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Client-side Monitoring and Metering Service Level Agreements for Cloud Services

A Thesis Presented

By

Eshetu Muleta Debe

to

School of Graduate Studies

of

St. Mary's University

In Partial Fulfillment of the Requirements for the Degree of Master of Science

in

Computer Science

June 2019

ACCEPTANCE

Client-side Monitoring and Metering Service Level Agreements for Cloud Services

By

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Accepted by the Faculty of Informatics, St. Mary's University, in partial fulfillment of the requirements for the degree of Master of Science in Computer Science

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DECLARATION

I, the undersigned, declare that this thesis work is my original work, has not been presented for a degree in this or any other universities, and all sources of materials used for the thesis work have been duly acknowledged.

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List of Acronyms

CSPs	Cloud service providers
CCing	Cloud Computing
AWS	Amazon Web Service
CPU	Central Processing Unit
IaaS	Infrastructure as a service
EC	Elastic computing
ICTs	Information Communication Technologies
IOT	Internet of Things
CoT	Cloud of Things
PaaS	Platform as a service
QoS	Quality of Service
SaaS	Software as a Service
SlaCP	Service level agreement Compliance Prediction
SLA	Service Level Agreement
Xaas	Any thing as a Service
NPMS	Network Performance Metrics Service
MTBF	Mean Time between Failures
MTRS	Mean Time to Restore Service
KPI	Key Performance Indicator
IT	Information Technology
WEEE	Waste Electrical and Electronic Equipment Directive
SLM	Service Level Management
CRM	Customer Relationship Management
PUE	Power Usage Effectiveness
DCP	Data Center Productivity
DCIE	Data Center Infrastructure Efficiency
OLA	Operation Level Agreement
TPM	Trusted Platform Module
NaDa	Nano Data Centers

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Abstract

Cloud computing is computing technologies that provide services to consumers and businesses allowing organizations to become more agile and flexible. Therefore, ensuring Quality of Service (QoS) is crucial for both service providers and service consumers. The information and communication technologies provide the convenient environment to the customer for computing, communication and cloud service providers are offering the services over the cloud computing platforms. The cloud computing platforms provide resources and services based on a service level agreement (SLA) between cloud service providers (CSP) and customers. Cloud computing is one of emerging virtualization technologies used in the Internet which provides unlimited computational, unlimited storage and service delivery over the Internet. To create a convenient atmosphere between the CSP and Customer both parties need to sign and agree upon the SLA. The SLA may specify availability, performance and other parameters for different types of customer's infrastructure components. SLA includes a plan for addressing downtime and documentation for how the service provider will compensate customers in the event of a contract breach. So, the credits (on demand) service are a typical remedy. But the current Service level agreements are monopolized by the cloud service providers. There is no monitoring mechanism on them client side. Because of this reason, the significant question arises in everyone's mind is that; is there any system that can monitor cloud services on the client side?

The study proposes to conduct client-side survey using some selected customers, technical observations, current cloud computing services conflict Analysis then Simulate and implement through system model using simulation tools like Appneta and Cloud-Sim based on best fit strategy. The proposed research aims to design a customer side monitoring and metering systems to reduce conflicts between the service provider and service receiver and increase the trust and transparency between both parties. As a unique knowledge contribution this is proposed to focus on client-side cloud computing services to meter monitor and decide the most suitable services as per requirement with cloud service level declaration. The proposed system is a new step for empowerment of cloud customer.

Keywords: Cloud computing, Service provider, Customer SLA, CSP

CHAPTER ONE

INTRODUCTION

1.1 Background

Cloud computing is the modern trend in distributed computing domain and has been the subject of much publicity. Its vision covers on-demand and reliable services provided over the network like Internet with easy access to virtually infinite computing, storage and networking resources. It is a current and latest Information Technologies trend has become more popular in companies' strategies and increasing its importance for bringing change to the operational and managerial dimensions [1]. The use of the Internet and Information and Communication Technologies (ICT) to deliver cloud computing resources is considered mainstream in the 21th century. The significant development of ICT has great role to improve our life style. The cloud computing is a great innovation in the world of computing. The cloud computing resources are available in the network (internet). The resources which available on the cloud computing can be accessed by the different stakeholder without any Digital divide. The resources can be accessed by any device at any time. But to access and to use efficient resources it needs an agreement between the customers and cloud service providers (CSP). Any organization to implement SLAs must ensure that the stakeholders understand key objectives, benefits and challenges associated with the contract of SLA between the customer and Cloud Service provider.

Users can access Cloud infrastructure from anywhere at any time in on demand manner and pay for what they use. Cloud uses virtualization technology in distributed data centers to allocate resources to the customers over the Internet in the form of configurable virtual machines and provides an illusion of infinite resources. One of the biggest advantages of cloud computing is accessing of the resources in different manner like Software as a service (SaaS), Platform-as a service (PaaS), Infrastructures as a service (IaaS) and Anything as a Service (XaaS) i.e. S-P-I-X according to the user interests (on demand self-service) [1]. But first it needs negotiation between the service provider and the customer.

Service level agreements (SLAs) are becoming an increasingly popular way to manage quality of services within organizations. However, widely the application of service level agreements might vary from one organization to another, they generally share the attributes of cloud computing resource - that is, and they are negotiated and agreed, with attention given to quantifying service levels and the responsibilities of both parties. Today SLAs are being increasingly used by both private and public sectors to manage internal service delivery, particularly in sectors where a significant part of the total cost is spent on central support services. In-house services are increasingly expected to be self-sufficient recovering costs from customers rather than being provided as part of the overhead costs. Service level agreements are also used today to achieve quality outcomes such as improved internal relationships, ensuring internal services are aligned to business needs; and assisting internal providers to develop a customer focus [3].

Service Level Agreement (SLA) specification and management becomes a key differentiator in the service provider's offerings. SLA management will allow service providers to offer different levels of service guarantees and to differentiate him from its competitors. It will improve its ability to satisfy customer expectations, as the Customer will exactly know what to expect in terms of quality of service. A Service Level Agreement (SLA) is a contract between a network service provider and a customer that specifies, usually in measurable terms, what services the network service provider will furnish and what penalties will assess if the service provider cannot meet the established goals. Service provider's differentiation will be driven by the reliability of the SLA Management and it's monitoring during exploitation to contributing to the customer's trust. To guarantee customers, the proper level of performance, service providers often offer services with SLAs, which provide customers with measurements of statistics like network availability, throughput, and latency [4]. Besides that, the Cloud Service Provider controls the Quality of Service (QoS) which provides to their customers according to their Service Level Agreement (SLA) between the Customer and Cloud Service Providers (CSP).

The benefits associated with cloud computing technology have caused its rapid growth. Due to such growth in terms of number of consumers adopting it, scientist have also put more effort in improving quality of cloud technology to meet the demand of consumers. For that reason, the relationship between the cloud provider and the customer is described with the Service level

agreement (SLA). SLA is the contract made between customer using cloud service and cloud service provider where by the cloud service provider make agreements for service delivery to the customer by defining how the service is going to be delivered and how is the service going to be used. The typical SLA document includes the information about the parameters used to measure the quality of the agreed service level. Examples of parameters defined in SLA are, the responsibility of the provider, responsibility of consumer, service availability, security measures adopted by the cloud service provider, auditing processes to monitor the service and the rates of the services [5].

Resource provisioning is the process of selecting, deploying, and run-time management of software (e.g., database management servers, load balancers) and hardware resources such as CPU, storage, and network for ensuring the guaranteed performance. This resource provisioning considers the Service Level Agreement (SLA) for providing services to the cloud users. This is like an initial agreement between the cloud users and cloud service providers to ensure the Quality of Service (QoS) parameters like performance, availability, power consumption, reliability, response time, etc. Based on the use and application needs Static Provisioning/Dynamic Provisioning and Static/Dynamic Allocation of resources must be made to efficiently make use of the resources without violating Service Level Agreement and meeting these QoS parameters. Over provisioning/under provisioning of resources must be avoided [6]. So, The Service Level Agreement (SLA) has no interesting value if it is not managed properly through the stakeholders.

1.2 Motivations

Monitoring tasks comprise a fundamental functionality in every distributed computing system. Every service should be monitored in order to check its performance and allow for corrective actions in case of failure. Monitoring data represents an operational snapshot of the system behavior along the time axis. Such information is fundamental in determining the origin of the problems or for tuning different system components. For instance, fault detection and recovery mechanisms need a monitoring component to decide whether a particular subsystem or server should be restarted due to the information collected by the monitoring system. Metering tasks are necessary for checking the disk space, network and memory usage from the machines of the

platform. This information is vital to allocate services under conditions of optimum performance. Metering and monitoring play an important role in Cloud computing, which can be attributed to the following reasons: From Cloud computing SPI model perspective – Customer consumes services provided by a service provider and service provider outsources the service hosting to the dedicated infrastructure providers. Service Level Agreement (SLA) is usually employed to serve as a bilateral contract between two parties to specify the requirements, quality of service, responsibilities and obligations. SLA can contain a variety of service performance metrics with corresponding Service Level Objectives (SLO). Therefore, we need to meter values of associated metrics defined in the SLA at the usage stage to monitor whether the specified service level objectives are achieved or not. From Cloud computing "Pay-per-use" / "Pay-as-you-go" / "Utility computing" perspective - Cloud service provider delivers QoS-assured services and other commitments in exchange for financial commitments based on an agreed schedule of prices and payments. This requires the service / resource usage to be metered, based on which the bill can then be calculated. From Cloud computing scalability / elasticity and data center perspective - These two perspectives have a feature in common, that is, capacity on-demand or called on-demand resources provisioning. The service and resource usage need to be metered and monitored to support this dynamic scale feature on an as-needed basis.

1.3 Statement of the Problem

In the current era all the activities of human beings are sustained by Information Communication Technology (ICT). The ICT has great role to improve the quality of services and life style of human beings. One of the major challenges in resource provisioning technique is to determine the right amount of resources required for the executing the task in order to reduce the financial cost from the user's point of view and to maximize the resource utilization from the service providers side So, SLA provides contract between a service provider (either external or internal) and the end user that defines the level of service expected from the service provider. During that time, it may cause disagreement between the customer and CSP. Besides that, the controlling mechanism is monopolized by the CSP only. It is expected that there should be transparency in SLA on the client side and Quality of Service (Qos) which provided by the Cloud Service

Provider. In addition to that an SLA on the client side should also provide information about power aware/green services and should minimize the conflict between customers and Cloud service providers.

Hence, the aim of this study will be answering the following four research questions.

1. Is there any Client-Side SLA designed and enforced effectively?
2. Is the current cloud service monitoring system on the client side efficient and transparent up to the level of acceptance of customers?
3. What if current ICT service delivery systems over cloud violate transparency in metering promises made under SLA?
4. Could Cloud Computing (CC_{ing}) model need an alternative Client-Side SLA framework for efficient ICT provisioning strategy and metering transparently for power aware /green cloud services in the Client side?

1.4 Objectives

1.4.1 General Objective

The general objective of this research is to design Client-Side Metering and Monitoring of SLA Framework for cloud services

1.4.2 Specific Objectives

The specific objectives are:

- To review the cloud computing service conflict parameters by metering and monitoring procedures
- To analyze the existing Cloud Computing service conditions and conflict frequencies for defining, recruiting the measuring and monitoring procedures for Cloud services in general.

- To design a Model for Customer Side Monitoring and Metering of SLA for cloud computing services with special reference to green cloud services for better customer satisfaction, trust, transparency, performance and quality of services
- To overcome the challenges of trust breach through shining promises from service providers and ensure correct and trusted billing with promised parameters

1.5 Significance of the study

The proposed research allows metering and monitoring the service level agreement on the client side for cloud services. The study gives insight to the business organization, governmental and non-governmental ICT industries to control the Service Level Agreement between the client and the Cloud Service Providers (CSP). Besides that, to know how to invest the ICT budgets and metering and monitoring services in the organization. The proposed research presents the measuring/metering of the Service Level Agreement (SLA) on the client side for the cloud service. The study can be used as a baseline for further to create new paradigm of Client Empowerment in ICT utilization strategies over cloud.

So, the proposed Client-Side SLA framework for cloud can be used as base line in the ICT managerial and business organization's decision-making processes. Hence, this new Service Level Agreement (SLA) can provide better business relations between service providers and Customers with improved trust and transparency.

1.6 Scope and Limitations

The main intent of this study is to examine the current measuring, monitoring service level objectives and evaluate measurable key performance indicators (KPIs) over the cloud services. It analyses the CSP SLA in general and design Client-side SLA framework for cloud services by using data/facts from clients in the real world.

1.7 Organization of the Thesis

This research work is organized as follows: chapter two provides a detailed literature review addressing most issues to the research topic. In chapter three, the methodology, sampling techniques and data collection are briefly discussed. In chapter four the data collected and gathered through interviews, observation and questioner are analyzed, described and summarized to gain clear understanding on the Metering and monitoring of client-side SLA cloud services functions, benefits and major problems in metering and monitoring SLA for cloud services at service provider side only is briefly discussed. From the data collected through interviews, observation and questioner of users and administrators, the researcher will gain and establish a meaning and understanding that assist to interpret the impacts, benefits gained from the new designed system. The researcher will go through analyzing and interpreting both the qualitative and quantitative data collected from different respondents. Chapter five describes the framework on Client-side measuring and monitoring Service Level Agreements (SLAs). The designed framework shows the proposed model to meter and monitor the SLA on the client side. This Framework has import role to increase the transparency between the involved parties.

In Chapter six conclusions is discussed by summarizing key findings as well as suggestions, recommendations and future works.

CHAPTER TWO

LITERATURE REVIEW

This literature review deals with the review of important concepts that are related to research work as well as those related works used in this work to identify the existing techniques and analyze the current situations of the areas.

The main purposes of this chapter is to elaborate the scientific concepts related to this research and critically relate and evaluate the effort made prior to this study and find a clear-cut research gap between existing knowledge and practice. Firstly, it gives fundamental overview of the cloud computing technology and its Service Level Agreement (SLA). The explanation of these models introduces the SLA. The introduction differentiates of SLA for cloud services and other concepts are mentioned.

Secondly, detailed concepts about the SLA on cloud services, computing, communication and collaboration are explained. Here we include the reasons behind moving to cloud and the importance client-side measuring and monitoring of SLA over cloud service for computing, communication and collaboration. The chapter presents technical information about the client-side measuring and monitoring SLA over cloud consumed services. Finally, we covered the main topic of the thesis which is client-side measuring and monitoring SLA of cloud consumed services and related researches with critical remarks.

2.1 Cloud computing

According to Jelani Basha et al. [7], Cloud computing servers and nodes having configurations, the Hadoop framework is requiring a high configuration for data storing and retrieving (processing) of wanted data. It is a pool of servers where all the servers are interconnected through Internet and loads the data from server files to Hadoop distributed file system. Storage problem is resolving with help of blocks in Hadoop distributed file system and processing is resolving with help of map reduce and pig, hive and spark etc.

According to Nandgaonkar et al. [8], 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. Cloud Computing is virtualized compute power and storage delivered via platform-agnostic infrastructures of abstracted hardware and software accessed over the Internet.

