplish the consumer's requirements. In this method, consumers use the functional requirements of services to obtain the list of all matched.

c) The brief of providers which are obtained in step (b) must be submitted to the trust management system to filter out non-trusted providers using credibility values and the reports of the SLA agent.

d) A trusted list of cloud providers should be sent to the SLA agent together with more details about business objectives.

e) When cloud consumers submit the request for cloud services, they will wait to get the Id of cloud provider with all details of SLA agreements. If the consumers admit to extend the contract, they will be demand to sign the SLA document with the agent and start to communicate with the selected provider.

3.5 Conceptual Platform of SLA in Cloud Computing

Architecture

Platform architecture is shown as:

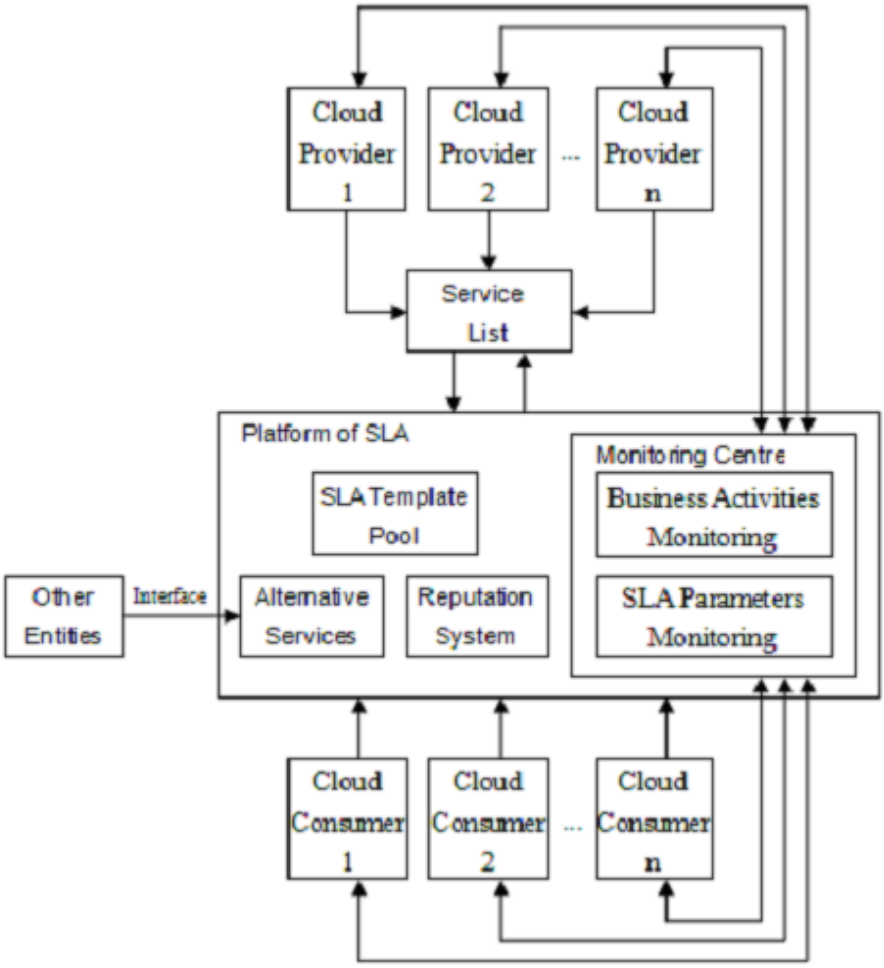

Figure 9: Architecture of Conceptual platform of SLA [11]

In the architecture, the platform is the third party between cloud providers and consumers. Cloud providers can advertise their services in the platform and cloud consumers can search and select the services in the service list. When the consumers find the services which meet their needs, they can make a negotiation with the providers

through the platform. This platform consists of four parties, SLA Template Pool, Reputation System, Alternative Services and Monitoring Centre. The Monitoring Centre is to monitor the providers and consumers activities, the quality of services and the parameters in the SLA documents.

1) SLA Template Pool

The performance of the SLA Template Pool is offering the SLA templates to the cloud providers and consumers. These SLA templates can be referred by providers or consumers to draft a new SLA document which is more adaptable to the current services. Moreover, providers or consumers can add these new SLA templates into the SLA Template Pool and so the new templates can be referred by the other providers or consumers. For each SLA template in the SLA Template Pool, there are some records which include its used times and comments which the users make. With the records and comments, the providers or consumers can make more excellent decisions on the selection of SLA templates. Moreover, with the continual application and modification of SLA templates in the SLA Template Pool, the SLA content for each cloud service becomes more reasonable, thus it is more equitable, transparent and convenient for providers and consumers to conduct the SLA negotiation.

2) Reputation System

With the development of cloud computing, there is more cloud providers emerge. Though the increase of cloud providers extends consumer's range of choice on providers, it also brings some difficulties to consumers in selecting the most reliable providers. Reputations can be used to distinguish the better one between two providers, but it is not possible to know the reliability of these reputations which providers list. In the platform, Reputation System is proposed to address this challenge.

The Reputation System in the platform not only records the provider's reputations, but also it records the consumers. For consumers, they can evaluate and make comments on the providers according to the quality of services. For providers,

they also can evaluate and make comments on the consumers according to their performance in the transaction, the items according to provider's opinion from which consumers can evaluate quality of service, attitude of service and credits of transaction. In consumer's reputations, there is one item that providers can evaluate is the credit of transaction. When the providers or consumers submit the evaluated scores, the calculation module in the Reputation System will record these scores and calculate the value of reputation.

The reputations that Reputation System presents are based on the data which large numbers of users (cloud providers and consumers) offer, so it has a high reliability. But it is possible for some users to cheat so that they can have higher reputations. In this situation, the reliability of reputations will be affected. In order to solve this problem, IP Monitor mechanism and Iterance Monitor mechanism are introduced.

When the users (cloud providers and consumers) log in, the IP Monitor mechanism records each IP address, and then makes an analysis (such as IP region and IP records) on each one. After the users submit the scores or comments, the Reputation System validates each score or comment using the Iterance Monitor mechanism. The Iterance Monitor mechanism checks the IP region, IP records and Transaction validity to determine whether the score or comment is valid or not. If a score or comment is treated as invalid, the Reputation System will record this issue as a dishonest behaviour and send a warning to the submitter. If the counted dishonest behaviours are greater than a threshold, the submitter will be punished by the Reputation System.

3) Alternative Services

For the cloud providers and consumers who have higher demands in services, the basic services are not enough to meet their demands, so some extra services is needed for them to achieve their goal. In this platform Alternative Services are there to provide extra services for users and so the users can acquire these services by paying

extra money. The Alternative Services include three services: Management Services, Measurement Services and External Interface.

a) *Management Services:*

Management Services is provided for cloud providers. The Management Services includes three services: selective SLA violation, resource over provisioning and redistribution estimation.

Recent studies present some rules which can maximize the provider's revenue. When the provider is not able to fulfill all the SLAs that has agreed, the selective SLA violation can perform a selective violation of some SLAs in order to minimize the economic impact of the penalties. The right SLAs which should be violated are chosen according to the future profit and penalties that are estimated. Selective SLA violation sometimes affects provider's reputations, so the providers can make decision whether they make use of these rules.

In some situation, idle resources are not enough to distribute to the consumers, and so the providers will refuse the SLA proposal from the consumers. However, the consumers do not always use the total resources they have reserved and hence these unused resources could be to other clients for increase the revenue.

b) *Measurement Services:*

Measurement Services is provided for cloud consumers. The Measurement Services includes three services: quality measurement, cost/price measurement and usage measurement.

Quality measurement is to measure the quality of services and it provides measurement result for the consumers. There are two kinds of measurement results. The first is the raw data which is not processed or calculated, and the other one is the composite data which has been processed or calculated according to some common method.

Cost/price measurement is used to measure the current cost/price when the billing methods or price of providers is the dynamic. Usage measurement is to measure the

current usage of the consumers. According to the information presented by cost/price measurement and usage measurement, consumers can know more about the services.

c) *External Interface:*

If the cloud providers and consumers consider the services that the platform offers still cannot meet their demands or they want the other service agencies to offer the better services (such as measurement services and monitor services), they can connect the other service agencies using the External Interface.