According to Swarnalatha et al. [9] Cloud computing is a major pattern for large data storage and analytics. The combination of cloud computing and IoT can enable the resource sharing more efficient than individually handle them.

2.2 Cloud computing deployment models

There are different types of cloud services classified based upon the underlying infrastructure deployment model [10]. The different infrastructure deployment models are distinguished by their architecture, the location of the datacenter where the cloud is realized, and the needs of the cloud provider‘s customers. This deployment models are: -

A. Public cloud

B. Private Cloud

C. Community Cloud and

D. Hybrid Cloud

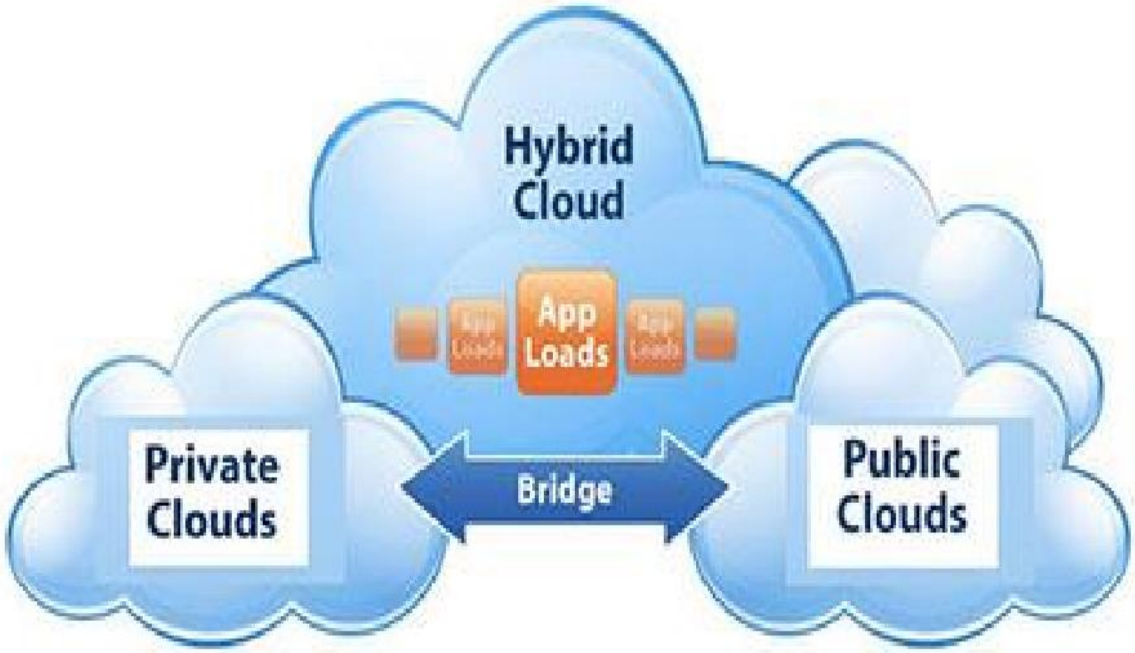


Fig 2.1: Cloud computing deployment model [10]

2.2.1 Public Cloud

A public cloud can be accessed by any subscriber with an internet connection and access to the cloud space [10]. A public cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling Cloud services. Public cloud or external cloud as a cloud computing in the traditional mainstream sense, whereby resources are dynamically provisioned on a fine-grained and self-service basis over the Internet via web applications/web services, from an off-site third-party provider who shares resources and bills on a fine-grained utility computing basis. The cloud services are available for anyone to subscribe and to use in a pay-as-you-go manner. A public cloud customer can access these services over the Internet from a third-party provider who may share computing resources with many customers. The public cloud model is widely accepted and adopted by many enterprises because the leading public cloud vendors as Amazon, Microsoft and Google, have equipped their infrastructure with a vast amount of data centers, enabling users to freely scale and shrink their

rented resources with low cost and little management burden. Security and data governance are the main concerns with this approach. Sharing applications and infrastructure with unknown co-tenants can lead to concerns over data security and data leakage. If a public cloud is implemented with performance, security, and data locality in mind, the existence of other applications running in the cloud should be transparent to both cloud architects and end users. Indeed, one of the benefits of public clouds is that they can be much larger than a company's private cloud might be, offering the ability to scale up and down on demand, and transferring infrastructure risks from the enterprise to the cloud provider.

2.2.2 Private clouds

The Cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise. This indicates that private cloud is established for a specific group or organization and limits access to just that group. It operates dedicatedly for a single organization. Private cloud infrastructure may be set-up On-premise or off-premise and may be managed either internally or by third-party service providers. Private clouds offer highest level of security and control but are expensive. A private cloud is built for the exclusive use of one customer, who owns and fully controls this cloud. Additionally, there are variations of this in terms of ownership, operation and so on. The fact that the cloud is used by a specific customer is the distinguishing feature of any private cloud. A private cloud might be owned by the customer, but built, installed, and managed by a third party rather than the customer. The physical servers might be located at the customer‘s premises or sited in a collocation facility. A recently introduced alternative to a private cloud is a virtual private cloud. In a virtual private cloud, a customer is allocated a private cloud within the physical infrastructure of a public cloud. Due to the allocation of specific resources within the cloud the customer can be assured that their data stored on and processing is done only on dedicated servers (i.e., these servers are not shared with any other customer of the cloud provider). An example would be the NASA‘s Nebula Private Cloud which is an infrastructure-as-a-service implementation for scientific data and Web based applications [10].

2.2.3 Community Cloud

A community cloud is shared among two or more organizations that have similar cloud requirements. The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, or compliance considerations) (CSA, 2009). In a community cloud, several enterprises with similar requirement can share their infrastructures, thus increasing their scale while sharing the cost. Another form of community cloud may be established by creating a virtual data center from virtual machine instances deployed on underutilized users' machines [10]. A community cloud provides many of the benefits of scale of the public cloud, while retaining greater control over compliance and data privacy.

2.2.4 Hybrid Clouds

The Cloud infrastructure is a composition of two or more Clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technologies that enables data and application portability (e.g., Cloud bursting for load-balancing between clouds. In the Hybrid cloud, many enterprises would prefer to keep their critical data and applications within their own control to ensure security firewall, while hosting the less critical ones on a public cloud. Under these cloud deployment model users typically outsource nonbusiness critical information and processing to the public cloud, while keeping business-critical services and data in their control (VenkateRao J. et.al [10]). A hybrid cloud can be delivered by a federated cloud provider that combines its own resources with those of other providers. Thus, hybrid cloud delivery model encompasses provisioning all components and services that are required to deploy services (e.g. Hardware, network services, operating systems, databases, middleware, applications, and third-party service provisioning). Hybrid clouds consist of a mixed deployment of private and public cloud infrastructures to achieve the maximum cost reduction through outsourcing whilst maintaining the desired degree of control over e.g. sensitive data by employing local private clouds.

2.3 Cloud Computing Features

There are four types of cloud computing features

- On demand
- Pay per use
- Rapid elasticity
- Maintenance and upgrading

2.3.1 On demand

To use computing resources on-demand is one of the most needed features for a large number of enterprises. One of its advantages is to eliminate the need for planning ahead, purchasing, and installing the resources they will require at some point in the future. This helps the user to avoid making an unnecessary investment in servers and computing resources. In addition, when comparing cloud computing with the traditional model of owning the servers, cloud computing will help to avoid the costs of having underused resources. Consequences of this feature of on demand computing resources are a lowering of the entry barriers to some business models, as software vendors can develop applications without thinking beforehand of provisioning for a specific number of customers and then bearing with the risk of greater success than planned, leading to the service not being available or, worse, having very few users and a large capital expense caused by purchasing resources that are very underutilized.

2.3.2 Pay-Per use

The other new aspect of cloud computing is application of usage-based billing model. Users simply pay for the services they get while providers bear the costs of hardware and software provision. Pricing may vary depending on the time of day due to peaks in demand or varying electricity costs and institutions may therefore carry out certain activities when costs are cheaper. Pricing is the process of determining what a service provider will receive from an end user in exchange for their services (C.Weinhardt, [11]) claimed that cloud computing success in the IT market can be obtained only by developing adequate pricing techniques. The pricing process can

be as follows: fixed, in which the customer is charged the same amount all the time; dynamic, in which the price charged changes dynamically; or market-dependent, in which the customer is charged based on the real-time market conditions. Fixed pricing mechanisms include the pay-per-use model, in which the customers pay for the amount they consume of a product or the amount of time they use a certain service.

2.3.3 Rapid elasticity

Originating from the field of physics and economics, the term elasticity is nowadays heavily used in the context of cloud computing. In this context, elasticity is commonly understood as the functionality of a system to automatically provision computing resources on demand as workloads change. In this type of cloud service feature there is a service level agreement to be signed between the customer and the service provider Based upon the specific of a service level agreement, the cloud provider scales up or down the resources that are provided to meet the customer‘s changing needs. This service level agreement must define the response time for the cloud provider to adapt to the customer‘s needs. Such an agreement is needed by the cloud provider, because the cloud provider does not in fact have infinite resources, so depending upon the service level agreement the cloud provider has to find a set of allocations of resources that satisfy the current demands of the aggregate of their users while meeting the various service level agreements of these customers otherwise the service level agreement may specify a penalty that the cloud provider has to pay to each customer for not meeting the relevant service level agreement.

2.4 Cloud computing service model

Each cloud computing service model serves a specific function, giving users control over their cloud depending on the type. When choose a provider, it is important to compare needs to the cloud services available. Cloud needs will vary depending on how we intend to use the space and resources associated with the cloud. If it will be for personal home use, it needs a different cloud type and provider than using the cloud for business [9].

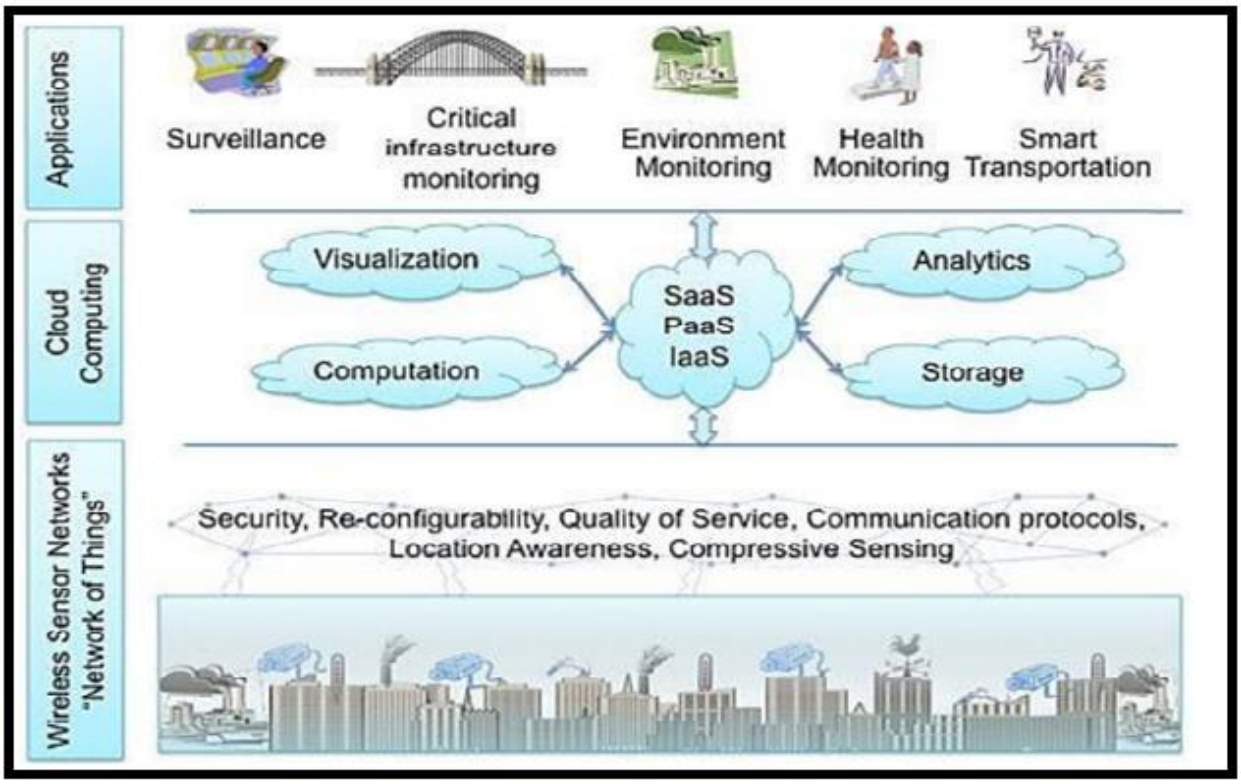


Fig 2.2: Service Model of Cloud Computing [9]

There are three types of cloud service models

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

These three types differ in the amount of control over information and conversely, how much we expect the provider to do for us the below subsection will briefly describe about each type.

2.4.1 Software as a Service (Saas)

Software or an application is hosted as a service and provided to customers across the Internet. This mode eliminates the need to install and run the application on the customer‘s local computers. SaaS therefore alleviates the customer‘s burden of software maintenance and reduces the expense of software purchases (Salama). A SaaS provider gives subscribers access to both resources and applications. SaaS makes it unnecessary to have a physical copy of software to install on devices. SaaS also makes it easier to have the same software on all of devices at once by accessing it on the cloud. In a SaaS agreement, there is least control over the cloud. The SaaS customer is an end-user of complete applications running on a cloud infrastructure and offered on a platform on-demand. The applications are typically accessible through a thin client interface, such as a web browser. Users are not allowed to customize the service but get access to a specific application hosted in the Cloud. Examples of SaaS implementations are the services provided by Google for office automation, such as Google Mail, Google Documents, and Google Calendar, which are delivered for free to the Internet users and charged for professional quality services. Examples of commercial solutions are SalesForce.com and Clarizen.com, which provide online CRM (Customer Relationship Management) and project management services, respectively [10].

2.4.2 Platform as a Service (Paas)

Platform as a Service PaaS system goes a level above the Software as a Service setup. Platform-as-a Service solutions provide an application or development platform in which users can create their own application that will run on the Cloud. More precisely, they provide an application framework and a set of API that can be used by developers to program or compose applications for the Cloud. PaaS solutions often integrate an IT infrastructure on top of which applications will be executed. This is the case of Google App Engine and Microsoft Azure, while other solutions, such as Manjrasoft Aneka, are purely PaaS implementations. Google App Engine is a platform for developing scalable web applications that run on top of data centers maintained by Google. It defines an application model and provides a set of APIs that allow developers to take advantage of additional services such as mail data store.

2.4.3 Infrastructure as a service (Iaas)

Infrastructure as a service also called Hardware-as-a-Service was coined possibly in 2006. As the result of rapid advances in hardware virtualization, IT automation and usage metering and pricing, users could buy IT hardware, or even an entire data center, as a pay-as-you-go subscription service. An IaaS agreement, as the name states, deals primarily with computational infrastructure. In an IaaS agreement, the subscriber completely outsources the storage and resources, such as hardware and software that they need. As we go down the list from number one to number three, the subscriber gains more control over what they can do within the space of the cloud. The cloud provider has less control in an IaaS system than with a SaaS agreement. What does this mean for the home user or business looking to start using the cloud? It means we can choose our level of control over our information and types of services that we want from a cloud provider.