Chapter Four: Design and Methodology

This chapter presents ranking method based on Permanent function and produces the suggestion list for cloud consumers based on their requirements. This approach gathers information about consumer requirements.

4.1 Matrix Method

Each Cloud alternative matrix of all the requirements is characterized by multiple criteria, which need to be converted into a single number index. This single number index is used to rank the matrices of all cloud providers in order of their parameters matching percentage with consumer requirement. The matrices lend themselves easily to mathematical manipulations and are suitable for computer processing. The size of matrix is $n \times n$ corresponding to n application requirement parameters. The diagonal elements ($a_{ii}'s$ or $a_i's$) and the off- diagonal element ($a_{ij}'s$) of a matrix give the aggregated ratings of different matrices. Thus criteria matrix is a combination of two matrices namely 'Cloud Alternative Rating Matrix' and 'Criteria Weight Matrix'.

4.1.1 Cloud Alternative Rating Matrix:

This matrix is formed on the basis of deterministic values of the aggregated ratings of the Cloud metrics versus different ranking criteria. This is a diagonal matrix whose elements ($a_{ii}'s$ or $a_i's$) represents the aggregated ratings of different Cloud metrics versus different ranking criteria.

$$\begin{bmatrix} a_{11} & 0 & 0 & \dots & 0 \\ 0 & a_{22} & 0 & \dots & 0 \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ 0 & 0 & 0 & \dots & a_{nn} \end{bmatrix}$$

4.1.2 Criteria Weight Matrix:

Criteria Weight Matrix is formed on the basis of the aggregated weights. Off-diagonal elements of this matrix represent the aggregated weights of the criteria e.g. the element (a_{ij}) of this matrix give the relative importance weight of j^{th} criteria with respect to i^{th} criteria. All diagonal elements of this matrix are zero because there is no significance of analyse a criterion to itself. Mathematically,

a_{ij} = weight of j^{th} criteria / weight of i^{th} criteria (a_{ij} = 1 for simplicity)

$$\begin{bmatrix} 0 & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & 0 & a_{23} & \dots & a_{2n} \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ a_{n1} & a_{n2} & a_{n3} & \dots & 0 \end{bmatrix}$$

Thus, 'Criteria Matrix' corresponding to n criteria, in general, is written as:

$$\begin{bmatrix} a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ \cdot & & & & \\ \cdot & & & & \\ \cdot & & & & \\ a_{n1} & a_{n2} & a_{n3} & \dots & a_{nn} \end{bmatrix}$$

4.2 Permanent Function

Variable Permanent Function or simply known as Permanent is a standard matrix function that is used in combinatorial mathematics [41]. It is a powerful tool for multi-criteria based evaluation and ranking of the systems in ascending or descending order. The Permanent is identical to the determinant of a matrix with a difference that no negative term appears in the Permanent. This function can be used to rank certain sequences [41] [42] [43] [44].

Ryser's formula computes the exact permanent in $o(n*2^n)$. Although permanents are defined similarly to the determinant, the permanent being computable in $T(n^3)$, no polynomial algorithm for permanent computation is known so far.

The computation of a permanent of a matrix is NP - complete, and a polynomial algorithm for permanents would particularly imply $P=NP$. However, similarity is feasible: "When there are nonnegative entries of matrix A, then permanent can be calculated approximately in probabilistic polynomial time, up to an error of $e*M$, where M is the value of the permanent and $e>0$ is arbitrary" [16].

4.2.1 Ryser's Formula

The quickest known exact algorithm for the computation of the permanent is due to Ryser's:

$$\text{per}(A) = \sum_{t=0}^{n-1} (-1)^t \sum_{X \in \Gamma_{n-t}} r_1(X) r_2(X) \dots r_n(X) \qquad (4.1)$$

where

$\Gamma_k = \{ X \in R^{n \times k} | X$ consists of columns of $A \}$ is the set of all $n \times n$ sub matrices of A, and

$r_i(X)$ = sum of row i of matrix X

is the i^{th} row sum of X. Ideally, Ryser's algorithm needs $(n-1) \times (2^n - 1)$ flops; the implementation presented here runs in $O(2^n n^2)$ [16].