According to the authors' Jayalakshmi Kanagasabapathy et al. [10], Cloud computing is a kind of on demand computing where we can share number of resources and information to the computer. Cloud Computing offers user to use different kinds of infrastructures, platforms and software that provides at very cheap cost and it allows us to create and customize different online applications and games.

According to the authors' Vishal R. Pancholi et al. [12] , Cloud Computing is a set of IT Services that are provided to a customer over a network and these services are delivered by third party provider who owns the infrastructure. It is often provided "as a service" over the Internet, typically in the form of infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS). Cloud computing allow us to create and customize different online applications and games. It also helps us in manipulating, accessing and configuring different kinds of hardware and software resources. It also provides us online data storage infrastructures and applications. Cloud computing is internet-based computing which is reliable and user friendly in nature.

According to the author's Shubhangi Ashok Kolte et al. [13] , Cloud computing plays an important role in internet era due to successive mobile applications. Cloud computing becomes more important it is the ultimate solutions for this mobile application. Cloud computing opens a

new era for computing technology presently there are various web services through different clouds some notable service is, Amazon webs services, elastic compute cloud, and Google cloud.

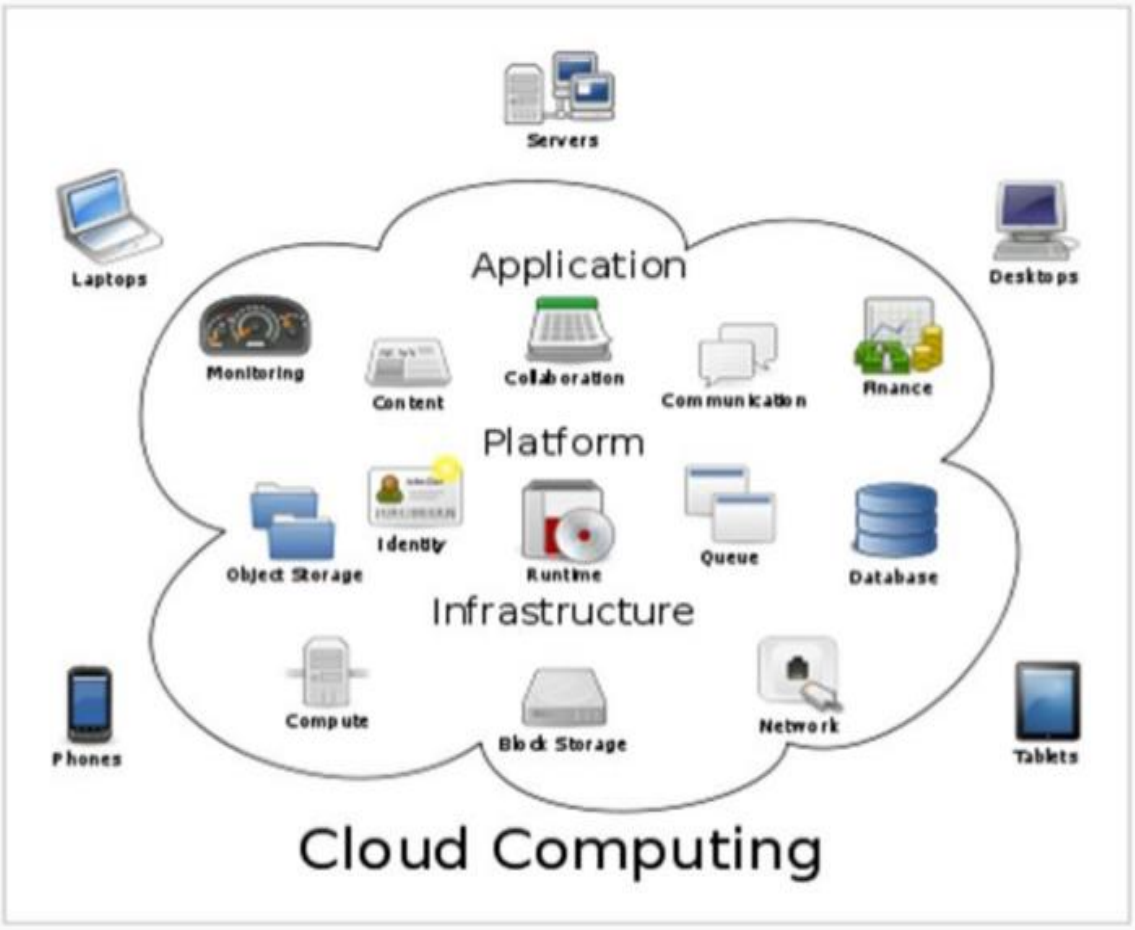


Fig 2.3: Network of Cloud Computing [13]

2.5 Services on cloud computing

According to the authors' [16], Cloud computing has formed the conceptual and infrastructural basis for tomorrow's computing. The global computing infrastructure is rapidly moving towards cloud-based architecture. Cloud computing illustrates the hierarchical arrangement based on

which cloud is perceived in the form of IaaS, PaaS, IaaS from any cloud end user points of view.

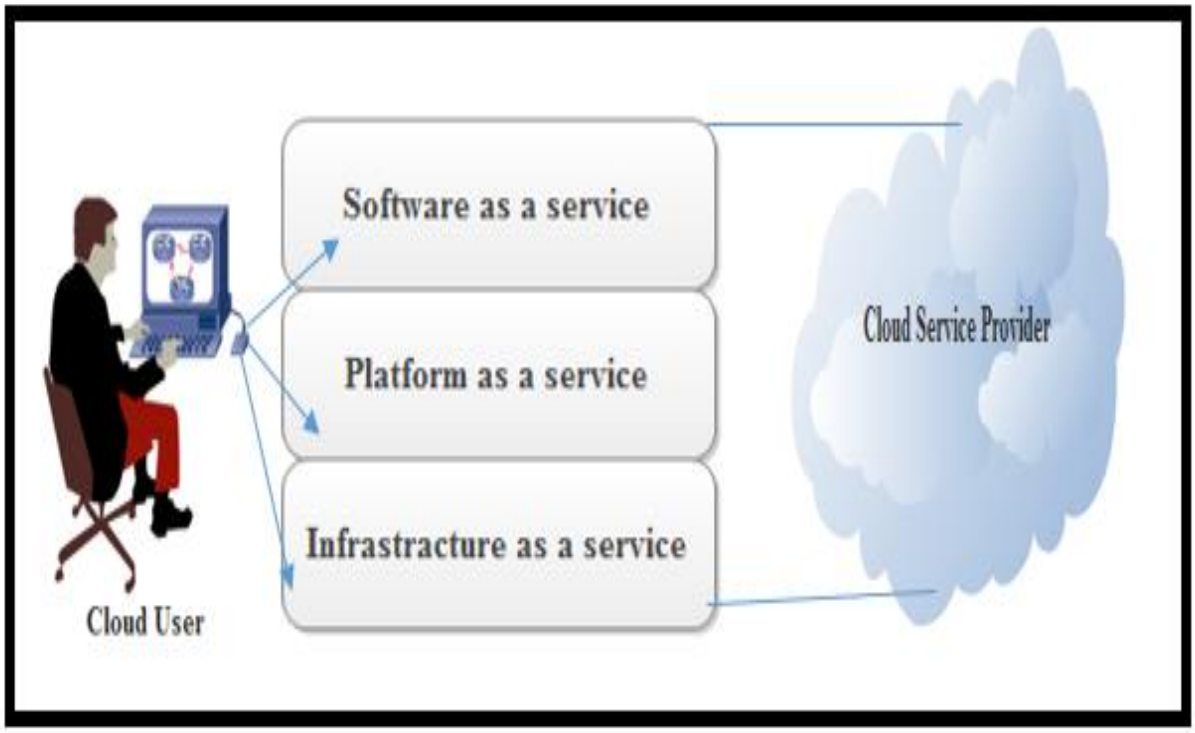


Fig 2.4: Cloud Service hierarchies [16]

As depicted in fig 2.4 [16], the technical details, arrangements and management of the cloud service providers' network is transparent to the cloud user. From the end of the cloud user, the service from the provider comes in the form of SaaS, PaaS or IaaS where the cloud user has no intention or worry about what goes on in the internal arrangement of the cloud service providers' network. The vast possibilities of cloud computing cannot be ignored solely for the security issues reason, the ongoing investigation and research for robust, consistent and integrated security models for cloud computing could be the only path of motivation. The security issues could severely affect cloud infrastructures.

According to Vidhya.V [17], Cloud computing is based on various technologies like virtualization, grid and utility computing. Without the installation or storage of software in their PC, cloud enable its users to access the shared resources through internet. Most of the IT industries today are moving onto cloud to meet their high computational Requirements with reduced cost. Cloud computing architecture can be modeled in to various layers based on the service they provide to the end users.

2.6 Security issue in cloud computing

The security issue is a big concern around area of cloud computing. Even they may have an agreement between the service provider and customer. But the security issue is a big challenge. So, it needs secure communication between the stakeholders.

According to the authors Newlin Raj Kumar et al. [18], On cloud computing the issue of privacy and security are considered as primary issues to its wide adoption. A set of security issues appears ahead and remains as a strong barrier for the users to easily adapt into Cloud Computing technology.

According to Chakradhara Rao et al. [19], in cloud computing CSPs and the cloud service consumer should make sure that the cloud is safe enough from all the external threats so that the customer does not face any problem such as loss of data or data theft. There is also a possibility where a malicious user can penetrate the cloud by impersonating a legitimate user, thus infecting the entire cloud and affects many customers who are sharing the infected cloud. The advantages of cloud computing may be very appealing, but nothing is perfect. Cloud got many issues when it comes to security especially on Data theft, Data loss and Privacy. The parameters that affect the security of the cloud and problems faced by cloud service provider and cloud service consumer such as data, privacy, infected application and security issues.

According to the authors V. Spoorthy et al. [20], for providing security for data storage in cloud data storage in cloud is more advantageous than traditional storage because of its availability, scalability, performance, portability and its functional requirements. it mainly focused on data storage aspects that cloud service providers are following to store the data and security aspects to be provided for that data stored in cloud. It tries to look on Amazon S_3 and third-party auditing (TPA) mechanisms which are used for data storage and security for data in cloud.

According to the author's Vishal R. Pan choli et al. [12], In cloud computing the security of the data in the cloud database server is the key area of concern in the acceptance of cloud. It requires a very high degree of privacy and authentication. To protect the data in cloud database Server

cryptography is one of the important methods. Cryptography provides various symmetric and asymmetric algorithms to secure the data.

2.7 History of Green Cloud computing

According to [21] green cloud computing is the act of optimizing its resources to minimize its environmental footprint. This includes the control of material, energy, water and other scarce resources, but also the limitation of electronic waste from manufacturing to recycling of components. The goals of green computing are like green chemistry which reduces hazardous materials by maximizing energy efficiency during recyclability or biodegradability of defunct products and factory waste.

Green computing is important for all classes of systems, ranging from handheld systems to large-scale data centers. Many corporate IT departments have green computing initiatives to reduce the environmental effect of their IT operations.

According to market research conducted by Pike Research, the wide-spread adoption of cloud computing could lead to a potential 38% reduction in worldwide data center energy expenditures by 2020. The savings would be primarily achieved by consolidating data centers and maximizing power usage efficiency (PUE). PUE (Power Usage Effectiveness) is a widely used metric to calculate power consumption. It is relation between the total energy consumption of the infrastructure and the consumption of computer equipment (processor, memories and storage).

According to Gaurav Jindal et al. [22], Green computing is the environmentally responsible use of computers and related resources. Such practices include the implementation of energy-efficient central processing units (CPUs), Servers and Peripherals as well as reduced resource consumption and proper disposal of electronic waste (e-waste). Green computing is the practice of efficient and eco-friendly computing. The principle behind energy efficient coding is to save power by getting software to make less use of the hardware, rather than continuing to run the same code on hardware that uses less power. “GREEN COMPUTING-GREAT COMPUTING”, Energy Star reduces the amount of energy consumed by a product by automatically switching it into sleep mode when not in use or reducing the amount of power used by a product when in

standby mode. The solution to green computing is to create an efficient system that implements these factors in an environmentally friendly way.

2.8 Technologies of Green Computing

VIA Technologies [22], a Taiwanese company that manufactures motherboard chipsets, CPUs, and other computer hardware introduced its initiative for "green computing" in 2001. With this green vision, the company has been focusing on power efficiency throughout the design and manufacturing process of its products. Its environmentally friendly products are manufactured using a range of clean-computing strategies, and the company is striving to educate markets on the benefit of green computing for the sake of the environment, as well as productivity and overall user experience.

1. **Carbon-free computing**

   One of the VIA Technologies' ideas [22], is to reduce the "carbon footprint" of users the amount of greenhouse gases produced, measured in units of carbon dioxide.

2. **Solar Computing**

   VIA [22], worldwide production of solar cells has increased rapidly over the last few years; and as more governments begin to recognize the benefits of solar power, and the development of photovoltaic technologies goes on, costs are expected to continue to decline.

3. **Lead-Free and RoHS computing**

   The European Union adopted the Restriction of Hazardous Substances Directive (RoHS) implemented [22], the legislation restricts the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment. The directive is closely linked with the Waste Electrical and Electronic Equipment Directive (WEEE), which sets collection, recycling, and recovery targets for electrical goods and is part of a legislative initiative that aims to reduce the huge amounts of toxic e-waste.

4. Energy-efficient computing

A central goal of VIA‘s green-computing initiative [22], is the development of energy-efficient platforms for low-power, small-form-factor (SFF) computing devices. In 2005, the company introduced the VIA C7-M and VIA C7 processors that have a maximum power consumption of 20W at 2.0GHz and an average power consumption of 1W. These Energy-Efficient processors produce over four times less carbon during their operation and can be efficiently embedded in solar-powered devices.

Power Usage Effectiveness (PUE) and its reciprocal Data Center infrastructure Efficiency (DCiE) are widely accepted benchmarking standards proposed by the Green Grid to help IT Professionals determine how energy efficient data centers are, and to monitor the impact of their efficiency efforts. The Uptime Institute also has a comprehensive benchmark it recommends named Corporate Average Data Center Efficiency (CADE). At their February 2009 Technical Forum, the Green Grid introduced new benchmarks named Data Center Productivity (DCP) and Data Center Energy Productivity (DCeP) which probe into the useful work produced by your data center. All benchmarks have their value, and when used correctly, they can be a useful and essential tool for improving your data center energy efficiency. 42U is a Direct NET, Inc. company expertise in delivering the best in data center infrastructure and management solutions. This is the technology leaders in datacenter cooling, power measurement/greenness, environmental monitoring, KVM, server cabinet enclosures, and rack mount products [23].

5. Vision through the pc-1 initiative

The VIA pc-1 initiative [22], seeks to enable the next 1 billion people to get connected, by providing wider access to computing and communications technologies. The company is concentrating on empowering new, emerging markets, looking at models that reach beyond individual ownership of a PC, such as local pay-for-use facilities. Products built for such a use are characterized by ultra-efficient energy consumption and the ability to withstand heat and dust in harsh environments.

According to authors’ Suman Kumar et al. [24], the data centers regularly wasted a huge amount of electricity they pulled from the grids; it forms large energy consumption and wastage of time.

So, there is a strong need of optimization of three factors CPU utilization, response time for task and number of tasks executed per minimum time. Reducing the energy utilization of cloud computing system and data center is a challenge because data and computing application are growing in a rapid state that increasingly disks and larger servers are required to process them fast within the required period. To deal with this problem and certifying the future growth of cloud computing and data centers is maintainable in an energy-efficient manner, mainly with cloud resources to satisfy Quality of Service (QoS) requirement specified by users via Service Level Agreements (SLAs), thus reducing energy utilization is necessary.

1. **Multi-Tenancy**

Multi-Tenancy [24], Green Cloud computing reduces unwanted energy usage and minimize carbon emissions. By this approach we can handle multiple customers with a single instance of application. Multiple customers are representing as tenant and they are having some authorization to make some changes in the some of the parts of the application. The SaaS providers give multiple organizations on same infrastructure and common software.

2. **Datacenter Efficiency**

Datacenter Efficiency [24], the datacenters power efficiency has major role on to the total energy consumption of Cloud computing. By using the best energy efficient techniques, Cloud data center providers can significantly improve the Power usage effectiveness of their datacenters. Cloud computing is also allowing services to be moved between various datacenters who are working with much better PUE values.

According to Ankita Atrey et al. [25], Cloud computing was introduced to an end for customers worldwide, providing high performance at a cheaper cost when compared to dedicate high-performance Computing machines. This provision requires huge data-centers to be tightly-coupled with the system, the increasing use of which yields heavy consumption of energy and huge emission of CO2. Since energy has been a prime concern of late, this issue generated the importance of green cloud computing that provides techniques and algorithms to reduce energy wastage by incorporating its reuse. The green matrices are an appropriate for data-centers and then throw light on green scheduling algorithms that facilitate reduction in energy consumption and CO2 emission levels in the existing systems.

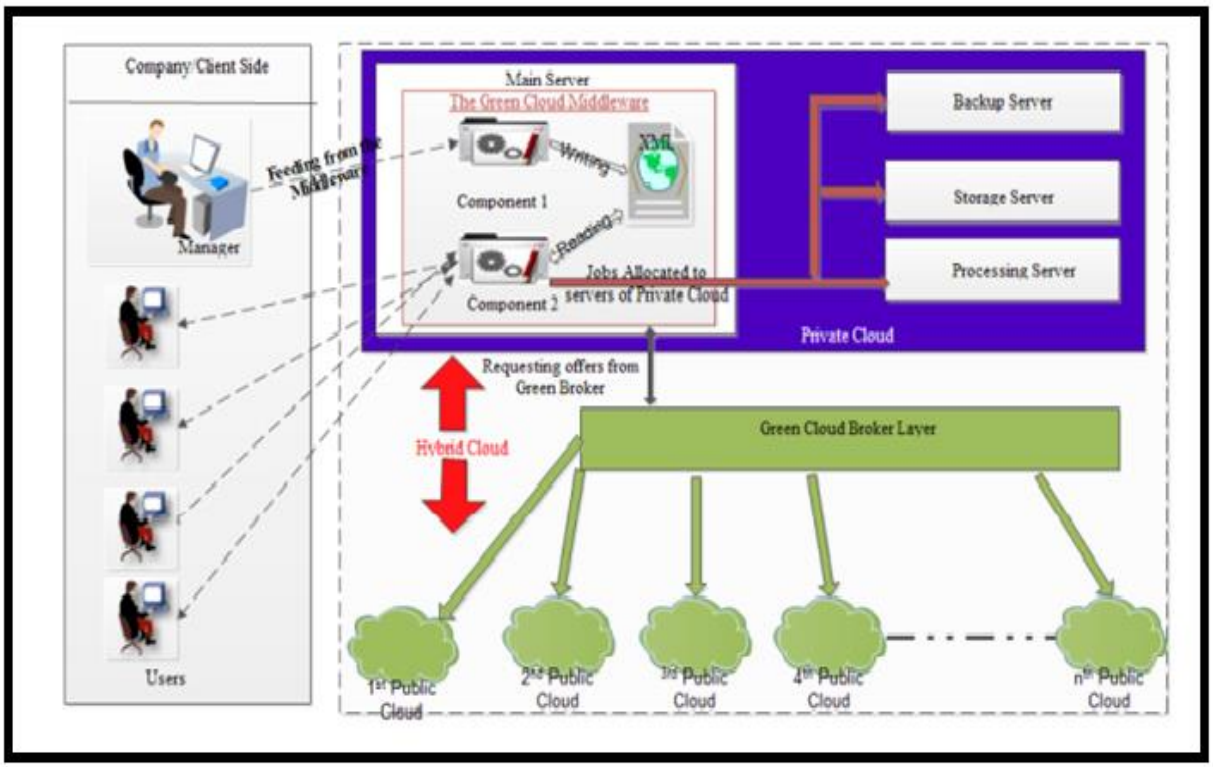


Fig 2.5: Integrated Green Cloud Architecture [25]

According to [25], the green cloud is the carbon emission and energy used for execution of job on the private cloud by servers, on the public cloud by using green broker or on the client's PC is calculated and show to the users. The best green offer is selected by the manager by taking into consideration the security level of the job also.

Table 2.1: Green Metric Power Management [25]

Metric	Explanation	Formula
Power Usage Effectiveness (PUE)	It is the fraction of total energy consumed by the service of a data center to the total energy consumed by IT equipment's	PUE=$\frac{Total\ Facility\ Energy}{IT\ Equipement\ Energy}$
Data center Infrastructure efficiency (DCIE)	It calculates the amount of useful work done by the datacenter	DCIP= $\frac{Total\ useful\ work}{total\ resources\ used\ to\ do\ this\ work}$

According to authors' Piotr Pazowski [26], Green computing refers to the practice of environmentally responsible and efficient use of computing resources while maintaining economic viability and improving its performance in eco-friendly way. To achieve social awareness and promotion of green technology solutions, main four complementary approaches are employed:

1. **Green Use**

   Green Use [26], Reducing the power consumption of computers, information systems and their peripheral subsystems in environmentally friendly manner.

2. **Green Disposal**

   Green Disposal [26], Refurbishing and reusing existing old computers and other electronic associated devices. Recycling unwanted used computers and electronic waste by IT vendors using their "take back" policy to take responsibility for the full lifecycle of products they produce.

3. **Green Design**

   Green Design [26], In broader aspect connecting companies, government agencies and environmental organizations to develop inventive management, business and regulatory processes that can improve environmental quality while enhancing economic development. In narrow practical aspect designing power efficient, eco-friendly computers its subsystems like servers and cooling equipment.

4. **Green Manufacturing**

   Green Manufacturing [26], Process of production of computers and associated devices include methods of manufacturing and biodegradable components for minimal or no impact on environment.

The cloud services [26], The Green broker uses the up to date information about cloud services and status of energy efficiency parameters using Carbon Emission Directory (CED) which is very important component of the architecture. Cloud providers need to reduce the electricity demand of clouds and take major steps in using renewable energy sources rather than just looking for economic incentives like cost minimization. Green ICT sustainability addresses issues such as: using renewable energy sources to power data centers, reducing e-waste, designing energy efficient hardware, middleware and software, running multiple operating

systems via virtualization, providing information to customers to encourage them make green choices, reducing transportation cost and emissions by telecommuting.

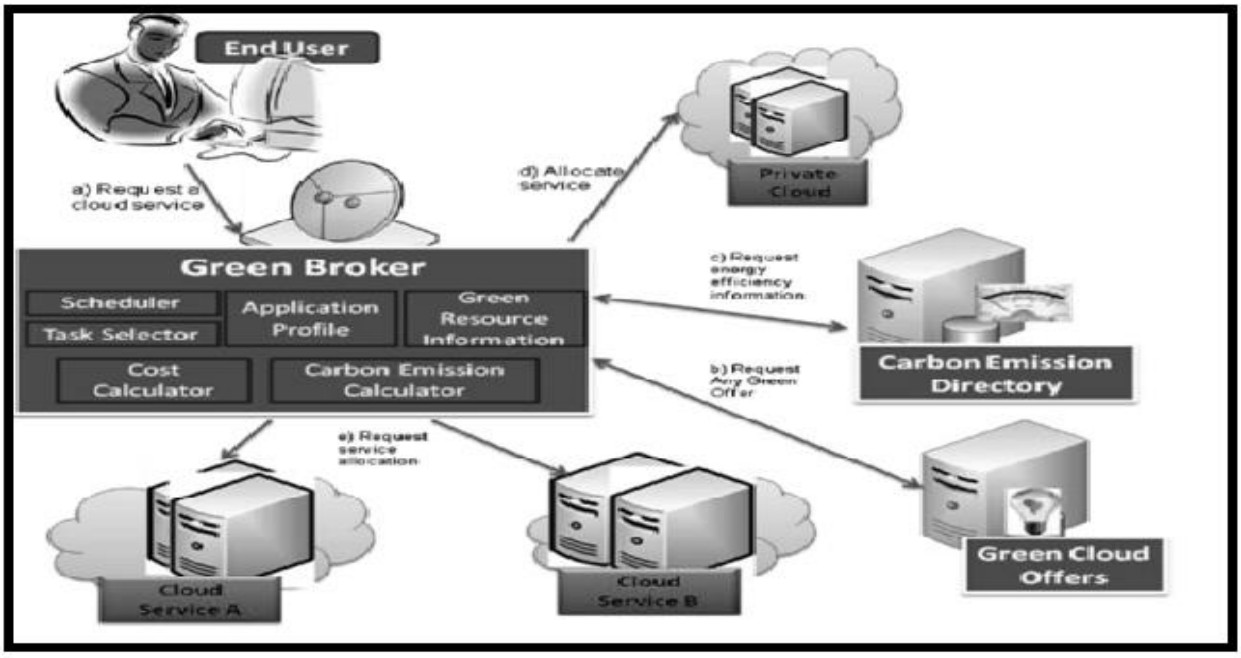


Fig 2.6: Integrated carbon aware Green Cloud Architecture [26]

According to Anwar et al. [27], Green computing is to improve environmental condition. The main aim of green computing is to reduce toxic materials. Green computing can facilitate us to safe, secure place and health environment all over the world.

Table 2.2: Power Consumption of Laptop

Laptop Components	**Percentages**
Power supply	10%
CPU	10%
Display (panel + inverter)	33%
Fan	2%
LAN	2%
DVD	2%
Intel I/O controller hub	3%
Clock	5%
Hard drive	8%
Graphics card	8%
Miscellaneous	8%
Intel memory controller hub	9%

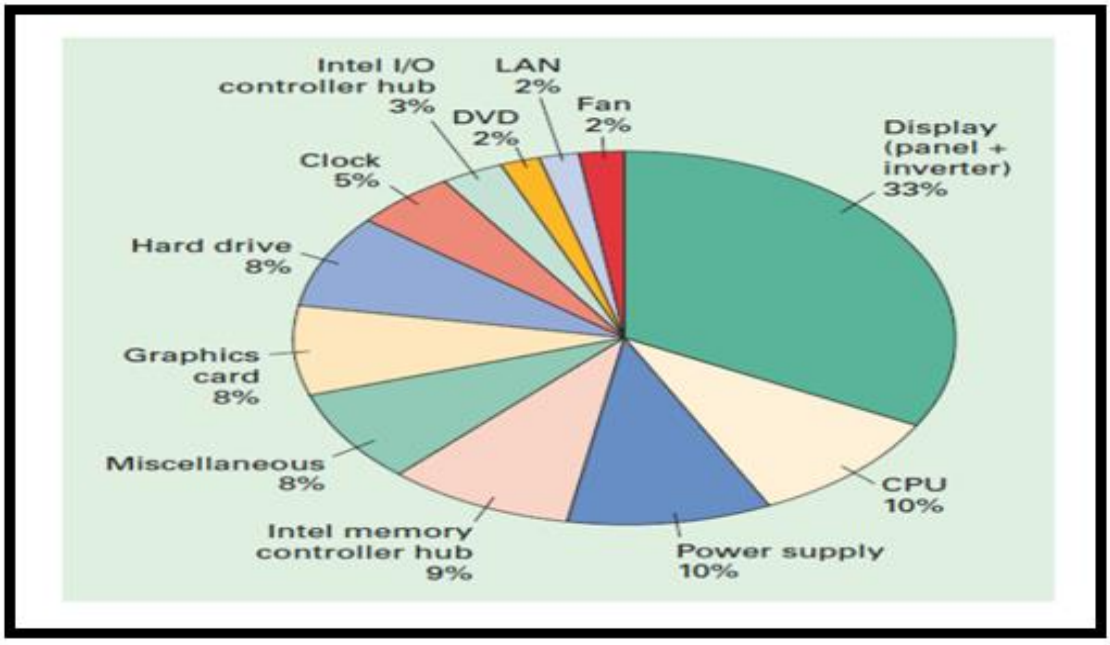


Fig 2.7: Power consumption of average laptop [27]

According to Swasti Saxena [28], Green computing is an effective in which disposing, recycling and manufacturing of computers and electronic devices is taken into consideration. The goal of green computing is to lower down the use of hazardous materials, maximize energy efficiency and popularize biodegradability or recyclability of outdated products and factory waste.

Table 2.3: Wastage by power usages on small, medium and large-scale organizations [28]

Business Type	IT power per User	Power usage effective	Total power per user	Annual Energy per User
Small	8W	2.5	20W	175KWH
Medium	1.8W	1.8	3.2W	28.4KWH
Large	0.54W	1.6	0.9W	7.6KWH

According to Amlan Deep et al. [29], Green IT is a study and practice which can reduce energy consumption significantly. Some energy saving (conserving) strategies are as follows.

1. Use Renewable Energy Sources

   Use Renewable Energy Sources [29], all datacenters of clouds maximum time use generator to provide backup power and with data center CO2 dissipation and GHGs.

2. Nano Data Centers

   Nano Data Centers [29], Energy consumption in modern typical data centers, a new, distributed computing platform called Nano Data Centers (NaDa) is preferred. NaDa provides computing and storage services and adopts a managed peer-to-peer model to form a distributed data center infrastructure.

   .

According to the S.V.S.S. et al. [30], stated that Green computing represents a responsible way to address the issue of global warming.

According to Ankit Kumar et al. [31], presents the aim of the green wall methodology in sustainable development is to overcome the environmental damage causing by the development

of technologies and process of informatization from the beginning phase.