4.3 Procedure for Ranking

4.3.1 Matching of Parameters

First step is the matching of application requirements with SLA parameters as listed below against the cloud provider's parameters.

- Virtual Machine (VM)
- Storage Capability
- Memory Capability
- Ethernet port
- Availability
- Processor Speed
- Response Time
- Server Reboot Time
- Service Credit

The Cloud with maximum number of instance matched is the suggestion Cloud for particular user. If there is more than one cloud with same number of instance match (equal to maximum number of instance matched) then permanent function is used on all those cloud instances equal to maximum number of instance matched to find the suggestion cloud for a particular set of requirement of an application.

4.3.2 Identification of Metrics

When there is a repetition of maximum number of instances matched then Cloud Alternative Rating Matrix is created with number of instances of cloud provider acting as diagonal elements ($a_i's$) of the matrix and all other elements ($a_{ij}'s$) are one.

4.3.3 Selection of Ranking Criteria

Cloud Alternative Metrics can be compared on several attributes, collectively termed as ranking criteria. Examples of such attributes are: repeatability (the fact that the repeated application of a measure provides identical results), cost, credibility (the fact that a measure supports the specified goals), etc. Some efforts have been made to identify attributes of Cloud Alternative Matrices with the purpose of improving the Cloud

measurement. Each of the ranking criteria relates to some particular aspect of the measure and is considered important to the objectives of the study. Using the experience gained from the literature, for the problem of identifying a single measure that can be used (per life-cycle phase) to characterize reliability, the ranking criteria need to cover the following aspects:

(1) The measurement's cost effectiveness (cost and benefit). This will determine whether or not the measure will be used in a 'real' software development process.

(2) The measurement's quality (whether it is reliable, repeatable, formally validated, and widely used in the industry). This will determine whether the measurement is credible.

(3) The measure's relevance to reliability (the direct objective of the study).

A detailed definition of ranking criteria is given in Table 10**.** Thus, it requires developing a set of criteria and corresponding levels for the ranking of Cloud Alternative Metrics

Table 10: Ranking Criteria Definitions

Ranking Criteria	**Definition**
Virtual Machine	A Virtual Machine is a software implementation of a machine that executes programs like a physical machine. Thus it is a software implemented abstraction of the elemental hardware, which is commenced to the application layer of the computer system. Virtualization can be ponder as the heart of cloud computing as it helps cloud resources to be scalable and flexible Criteria in Virtualization are grouped as follows: VM (virtualization) Type, Quotas, VM Technology, Cloning, Prioritization, Migration, Provisioning and Hot configuration. These groups specify the virtualization type such as specific virtualization technology (Xen, Open VZ etc.), full, Para-virtualized or containers, , Prioritizing the CPU and quotas, disk and memory IO, network, hot reconfiguration and provisioning, live and offline migration and cloning.
Management	The Management category describes features directly as how the

	clouds are managed by the measured products. Integration, Reporting, Recovery and Accounting are the grouped criteria within the management category. Between the customer and the provider operating systems, the Integration group targets on software integration. It also focuses on the base for specific and mass management of both, and the applicable options for integration with third party software via consumed APIs. Billing and Data collection of resource operation to cloud users is being dealt by the accounting group. In the Reporting category combining of the criteria for reporting on historical logs and current system status take place. The criteria also characterize high availability features, administrative alerting, and product's automatic recovery abilities about exceptional operational conditions.
Security	Security attributes are most important for computer system deployments and thus also for Clouds. Certification, Integration, reporting, Permission, Auditing, Support, and Encryption are Security criteria groups. Permission group handles authorization levels for specific resource (e.g. VM server or storage servers) or virtual machine access and the Integration group describes the product's capacity to integrate with generic LDAP (Light-weight Directory Protocol) and Active Directory servers for user authentication. The security report types available to cloud administrators are covered by Reporting, and the types of case which can be audited are covered by Auditing.
Network	Network plays an important role in managing the entire cloud environment as well as deploying the services inside the virtual machines. The division of Low-level network into 4 groups such as: *Firewall, VLAN, Integration and Performance.* The support for VLAN packet tagging (IEEE 802.1Q) for isolation and network