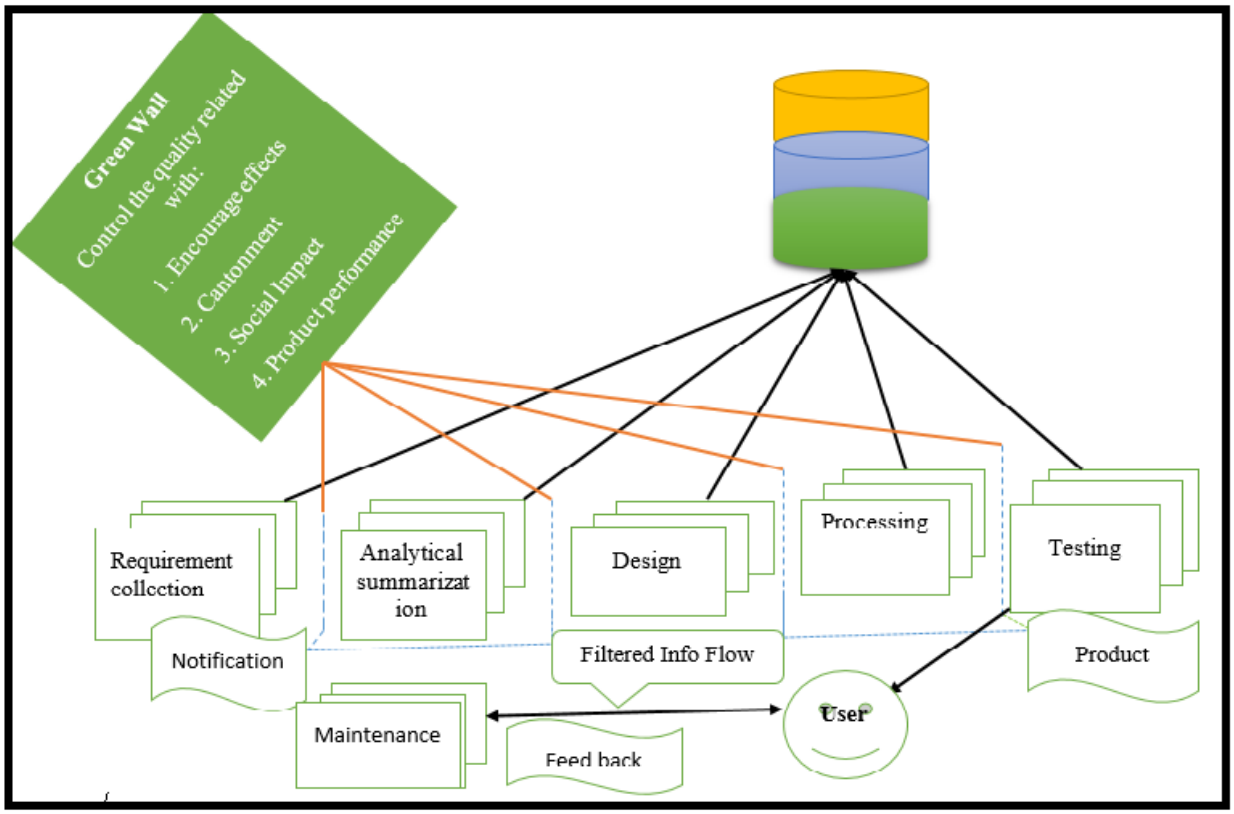


Fig 2.8: Green Wall models [31]

Ankit Kumar et al. [31], the main objective of our proposed green wall (GW) model is to inherit the concept, procedure and phenomena of green computing during the development process of software as well as hardware.

The Vishnu Kumar et al. [32], Green within Computing is a term used to describe an innovative way on how technology and ecology converge together. Green computing ultimately focuses on ways in reducing overall environmental impacts. Some of the powers saving modes are listed below.

- Hard Disk Sleep Mode
- Screen Savers
- Monitor Sleep Mode
- System Standby Mode
- Hibernate Mode

Green computing has come a long way, but with so many new innovations coming along in regards of preserving the environment, it is safe to say that green computing is a great development.

According to the Parichay Chakra borty et al. [33], Green Computing is focusing on not only environmental organizations, but also businesses from other industries.

After rigorous analysis the paper try to analyze so green computing is a mindset that asks how we can satisfy the growing demand for network computing without putting such pressure on the environment. It opens a new window for the new entrepreneur for harvesting with E-waste material and scrap computers.

2.9. Review of Related Works

2.9.1 History of Service Level Agreement (SLA)

According to the Wiki [34], Originally, SLAs come from IT services but are now used for other services, such as building, cleaning, maintenance, financial management, book keeping, and payroll. In Germany and Switzerland, SLAs have become known through the IT Infrastructure Library (ITIL). SLAs are an essential component of service level management (SLM). A service level agreement (SLA) refers to an agreement or the interface between the customer and the service provider for repeated services. The goal is to make the control options for the client transparent, by accurately describing the performance attributes, such as the scope, response time and speed of the processing. An important component is the service level, which describes the agreed performance quality and contains information on the service spectrum. e.g. time, scope, availability, response time of the provider and so on. Typical example is the operation of servers running 24 hours a day, 7 days a week with a failure rate of, for example, a maximum of 0.1% per year and a response time of 30 minutes after the occurrence of a damage report by an external service provider. The Service Level Agreement (SLA) must be distinguished from the Operational Level Agreement (OLA). An OLA is often used to support or secure an SLA. The service guarantee has a very similar objective, but this is promised to a consumer in a standardized form. The definition of SLAs is to follow the SMART principle. The client receives

a service fixed in the SLAs (e.g. reaction times of the support, restoration of data and so on) at an agreed price and the contractor guarantees that they adhere to this agreement. SLAs are intended to provide price performance transparency for customers and partners. On the other hand, they offer support in dispute resolution or dispute avoidance by clarifying the critical points in the possible elaboration or presentation of the SLA. But the measuring and monitoring mechanism is in the hand of CSPs.

According to U.Yamini et al. [35], In a secure and non-obstructive billing system using the concept THEMIS. The main objective of this system is to provide a full-fledged trusted billing system tailored from a cloud computing environment. The SLA (Service Level Agreement) sharing is done between user and CSPs (Cloud Service Providers). S-Mon forgery-resistive SLA monitoring mechanism is devised by TPM (Trusted Platform Module). THEMIS assures actual confirmation of any transaction between a user and a CSP. Furthermore, our mutually verifiable billing protocol cogently reduces the billing overhead. But the work focuses on the service provider side besides that it puts the platform between the service provider and customer side. The paper conducts about the billing mechanism between the involved parties. It didn't cover the measuring and monitoring mechanism on the client side.

Nuno Palhares et al [36], proposed a layered model for Cloud Services monitoring, identifying the multiple dimensions of monitoring, while combining the perspectives of service providers and customers. This process involves the identification of relevant parameters and metrics for each monitoring dimension, focusing on monitoring of resources, quality of service, security and service contracts. Taking a stratified view of the problem, this study contributes to achieve a clearer and more efficient approach to cloud services monitoring. This fact is particularly important and complex when trying to perform monitoring of cloud services across multiple clouds, involving geographical, quality and legal issues. Contributing to the efforts towards modeling and standardization, this work has proposed a stratified approach identifying and suggesting parameters, metrics and best practices for efficient monitoring of cloud services and environments.

As the research conducted metering and monitoring are still in the hand of CSPs. The cloud consumer has no right to measure/meter and monitoring on the client side.

Adrian Paschke et al. [37], proposed that effective SLAs are extremely important to assure business continuity, customer satisfaction and trust. The metrics used to measure and manage performance compliance to SLA commitments are the heart of a successful agreement and are a critical long-term success factor. Lack of experience in the use and automation of performance metrics causes problems for many organizations as they attempt to formulate their SLA strategies and set the metrics needed to support those strategies. This paper contributes to a systematic categorization of SLA contents with a focus on SLA metrics. The intended goal is to support the design and implementation of automatable SLAs based on efficient metrics for automated monitoring and reporting. The categorization facilitates design decisions, analysis of existing SLAs and helps to identify responsibilities for critical IT processes in disruption management during the execution of SLAs.

Filipe T. Marques et al. [38], a business-driven approach to designing Service Level Agreements in an e-commerce environment is proposed. In contrast to conventional SLA design approaches, the one proposed better capture the linkage between service provider and service client by considering the negative business impact (business loss) originated from IT infrastructure failures and performance degradation and factors such knowledge into the SLA itself. A complete example scenario shows the value of the proposed approach. To that effect, the needs of the business must be captured and linked to the IT World so that adequate service be designed and deployed. Now, how does one express business needs in a way understandable to the technical IT world? In the last few years, this has been done through Service Level Agreements (SLAs) that contain Service Level Objectives (SLOs) for technical service metrics such as availability, throughput, and response time and so on. The reason that IT metrics used are:

i) They are easily understood by IT personnel and

ii) They are easily measured and are thus more trusted than, say, human opinions on the quality of service. Approaches to the SLA design problem to consider outsourced services but maintaining the business perspective captured by recent models. To that end, one must properly model the linkage between IT and the business that is captured by an SLA.

The approach we describe here yields a multidimensional design problem, some of whose dimensions will be explored here. The dimensions explored are:

1) To choose the SLA parameters minimum service availability and maximum mean response time (or per-centiles of the response time distribution) and

2) To design a server farm to provision the service.

A main conclusion is that the SLA established using the business-driven perspective is superior to the one using a conventional approach since both service provider and client can simultaneously obtain higher profit. But the measuring and monitoring mechanism is in the hand of the CSPs.

Linlin Wu et al. [39], presented the literature survey, issues and solutions of SLA management in utility computing systems and how SLAs have been used in these systems. In this work, it has summarized the fundamental concepts of SLA and analyzed two types of SLA lifecycle. One is the three-phase high level lifecycle, which includes creation phase, operation phase and removal phase. The other is more specific lifecycle including six steps, which are discover-service provider, define-SLA elements, establish-agreement, monitor-SLA violation, terminate-SLA and SLA violation control.

It is found that, there are still some open challenges such as scalability, dynamic environmental changes, heterogeneity, SLA management automation, multiple QoS parameters, and SLA suitable for cross domains among others.

In [40], it is presented that Service Level Agreement (SLA) becomes very important for the both the business providers/vendors for user/customers. There are many ways to inform users/customers about the various services with the inherent execution functionalities and non-functional/quality of services (QoS) aspect through SLAs. However, these basic SLA didn't cover eco-coefficient green issues or IT ethics issue for sustainability. Therefore, Green SLA (GSLA) should come into play. Green SLA is a formal agreement incorporating all the traditional commitments as well as green issues and ethics issues in IT business sectors. GSLA research would survey on different basic SLA parameters for various services such as network, compute, storage and multimedia in IT business areas. At the same time, this survey focused on finding the gaps and corporation of this basic SLA parameter with existing green SLAs, defining

GSLAs with new green performance indicator and their measurable units. This new proposed GSLA could help and clarify different service providers/vendors to design their future business strategy in this new transitional, sustainable society.

Daniel Pukka et al. [41] presents the Service Level Agreement (SLA) as contractual due to large changes in the market place and growth in the number and complexity of service on offer in order to guarantee a certain quality of offered service and in response to customer needs, some mechanism of service Level Management must be applied. The Service Level Management in telecommunication network is made by agreement established during the service subscription which is used by customer and service providers to control the service level.

It introduces a Service Level Management (SLM) system. Initially, architecture for service Level Management is presented including many aspects from the creation of the service level contract up to monitoring the service level. The service provider will have available an efficient management tool, that will allow them to take proactive actions to maintain the QoS levels, or when this is not possible, to adopt compensatory mechanism to improve the customers' satisfaction.

Mohammed Alhamad et al. [42] defines cloud-based framework for university according to its services and users. It also suggested conceptual framework of service level agreement for university and represent the SLA life cycle which is require thoroughly for contract and its architecture.

Mohammed Alhamad et al. [43], integrates the conceptual SLA framework for cloud computing for trust management model to the solution of the reliability criteria for the selection process of cloud service providers. All the functionality provided in the SLA is monopolized by the CSPs.

Eman Aljoumah et al. [44], explains about the SLA between the CSPs and consumer. The paper explains about the general structure of SLA, its component's, the management process (SLA monitoring), SLA life Cycle and pricing explores the importance of SLA for cloud computing services related to service provider including the difference between the SLA for cloud services and other web services. It also compares the current major cloud computing services providers in terms of SLA's. But all the functionality performed in the SLA is monopolized by the CSPs.

2.10. Importance of Service Level Agreement in Cloud Computing

Many cloud providers are vague on the specifics of the underlying hardware and software stack they use to deliver a virtual server to the end customer, which allows for over commitment. Techniques for overcommitting hardware include (but are not limited to) specify memory allocation and leave CPU allocation unspecified, allowing total hardware memory to dictate the number of customers the hardware can support.

SLA must point the volume of service rendered for the cloud services such as contract KPIs:

- The volume of service
- The quality of service
- Peak and average loads of work
- The volume of demand at different times of day and
- The penalty for the cloud provider in case the provider fails to meet these service requirements

2.11. SLA Requirements

- A signed agreement with each customer
- Transactions by hour and jobs by day for each application
- A method of reporting SLA results
- Priority of services in case of insufficient availability
- Agreed methods of penalty in case customer exceeds his limits
- Agreed methods of penalty in case cloud provider fails to meet contract specifications
- Schedule of virtual or actual meeting between the customer and the cloud provider if necessary

2.12. Summary of Related Research Works and Gap analysis

Table 2.3: Summary of focused and related Research works

No.	Title of Research/ Thesis/ Dissertation/ Journal Article	Model/Framework used/Life Cycle	Purpose/Objective/Problem
1	Trusted SLA Monitoring for Billing System in Public cloud computing Environment	Developing Trusted SLA for the billing system in the public cloud environments with secure and non-obstructive system	To provide a full-fledged trusted, billing system tailored from a cloud computing environment. It does not say anything about client-side measurement or monitoring along with QOS like SLA Frame works
2	A Multidimensional Model for Monitoring Cloud services	Proposes a layered model for Cloud Services monitoring, identifying the multiple dimensions of monitoring, while combining the perspectives of service providers and customers	To achieve the clear and more efficient approach to cloud service monitoring. It does not provide any knowledge about client-side measuring or monitoring of services
3	A Categorization Scheme for SLA Metrics	Designing and implementation of automatable SLAs based on efficient metrics for automated monitoring and reporting	Systematic categorization of SLA contents with a focus on SLA metrics. The study has lack of focus on client-side measuring and monitoring over cloud
4	Service Level Agreement Design and Service Provisioning for Outsourced Services	A business-driven approach to designing Service Level Agreements in an e-commerce environment is proposed	To establish business-driven SLA perspective in E-com environment. Does not focus anything on customer-side SLA
5	Green Service Level Agreement	Design SLA for both the CSPs and users (customers)	Focuses only on the Green SLA for the formal agreement incorporating all the traditional commitment as well as green and ethics issues. Besides it focuses on the integration of Green parameter on existing SLA
6	Service Level Management in ATM Networks	To study contractual relation between customers and telecommunications services providers in ATM environment	Introduces about service level management system, which can be applied to different telecom systems. More, it presented a complete service level management system for ATMs only
7	Service Level Agreement (SLA) in	Managing fundamental issues of SLAs, including SLA	Focuses on the comprehensive survey of how SLAs are created, managed and used in utility