	management is explained by VLAN group, In the form of state full packet analysis, the user guide for network filtering is described by the firewall group, the Performance group includes Ethernet QoS metrics and the Integration group describes the help for VPNs (virtual private networks) and IPv6 for virtual machine access and management.
Vendor	Users need support, can be given through following groups: Certification, Community, support and Documentation Vendor. The Community group accommodates help through mailing list and forums. Certification groups explain possibility of third-party audition for conformity with laws, business rules and regulation. The merchant group affords support for the product by means of SLA (Service level agreement) and the support group covers the CRM (customer relationship management).
Storage	*Direct-attached storage* (DAS), *Network-attached storage* (NAS) and *Storage area networks* (SAN) are the main technology association in which the backup and storage is implemented in cloud computing. These main technology associations have some standard which fully brace particular technologies for e.g. the NAS group considers the guide for NFS (*Unix Network File System*) and CIFS (*Microsoft Common Internet File System*) network file systems, and the DAS association implies the supported file system and block-based replication. Similarly, the backup association comprises criteria for backup over remote (NAS) and local (tape and DAS) storage.
Cost	This ranking criterion identifies relevant measure for using the cloud resource. There is no consistency among providers in regards to the resources customers actually receive and pay for. Providers offer virtual machines (VMs) that vary widely in CPU clock speed,

	memory capacity, and various other features. Additionally, the units that are actually served to customers are generally virtualized, building even further confusion as to what the customer is actually getting and how it might be affected by other customers on the same cloud.
Reliability and Service Level Agreement (SLAs) and	Some cloud providers offer guarantees for higher levels of service as a way to separate themselves from the bundle. In Rackspace: The SLAs, describes how Rackspace has higher levels of cloud service SLAs to challenge with Amazon, the 800-pound gorilla of cloud computing. Note that SLAs are often merely an indication of the consequences when the service fails and not the service's actual reliability. Although the SLA is a good indicator of any provider's level of commitment, knowing the actual uptime levels of a particular cloud provider is a trickier proposition. Most merchants have a condition page that acts as a dashboard for the condition of their available services, but these generally shows only stats from a few days ago at the earliest. To get real long-term numbers for reliability and availability, it's better to depend on customer character and comparison services such as CloudSleuth and CloudHarmony.
Performance	Performance is one of the main concerns for enterprises that are considering cloud computing. Attaining high-speed delivery of applications in the cloud is an all-round challenge that requires a holistic method and an end-to-end view of the application request-response path. Performance issues include network performance both within the cloud and in-and-out of the cloud, geographical proximity of the application and data to the end user, and I/O access speed between the compute layer and the multiple categories of data stores. Number of services and research reports such as CloudSleuth

	and CloudHarmony has recently experimented to evaluate the performance of cloud providers from various locations and with different application use cases.

4.3.4 Calculation of Permanent of matrix

Criteria matrices of all the required cloud are formed and the value of the Permanent of each such 'Criteria Matrix' is obtained using equation 4.1. Finally, the Different Cloud matrices are ranked in accordance with the values of the Permanents. The cloud provider matrix with the highest value of the Permanent is ranked at number 1, the next as number 2, and so on.

Flow chart of proposed algorithm is shown in fig 10:

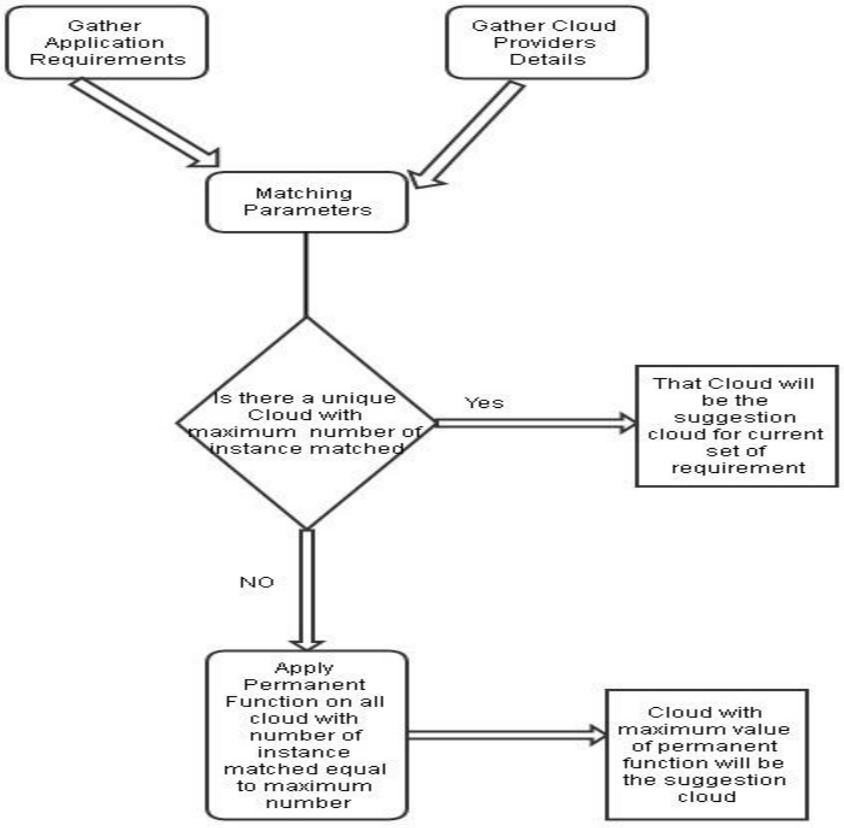

Figure 10: Flow chart of Proposed Algorithm

Chapter Five: Result and Discussion

This Chapter explains the experimental setup used to find results for our Service Level Agreement - Parameter Matching and Cloud Suggestion using Permanent Function.

5.1 Experimental Setup

Proposed Algorithm is implemented in JAVA. For this analysis, 16 clouds and 9 different application requirements with SLA parameters as listed below are considered.

- Virtual Machine (VM)
- Memory Capability
- Availability
- Storage Capability
- Ethernet Port
- Processor Speed
- Response Time
- Server Reboot Time
- Service Credit

Table 11 shows the instance count of Cloud SLA parameters that are declared in cloud capability model. Table 12 shows the instance count of application SLA parameters that are declared in application requirement model.

Cloud Names:

C1: 3 Tera
C2: Amazon EC2
C3: Amazon S3
C4: AT & T
C5: Azure Storage
C6: Cloud Scale
C7: Cloud Switch
C8: Cloud Works
C9: enStratus
C10: GoGrid
C11: IBM
C12: Orange Space
C13: Oxygen Cloud
C14: Rack Space
C15: Relia cloud
C16: VMware

Table 11: Instance Count of Cloud SLA Parameters

	Virtual Machine	Storage Capability	Memory Capability	Ethernet	Availability	Processor Speed	Response Time	Server Reboot	Service credit
C1	1	1	1		1	1			
C2	1	2	1	1	1	1			
C3	1	2	1	1	1	1			2
C4	1	2	2	1	1	1			
C5	1	2	1	1	1	1	1		2
C6	1	1	1		1	1	1		
C7	1	1	1		1	1	1	1	
C8	1	1	1	2	1	1	1	1	
C9	1	1	1	1	1	1			
C10	1	1	1	1	1	1	1		2
C11	1	2	2	1	1	1	1	1	
C12	1	1	1		1	1	1		
C13	1	1	1		1	1		1	
C14	1	2	1		1	1	1		1
C15	1	1	1	1	1	1	1		
C16	1	1	1	2	1	1		1	3

Table 12: Instance Count of Application SLA Parameters

	Virtual Machine	Storage Capability	Memory Capability	Ethernet	Availability	Processor Speed	Response Time	Server Reboot	Service credit
Requirement 1	1	1	1	1					
Requirement 2	1	1	1	1	1				
Requirement 3	1	2	1	1	1	1			
Requirement 4	1	1	1	1	1	1	1		
Requirement 5	1	1	1	1	1	1	1	1	
Requirement 6	1	1	1	1	1	1	1	1	1
Requirement 7	1	1	1	1	1	1	1	1	1
Requirement 8	1	2	1	2	1	1	1		1
Requirement 9	1	2	1	1	1	1	1		
Requirement 10	1	2	2	2	1	1	1	1	1