	Utility Computing Systems	autonomy management or trade off among multiple Quality of Service (QoS) parameters	computing environment only. This research paper has sound contribution on SLA but not explain about trust and transparency along with SLA frameworks for cloud services
8	Cloud based Conceptual Framework of Service Level Agreement for University	The paper is suggested that conceptual framework of service level agreement for university and define the SLA between the Cloud providers and university.	The paper defines the SLA between the CSPs and university. It didn't say anything about the measuring and monitoring the Service which provide from the CSPs
9	SLA-Based Trust Model for Cloud Computing	The paper conducts a trust model to evaluate the cloud service	The paper focuses on the trustworthiness of cloud service on the CSPs side. It didn't give any explanation about the measuring and monitoring of cloud services especially on the client side
10	A Trust-Evaluation Metric for Cloud Application	The paper develops a model for the cloud services (IaaS) to evaluate the cloud metrics. Especially on E-Learning	The paper focuses on the trust Evaluation on the IaaS and PaaS on the CSPs side using fuzzy theory
11	SLA in Cloud Computing Architectures: A comprehensive Study	The paper provides study about the general structure of SLA and management process	The paper is relevant to the study.it explores the importance of SLA for cloud computing services. As well as it tries to compare the current major cloud computing services providers in terms of SLA's, but the paper didn't explore any idea about the metering and monitoring on the client side.
12	Cloud Computing Service Metrics Description	The Paper discusses Cloud service Metric selection and Propose Cloud service Metrics model for stakeholders	The Paper explore Cloud Service Metric selection and Propose Cloud Service Metrics model by reducing challenges between stakeholders or customer and cloud service provider)
13	Cloud-Computing: Adoption Issues for Ethiopian Public and Private Enterprises	The paper indicates the benefits of cloud technologies for enterprises	This research raises awareness of the challenges and potential benefits of cloud adoption
14	QoS Metrics for Cloud Computing Services Evaluation	To select suitable and best Cloud providers among several Cloud services evaluation metrics	QoS (Quality of Service) metrics playing an important role in selecting Cloud providers and optimizing resource utilization efficiency

15	QoS Based Framework for Effective Web Services in Cloud Computing	To Design QoS Based Framework for Effective Web Services in Cloud Computing	The goal of the QoS in agent is to support advanced Web Service Discovery with QoS applied in registration, verification, certification and confirmation
16	SLA-based Optimization of Power and Migration Cost in Cloud Computing	To minimize the total energy cost of cloud computing system while meeting the specified client-level SLAs in a probabilistic sense	Specifies constraints on performance and/or quality of service result in a basic trade-off between the total energy cost and client satisfaction in the system
17	A Multidimensional Model for Monitoring Cloud Services	Proposes a layered model for Cloud Services monitoring, identifying the multiple dimensions of monitoring, while combining the perspectives of service providers and customers	To achieve a clearer and more efficient approach to cloud services monitoring
18	Cloud SLA Considerations for the Government Consumer	Analyses and recommend investigations of the latest trends in Cloud SLA management within the federal government	Explored the role of SLAs in managing performance of government procurements through Public Clouds
19	Trusted SLA Monitoring for billing system in Public Cloud Computing Environment	Analyze a secure and non-obstructive billing system using the concept THEMIS	To provide a full-fledged trusted, billing system tailored from a cloud computing environment
20	SLA Violation Prediction in Cloud Computing	SLA Violation Prediction in Cloud Computing by Machine Learning Perspective	To predict SLA violations favors both the customers and the Cloud service providers

In this chapter an attempt has been made rigorously analyses literatures from various resources and based on the existing research work in the field of cloud computing, SLA trust and transparency, Green SLA and energy efficiency/optimization in Cloud/IT industry among others. Most of the papers reviewed in this study did not cover any clue regarding the client-side measuring and monitoring mechanism. It was observed during analysis and review of research studies that the services and their SLAs are monopolized by the CSPs. After the rigorous review of concepts and related research studies; it was concluded that the proposed research on client-side measuring/metering and monitoring of SLA with QoS will certainly be a new knowledge contribution to the knowledge domain of cloud computing services

Table 2.4: Attributes used in SLA Models

Model/Framework/Lifecycle	Used Attributes	QoS Dimensions
Quality of Service Attributes for Saas, Paas and Iaas	Availability	Uptime
	Performance	Response time, Throughput and Timeliness
	Reliability	Uptime History
	Scalability	Granularity, Elasticity
	Security	Compliance Certifications, Authentication, Authorization, Attack Prevention, Backup Coverage, Backup Periodicity, Recovery Velocity and Infrastructure Architecture
	Support	Resolution Rate, Resolution Time, RFC Implementation Rate, Community
	Interoperability	API Coverage, API Form
	Modifiability	Data Layer Modifiability, Logic Layer Modifiability and Presentation Layer Modifiability
	Usability	Satisfaction, Accessibility, Efficiency
	Testability	QoS Testability, Application Testability
	Service-Level Agreements (SLA)	Strong SLA can offset the impact on a business when a service does not perform to the guaranteed level

CHAPTER THREE

METHODOLOGY

3.1. Research Approach

To answer the research question and achieve the research objectives, the study followed research methodology illustrated in this chapter using selected methods and tools. The research methodology incorporates the statistical analysis of the data collected quantitatively and qualitatively both through questionnaire, interview, technical observation and case-based documents analysis. This research study applied three data collection and fact-finding techniques

1) Evidences using Secondary source analysis

2) Technical observation on selected Cloud Service Providers (CSPs) and

3) Experiential Evidences of Cloud Service End Users.

Based on analysis of qualitative and quantitative facts; the research study developed a Client-Side SLA Model for measuring and monitoring utilized services towards empowering client for the better trust and transparency between Cloud Client and Cloud Service Providers. Finally, the results are analyzed for validation of the new knowledge-based SLA model produced as deliverable contribution.

3.1.1 Secondary Source Analysis

To justify the identified research question and gap in the conference and currently available solutions, several related researches work from literatures such as journal papers, research thesis's and dissertations were reviewed and analyzed in the context of the target research problem. In addition, to understand the domain area with available techniques and technology, concepts from books and sites were also studied and referenced at appropriate place with critical remarks. Using reviews of literature an attempt was also made to analyze that what type of research strategies, methods and tools were used by different researchers. Based on the detailed literature, different techniques and tools which are relevant for this research study i.e. client-side measuring and monitoring SLA for Cloud Services. Here critical analysis was done for evaluation of the selected tools and methods using certain parameters. To justify the significance

of the research a detailed review of the literature covering concepts and related works have been done in Chapter 2.

3.1.2 Observation made on selected CSPs

In this phase data and facts (using selected features) were collected through technical observation from both CSP and Client-Side SLA about trust, transparency, trust breach and conflict resolutions and greenness using case studies and analytics from Literature. In this section researchers heavily involved in collecting and analyzing the facts on SLA for Measuring, Metering and Monitoring (3M) of the promised services. The parameters considered were related to quality and performance to diagnose the 1) trust, 2) trust breach, 3) conflict frequency, 4) trust resolution mechanisms, 5) transparency and 6) greenness of SLA framework in the proposed SLA model using simulation.

3.1.3 Questionnaire

In this phase selected Cloud service users from different levels were approached using questionnaire. Their experience and observations were analyzed for trust on measuring and monitoring of cloud services that are promised under SLAs. This was done to check the awareness level of end users about their level of trust, awareness, rights and empowerment, who usually trust on the measurements, metering and monitoring of the sold cloud services by CSPs. The research tried to analyze how salient type of cloud service users like Academicians and Technical Administrators and Simple End users like learners are aware of the trust on measuring, metering and monitoring of cloud services promised under SLAs by CSPs for quality, availability, metering and billing.

3.1.4 Building A Model for Client-Side metering and monitoring of SLA

It is proposed to design a Client-Side Metering and Monitoring of SLA for Cloud Services. This model must be accepted between CSPs and Clients/Customers for Measuring, Metering and Monitoring of Cloud Services for the improvement of Trust, Transparency and Greenness of the Cloud Services. This will minimize the monopolization of cloud service providers of SLA and empower the Clients and Customers.

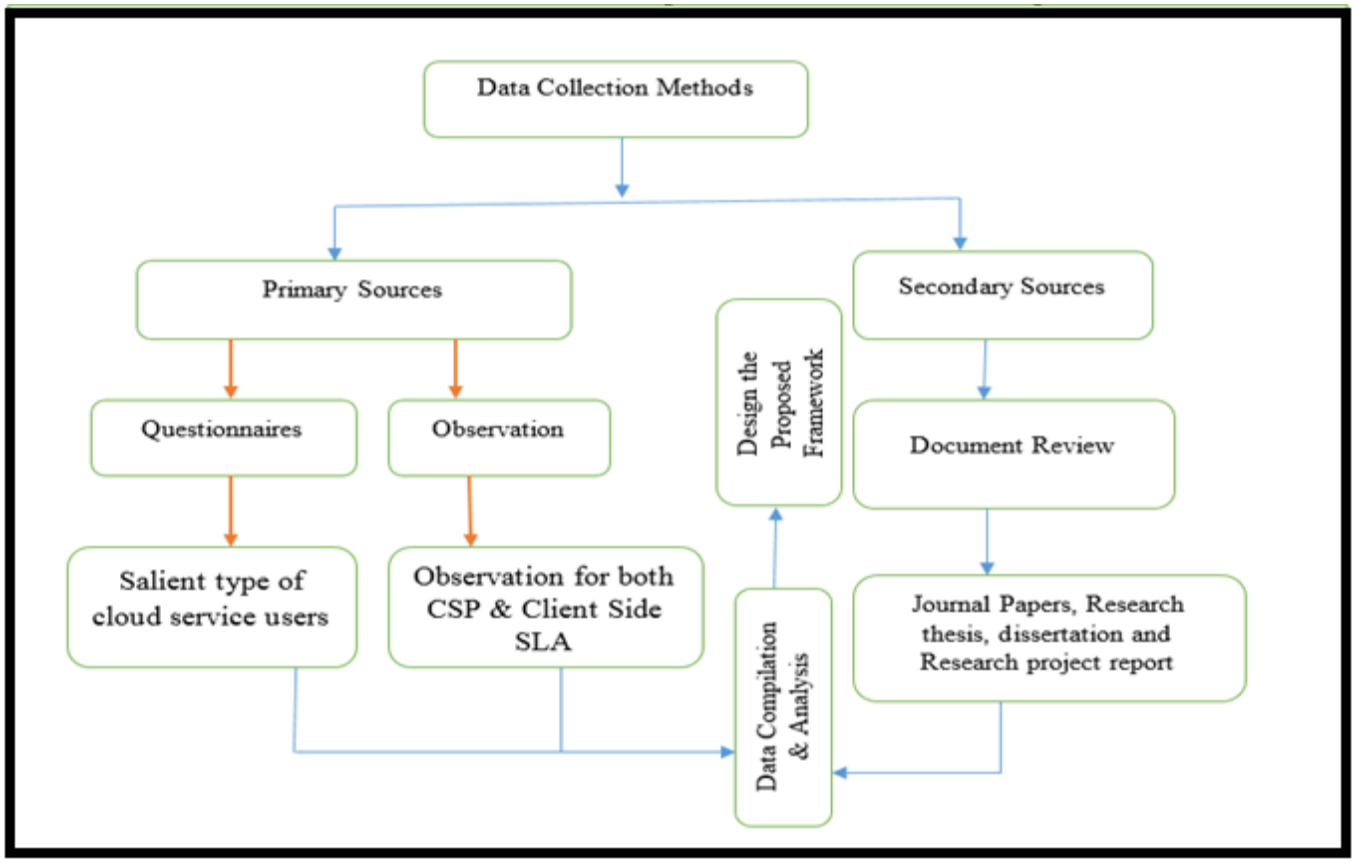


Fig 3.1: Data Collections, Analysis and System Modeling flow chart used in the research

3.2 Research Tools and Technologies

To Collect, Analyze and design the proposed SLA measuring and monitoring Model, different methods, software, designing tools and techniques were applied to accomplish the research tasks. Open source cloud computing tools are used in this work. AppNeta was selected for metering and monitoring SLA on the client side for the cloud services.

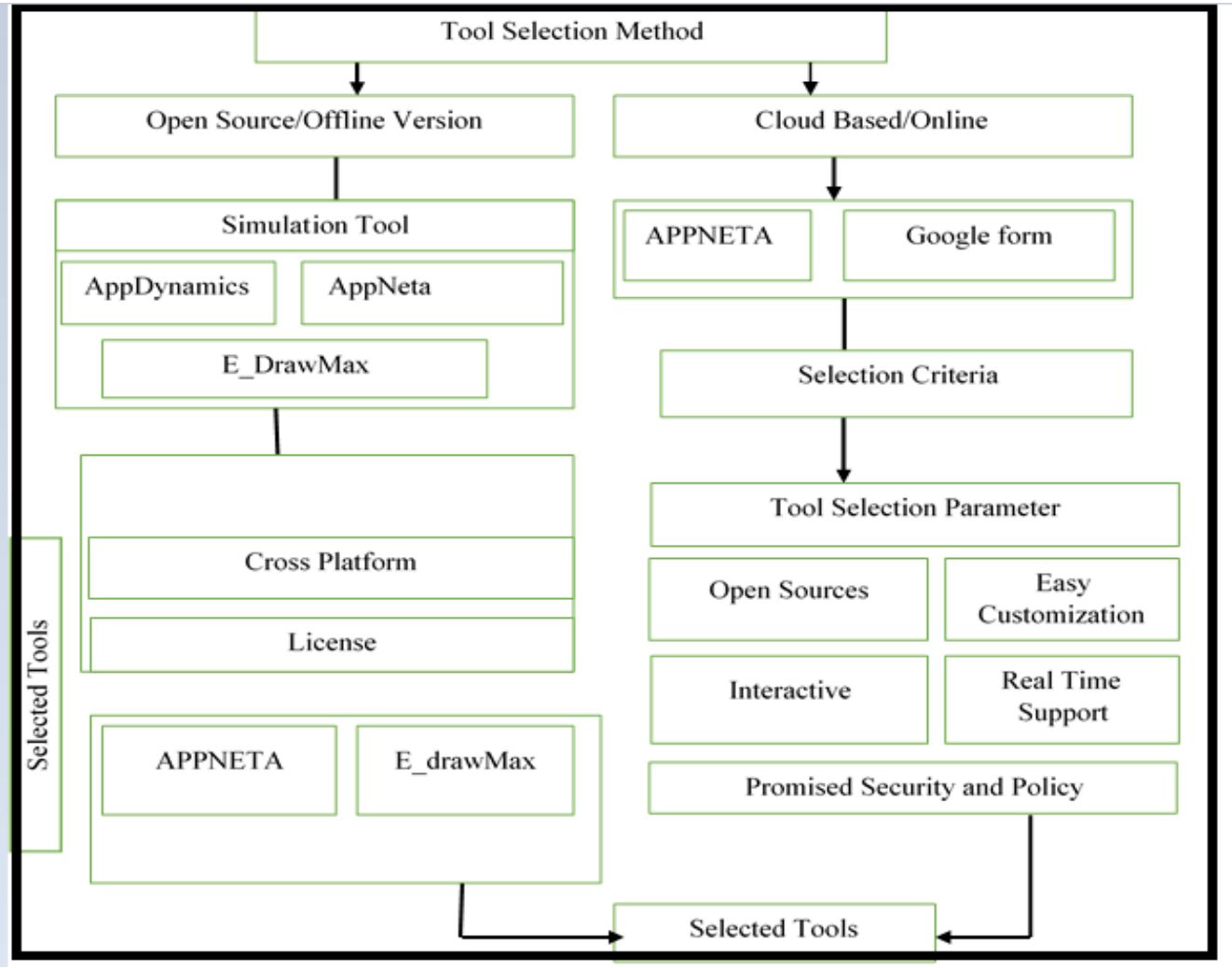


Fig 3.2: Selection Criteria and steps used for Software tools and Technologies

3.3 Description of Selected Tools

In this phase the Simulation tools was done using feature based most/best fit strategic analysis under specified scope and limitations for their representation of real-life system of Cloud Service usage in organizations or individuals with special reference to SLAs. To conduct the proposed research, different software and design tools were selected using best fit strategy. The study tried to focus on the following Open Source tools:

AppNeta: It is the most popular simulator tool in cloud computing environment. It is end user performance monitoring solution for application over any network. This tool uses a base for other cloud simulators.

Google Form: The Google form software tool over cloud is used for collecting the end user's data using Questionnaire

E-Draw Max 7.9.4: The research study used this tool for modeling and designing of the proposed Model /framework. The selected tools can be used as offline or cloud-based environment. Each tool has its own contribution in the research. The following diagram shows the procedures of the selection of the tools in this research [64].

CHAPTER FOUR

DATA ANALYSIS AND RESULTS

4.1 Primary and Secondary Data Analysis

In this research, data gathering techniques like personal interviews of stakeholder and personalized technical observations of researcher were used for collecting existing facts about Client-side measuring and monitoring SLAs of cloud services. Whether the current SLA which are provided by the CSPs are reliable, transparent strategy is green, energy efficient or not? Given below are results of interview and observations. The responses and observations are summarized to present the existing state of problem.

4.1.1 Primary Data Collection and Analysis

Here responses obtained through the open-ended detailed interview used for different stakeholders who uses the cloud service either in freemium or premium mode were collected and summarized for getting existing status and practices of client-side measuring and monitoring of SLAs for the cloud services-based computing and communication with special reference to green services. Finally, the results in different formats (graphical and tabular) are compiled and presented to showcase the status insights and practices of Client-side metering and monitoring SLA for computing and communications. As an alternative the client-side measuring and monitoring of SLA for the cloud services-based computing and communication has been hypothetically proposed in order to analyze, design and simulate for enhanced greener performance and add-on features. Furthermore, selected features were considered for validation with functional implementation.

It has been observed that in most of the developing countries like Ethiopian organization didn't have any policy and legislation to enforce and implement cloud services and green ICTs. With the emerging ICT infrastructure in Ethiopia, based on direct observations and interview inputs of ICT professionals and cloud service users, it has been observed that awareness and strategy for cloud service measuring and monitoring SLA for green service-based computing and communication is not considered in usages and design decision processes. In the absence of

client-side measuring and monitoring of SLA for green strategy/framework base line, SLA for cloud service may result into negative effects on the involved parties i.e. between consumer and CSPs. After the interview and technical observation, some factors are identified which contribute for client-side measuring and monitoring SLA for green services.

Question 1: Do you use Cloud Services for computing, communication and collaboration?

Responses: When the cloud service user from different angles of the world were interviewed about their understanding of cloud service, they clearly mentioned about un-awareness of such cloud service efficient measurement considerations in ICT usages in general and cloud service-based computing and communication. From their responses, it has been observed that many respondents. That means 28.6% may not use the cloud service for different purposes and the rest one which is 71.4% of the respondents uses the cloud service for different purpose. According to the respondents they have interest to use the cloud service for different purposes.

Table 4.1: The cloud service user from different angles of the world

Cloud Services user	Response	Percentages
Cloud Services Users	Yes	71.4%
Not Cloud Users	No	28.6%

Question2: Do you use free or paid cloud services (Free-mium users or Premium users)?

Responses: According to response of cloud Service users, around 92.9% are free-mium users of cloud services without any Service level agreement between the customer and cloud service providers (CSPs). The remaining 7.1% are Premium users of cloud services. That means Service Level Agreement is available between parties. The cloud service provider provides the service according to the SLA which is provided by the CSPs.

Table 4.2: Cloud service users either Free-mium or Premium

Cloud Services users types	Response	Percentages
Free-mium	Yes	92.9%
Premium	Yes	7.1%

Question 3: Are you satisfied with the terms and conditions of CSP's SLA?

Response: The service providers provide service to their customers according to the SLA with different Quality of Service (QoS) which is specified in the service Level Agreement. But all the terms and conditions were measured and monitored by the service providers. So according to the response of different respondents around 64.3% are partially satisfied, 28.6% are satisfied by the terms and conditions of CSPs SLA which provide by the service providers. The remaining around 7.1% are partially unsatisfied by the terms and conditions of CSPs SLA.

Table 4.3: Satisfaction of terms and conditions of CSPs SLA

Services Satisfaction	Percentages
Partially Satisfied	64.3%
Satisfied	28.6%
Partially unsatisfied	7.1%

Question 4: What are the main issues in CSP's SLA (Tick the best fit issues)?

Responses: The Service Provider provides SLA to their customers and the customers also pay according to the SLA provided by the provider without any hesitation. According to the survey of the respondents around 42.9% are billing system of cloud services by the CSPs, 35.7% are performance delivery as per SLA by CSPs, 14.3% meting cloud service by the CSPs. This indicates that the monopolization in the hand of CSP.

Table 4.4: The Issue in CSP SLA from the user

SLA Types	Percentages
Billing system	42.9%
Performance delivery by SLA	35.7%
Metering cloud services by the CSPs	14.3%

Question 5: Do you believe that every service provided over the cloud are required to be covered and declared for performance and greenness by CSPs for better transparency, trust and energy efficiency?

Responses: The Service provider provides service to their customers according to the Service Level agreement between the involved parties. But all activities which are provided by the service provider are monopolized by them. This raises questions that Quality of Services (QoS) is covered by the service provider? So, according to the respondents around 41.9% don't believe on the service provided by the service providers, the remaining around 42.9% believe on the Service providers covered and declared for performance and greenness for better transparency, trust and energy efficiency. The remains around 7.1% don't have any idea about the QoS provided by the service provider.

Table 4.5: QoS provided by the service providers

Qos Performance	Percentages
Don't believe on the service provider	41.9%
Believe on the service provider	42.9%
Don't have any idea about Qos of CSP	7.1%

Question 6: Do you believe that CSPs can violate the promises covered under SLA?

Responses: The service provider provides services according to the SLA which made between the involved parties. But, according to respondents around 64.3% agree on the SLA violation, the remains 21.4 % never seen such kinds of events in their SLA. But the remaining respondents which are around 7.1% don't believe the SLA provided by the service provider and no idea about the SLA violation.

Table 4.6: Violation of promises covered under SLA

SLA Violation	Percentages
Agree SLA violation	64.3%
Never seen such kinds of events in their SLA	21.4 %
Don't believe the SLA provided	8.1%

Question 7: What if the CSP doesn't fulfill the promises covered under SLA?

Responses: The Service Level Agreement (SLA) creates the convenient atmosphere between the cloud service provider and customer, However, service level agreement cartel by service provider. That monopolization leads to SLA violation. In such cases, what customers do? Around 50% of the respondents complain to the service provider. The remaining 50% don't do anything.

Table 4.7: Shows CSP doesn't fulfill the promises covered under SLA

SLA Promises	Percentages
Complain the Service Provider	50%
Don't do any thing	50%

Question 8: Do you have any mechanism for measuring and monitoring of services and a level of greenness at client side?

Responses: Still the service level agreement monopolized by the cloud service providers. So, it needs a mechanism to measure and monitor services for greenness level at the client side. According to the respondents 92.9% needs client-side measuring and monitoring for the greenness level and the remains 7.1% said no need of measuring and monitoring SLA on the client side.

Table 4.8: Measuring and monitoring SLA on the client side and level of greenness

Level of Greenness	Percentages
Client-side measuring and monitoring	92.9%
No need of measuring and monitoring SLA on the client side	7.1%

Question 9: Do you want that a transparent meter for measuring and monitoring the cloud services is required at client level for better trust, transparency and empowerment of cloud clients?

Responses: The cloud service users' needs transparent meter for measuring and monitoring cloud services at the client level for better trust, transparency and empowerment of the cloud clients. Among the respondents 78.6% accepted the measuring and monitoring at the client side. The remaining 21.4% responded not needed.

Table 4.9: Measuring and monitoring the cloud services is required at client level

Transparency of CSP	Percentages
Accepted measuring and monitoring at client side	78.6%
No need of measuring and monitoring SLA on the client side	21.4%

Question 10: Will you accept if a client-side monitoring, measuring, verification and auditing system is developed for the client side?

Responses: The user accepts the client-side monitoring, measuring, verification and auditing system according to the service level agreement. According to the user's information around 92.9% needed the client-side measuring and monitoring and the remains 6.1% have no idea about the client-side measuring and monitoring mechanism at all.

Table 4.10: Client-side measuring and monitoring SLA

SLA Promises at client side	Percentages
Need measuring and monitoring at client side	93.9%
No need of measuring and monitoring SLA on the client side	6.1%

Question 11: Do you need a trust, transparency and green level of services monitoring and measuring tool by either third party or competent agency to hear the grievances of clients?

Responses: The level of greenness as well as the measuring and monitoring mechanism on the client side is important to increase trust and transparency between the involved parties. According to the respondents around 57.1% strongly needed the monitoring mechanism, the remaining 35.7% need the monitoring mechanism and the remaining 7.2% said no need of control mechanism. They believe on the providers measuring and monitoring mechanism.

Table 4.11: Show the Level of greenness for service trust and transparent

Measuring SLA by third party	Percentages
Strongly needed the monitoring mechanism	57.1%
Need the monitoring mechanism	35.7%
No need of control mechanism	7.2%

4.2 Secondary Sources Analysis

4.2.1 Overview of Cloud Service Provider and Their Service Level Agreements

4.2.1.1 Cloud Service Providers

According to [45], Cloud service providers (CSP) are companies that offer network services or infrastructures or business applications in the cloud. The cloud services are hosted in a data center than can be accessed by companies or individuals using network connectivity. The large benefit of using a cloud service provider comes in efficiency and economies of scale. Rather individuals and companies building their own infrastructure to support internal services and applications, the services can be purchased from the CSP, which provide the services to many customers from a shared infrastructure. There are several different forms of services that can be used “in the cloud” by CSPs, including software, often referred to as Software as a Service (SaaS), a computing platform for developing or hosting applications, known as Platform as a Service (PaaS) or an entire networking or computing infrastructure, known as Infrastructure as a Service (IaaS).

Table 4.12 List of CSPs and their Service Products [45]

No	Cloud Service Providers	Service Models (IaaS)	Service Models (PaaS)	Service Models (SaaS)
1	Amazon Webservice	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
2	Century Link	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
3	Google Cloud Platform	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
4	IBM	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
5	Microsoft Azure	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM, Email, Virtual Desktop, Communication and Games
6	Rackspace	Virtual Machines, Servers, Storage, Load balancers	Execution run time, Database, Webservers	CRM,Email, Virtual Desktop,

		and Network	and Development tools	Communication and Games
7	Salesforce.com	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
8	SAP	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
9	Verzon Terremark	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
10	Kamatera	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
11	VMware	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games
12	Adobe	Virtual Machines, Servers, Storage, Load balancers and Network	Execution run time, Database, Webservers and Development tools	CRM,Email, Virtual Desktop, Communication and Games

4.2.2 Cloud Service Level Agreements

According to [46], Cloud service agreements are important to clearly set expectations of services between cloud consumers and providers. Providing guidance to decision makers on what to expect and what to be aware of as they evaluate and compare SLAs from cloud computing providers is critical since standard terminology and values for cloud SLAs are emerging but currently do not exist.

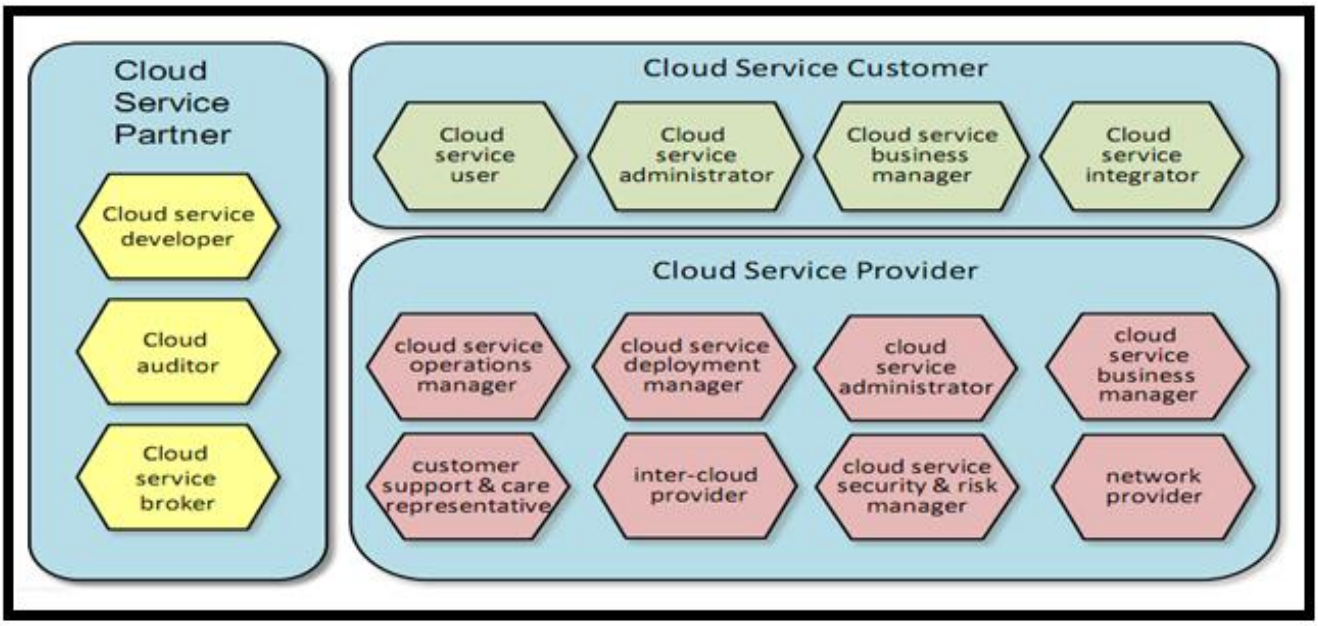


Fig 4.14: The responsibility of CSPs and Customers [46]

Full understanding of cloud service provider and customer are critical. Ensuring Cloud Service Agreement (CSA) makes clear statements about activities and responsibilities of the various customer and provider sub roles. Responsibility for detecting and reporting incidents should be clearly stated in the Cloud Service Provider (CSP).