Table 13: Number of Instance Matched

Requirement	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	Suggestion
1	3	5	5	6	5	3	3	5	4	4	6	3	3	4	4	5	C11
2	4	6	6	7	6	4	4	6	5	5	7	4	4	5	5	6	C11
3	5	7	7	8	7	5	5	7	6	6	8	5	5	6	6	7	C11
4	5	7	7	8	8	6	6	8	6	7	9	6	5	7	7	7	C11
5	5	7	7	8	8	6	7	9	6	7	10	6	6	7	7	8	C11
6	5	7	9	8	10	6	7	9	6	9	10	6	6	8	7	11	C16
7	5	7	9	8	10	6	7	9	6	9	10	6	6	8	7	11	C16
8	5	7	9	8	10	6	6	8	6	9	9	6	5	8	7	10	C16
9	5	7	7	8	8	6	6	8	6	7	9	6	5	7	7	7	C11
10	5	7	9	8	10	6	7	9	6	9	10	6	6	8	7	11	C16

5.2 Results

Table 13 shows the number of instances matched.

A cloud having maximum number of matched instances will be suggested for particular application requirement. Table 13 shows the suggested cloud for particular applications.

In case of multiple clouds having same number of instance matched, the criteria matrix for that cloud with maximum value of permanent function becomes the suggested cloud. Consider Requirement 1, maximum number of instance matched is '6' which appear at AT & T and IBM Clouds, matrices of these clouds are shown below:

Criteria Matrix for AT & T Cloud

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 2 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

Criteria Matrix for IBM Cloud

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 2 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

The Value of permanent function using equation 4.1 for AT & T Cloud and IBM Cloud matrix are 314016 and 397440 respectively. Since value of permanent function of IBM cloud is maximum. Hence IBM cloud will be the suggested cloud for requirement 1.

Chapter Six: Conclusion and Future Scope

Cloud computing is one of the emerging and growing topic in IT industry. Many organizations are exploring cloud computing as cost effective computing method for their enterprise needs. Some organizations already assigned their work of storing their sensitive information in cloud computing environment. There are number of issues such as security, privacy, lack of standard for measuring the SLA template, regularity and legal issues (data might be processed and stored beyond the cloud boundaries), that make it difficult for the adoption of cloud computing.

A simple and structural approach is presented here which is based on permanent value of matrices and useful for matching SLA parameters to identify compatible cloud provider with the requirement of an application. This study has addressed the issue of matching application requirement parameter with the cloud SLA.

Many researchers have suggested that SLA may be used by both cloud consumer and cloud providers as a tool for establishing common expectations and goals. In this work, a new method for cloud suggestion is proposed based on *permanent function*. Variable Permanent Function or simply known as Permanent is a standard matrix function that is used in combinatorial mathematics. Ryser's Equation is applied to calculate the permanent of the matrices and according to him no polynomial algorithm for permanent computation is known so far.

In this study 16 clouds and 9 different application requirements with SLA parameters as defined in previous chapter are considered. This algorithm helps the user to define compatible cloud provider for an application by matching parameters of application requirements and cloud SLAs. It gives suggestion to consumer in terms of number of matched parameters. A cloud having maximum number of matched parameters with the requirement of an application is a compatible cloud for an application. In case of repetition of maximum number of matched parameters permanent function is used to decide compatible cloud. For example, as discussed in previous chapter for *requirement 1* maximum number of instance matched is '6' which appear at AT & T and IBM Clouds.

In this case permanent function is applied on these cloud matrices and compatible cloud is defined using permanent value for these cloud matrices. Since value of permanent function of IBM cloud is greater. Hence IBM cloud is the suggested cloud for requirement 1.

This algorithm can be used as a plug-in code to any existing middleware tool or it can also be used as an independent tool.

As the subject of cloud computing is still developing and evolving. It is assumed that cloud computing will gain attention from IT professionals in industry. Several researchers also believe that cloud computing will be widely integrated in the industry. In this study focus is on requirement parameter matching for any particular application. In future this can be done by using optimized permanent function.

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