4.2.3 Summary of Cloud Service Provider and Their SLA Monitor

Cloud computing provide us a means by which application as a service, network as a service are provide as a utility over the internet as well as it pays as you use model while the cloud computing environments, the CSP provides the services to the user (customer) according to their Service Level Agreement between the parties. The service level agreement may differ from service provider to service provider. We may have different kinds of service providers, Such as, Amazon EC2, Amazon S3, Microsoft Azure Compute and Microsoft Azure storage. Each Cloud Service provider may have different kind of Service Level Agreement. However, different cloud providers have different service level agreements and monitoring service level agreement mechanisms are different too. Most of the providers monitor service level agreements by third parties and service consumers have no chance to participate in monitoring service level agreement. They signed an agreement to obtain services, however the service may or may be not delivered according to the service level agreement they signed. For example, Amazon web service monitors service level agreement using cloud watch application. This application is functional only for the provider. If violation occurred, they give credit to the consumers as a penalty. But service level agreements do not guarantee on quality of services. After rigorous analysis of different Cloud Service Provider compare the following Cloud Service Providers and their Service Level Agreement.

Table 4.13: Cloud Service Provider and how they monitor their SLA

Cloud Service Provider	Service Type	Step-1 Discoveri ng Service Provider	Step-2 Define SLA	Step-3 Establish Agreement	Step-4 Monitor SLA Violation	Step-5 Terminate SLA	Step-6 Enforce Penalty for SLA violation
Amazon Ec2	IaaS Comput ing	Discover Manually (via Website)	Predefined SLA terms and Qos Parameters	Predefined SLA document by the service provider	Can use third party monitor system (eg cloud watch)	By user, or programmatic ally or Manually	Service Credit given by Provider
Amazon S3	IaaS (Storag e)	Discover Manually	Predefined SLA terms and QoS parameters	Predefined SLA document by the provider	Can use third party monitor system (eg cloud Status)	By user, or programmatic ally or Manually	Service Credit given by the Service Provider.
Micro Soft Azure Compute	PaaS	Discover Manually (Eg.Websit e)	Predefined SLA terms and Qos parameters	Predefined SLA documents by providers	Can use third party monitor system (eg Moni-tis)	By user, or programmatic ally or Manually	Service Credit given by the Service Provider.
Micro Soft Azure Storage	PaaS	Discover Manually	Pre-defined SLA terms and QoS parameters	Predefined SLA documents by providers	Can use third party monitor system	By user, or programmatic ally or Manually	Service Credit given by the Service Provider

4.4 Green IT Service

According to [47], the Green IT service for SLA is based on the number of integrative activities. This includes 1) analyze and leverage from current efforts in green IT, 2) project and improve best practices including metrics, 3) Provide green monitoring and auditing service, 4) provide service supporting Green IT service level agreements and 5) Provide a green portal component and develop a coordinated infrastructure for green IT services.

To create integrated and well-formed service level agreements it needs the close integration with other service level agreements and the components or parameters. They will be formed, and integrate SLA provided contract establishment, contract fulfillment and contract evaluations on service providers and service consumer especially on the client side. The services can assess potential service level agreement candidates such as minimizing failure time during the service execution and service fulfillment.

4.5 Summary of Data Analysis

In this chapter, data from primary and secondary sources were critically analyzed and discussed. The study used data source for critical analysis and find out the research gaps and limitations with reference to different SLAs being used by CSPs and cloud customers.

CHAPTER FIVE

DESIGN, IMPLEMENTATION AND DISCUSSIONS

5.1 Introduction

This chapter describes the detailed description of the framework for Client-side measuring and monitoring Service Level Agreements (SLAs). The framework in Fig 5.1 shows the proposed model to meter and monitor the SLA on the client side. This Framework has important role to increase the transparency between the involved parties.

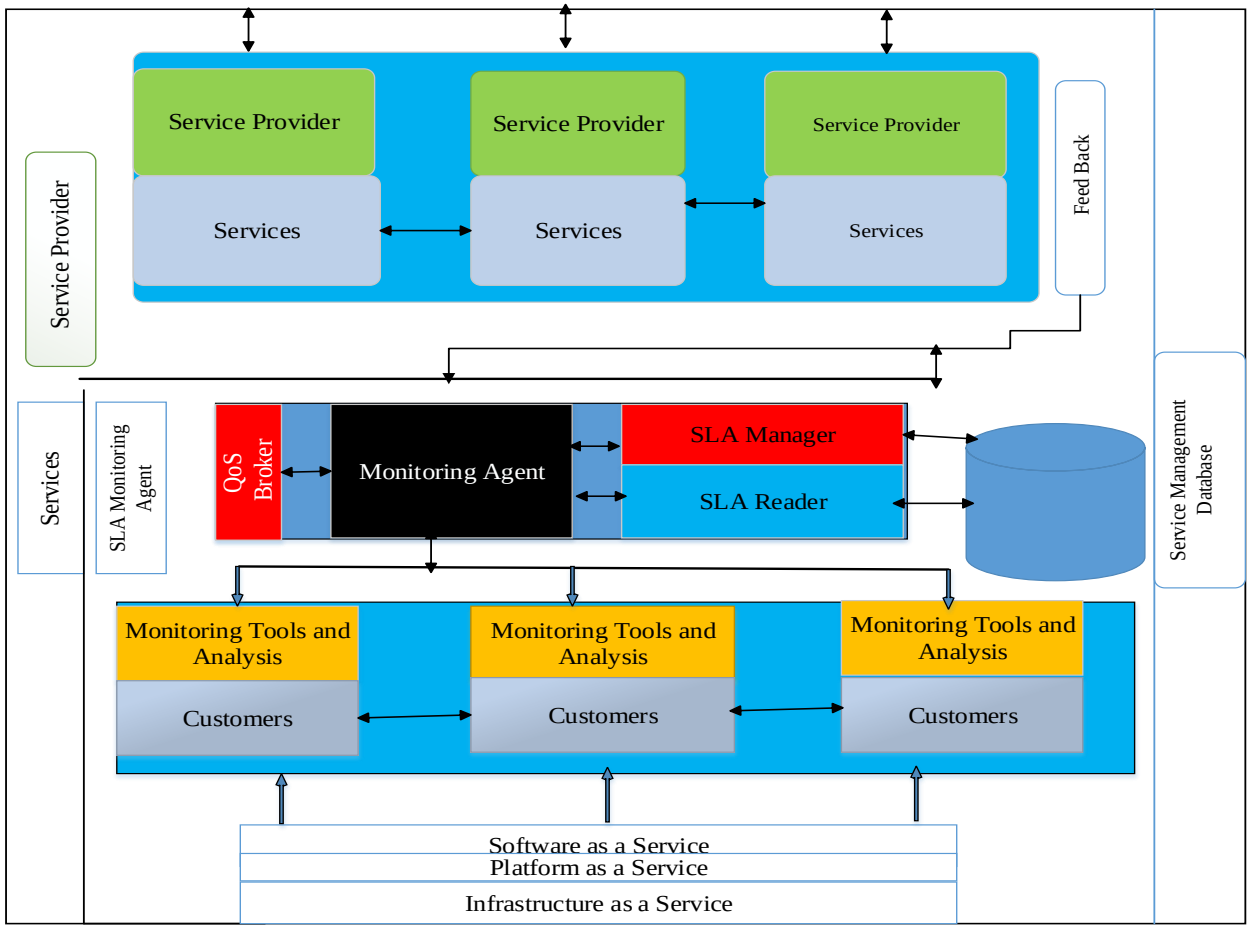


Fig 5.1: Proposed frameworks to measure and monitor SLA at the client side

5.2 Description About the Proposed Framework

To survive in today's world, one must be able to expect the unexpected as there are always new, unanticipated challenges. The only way to consistently overcome these challenges is to create a strong initial set of ground rules and plan for exceptions from the start. Challenges come from many fronts such as network, database, security and software availability or even legislation or regulatory changes. As cloud customers, operate in an environment that can spans geographies, networks, and systems. It only makes sense to agree on the desired service level for your customers and measure the real results. To reduce the challenges that come from service providers and service consumers need an agreement between them. Service Level Agreement (SLA) is a negotiation agreement between the Service Provider and customer to provide service according to their agreement. All the service such as Software as a service, Platform as a service and Infrastructure as a service are provide according to the Service Level Agreement (SLA) which provided by the service provider.

The proposed framework can be used to measure and monitor the service level agreement on the client side over cloud service. The service provider provides service to the customer according to their Service Level Agreement. The Service provider prepares the service Level agreement with the different parameters according to the consumer's preference. The consumers also agree if the preferences parameters are available. But there is lack of transparency between stakeholders. To minimize the conflict between the stakeholders the above proposed framework may be used as a solution. The above framework contains different agents Such as SLA readers, monitoring agent and Qos Broker. The functionality of the agents may be varying. SLA reader: it reads the signed SLA from service providers and customers which is stored in the database with the exact value of parameter with full transparency via Internet. It feeds the signed SLA to the monitor agent. The monitoring agent collects the information about the SLA from both sides from the SLA reader and running SLA reader. The monitoring agent compares the results of the SLA which are provide by the cloud service provider (CSP) and the result of the SLA which run on the client side. After comparing the results, the monitoring agent provides the feedback to the client via Internet. The SLA monitoring agent generally provides the result of SLA which is provided by the two agents. After that it gives notification whether the SLA rule is applicable as is or violates it. So, the application also increases the transparency between the parties without any interference. Besides, the application gives the notification of all the values of the SLA. All

SLAs which are signed by the parties are stored in the database. It can be able to identify whether the Service Level Agreement is violated or achieved. If the SLA is violated the consumer may ask to compensate or terminate the agreement according to the preference of the consumer. The Qos Broker collects data from customers and disseminates the information to the service provider.

5.3 Modeling SLA Monitoring Using Layers

To implement the proposed model, it may contain different layers. The functionality of the layer may differ according to the assigned value. The layers which are included in the framework are the following:

I) Presentation Layer: is responsible for delivering and formatting of information to the application layer for further processing. According to the proposed framework the presentation layer accepts the results of lower layers. Monitoring agent provides the notification whether the SLA is violated or achieved. So, the presentation layer displays the results of the monitoring agent to the user. This Layer provides all functions which are performed in the system. The relationship between customer and service provider is considered, targeting SLA auditing (usage) of a specific service.

II) Service Management Layer: The monitoring layer provides the results to layer above it which is presentation layer. The monitoring layer may include different components just like SLA reader, Qos Broker and monitoring (comparative) agent. The functionality of these components may vary. The function of SLA reader is to read the Signed SLA from the service provider with the exact parameter which is specified in the SLA to the user via Internet. The second component of the SLA Reader reads, transfer the signed SLA between the involved parties. After it reads the current running SLA it gives it to the comparative (monitoring agent) agents. After that, it displays the result of the SLA on the client machine displayed on the application layer. During that the SLA might be violated, service outage may be occurred or satisfied, and configuration update occurs giving notification to the presentation layer. The application agent gathers the data from the client and disseminates it to cloud service provider to compensate the violated services.

III) Database Layer: the third type of layer which is included in the framework is database layer. This layer stores the information of the SLA. It stores all the information about the SLA

with exact parameter as specified in the SLA. The database contains different SLA which are specified by the Service provider and service consumer. Fig 5.2: shows the layer of the proposed framework.

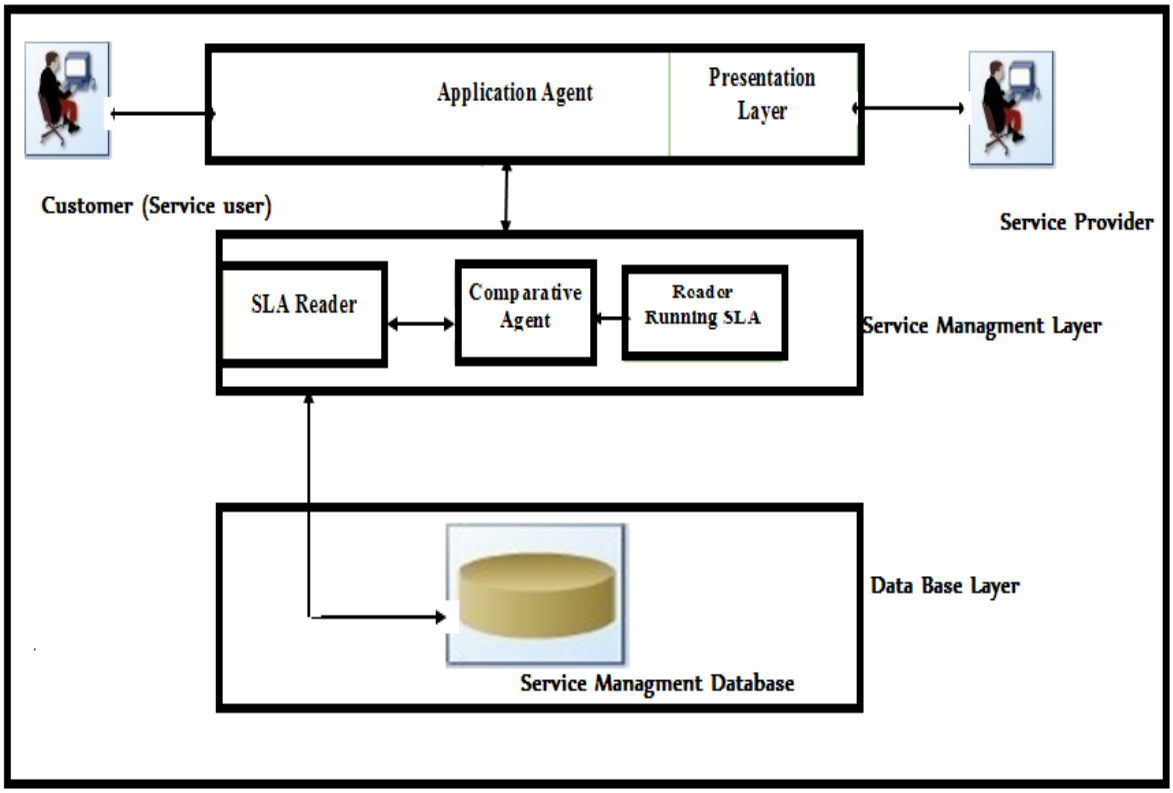


Fig 5.2: Designs SLA with Layers and Monitoring Application

5.4 Implementation and Discussion

The proposed framework contains different components. Each layer has its own functionality. The application layer displays the results of the lower layer. The result of the monitoring layer is displayed on the application layer of the designed framework. The monitoring application layer contains different components as defined in the specified framework. The SLA reader which reads the signed Service Level Agreement (SLA) between the parties. The parties are agreed based on the SLA parameters specified during the agreement. The SLA reader fetches SLA from the database. The second component the monitoring layer is reader running SLA. This component reads the currently running SLA on the system and feeds it to the comparative agent

to compare the SLA which is running in the system and the SLA which is provided by the service provider. The comparative agent displays the result of the SLA which are provided by the Service provider and the currently running SLA on the system according to their agreement. During that the comparative agent displays the result after it compares the results of the SLAs. After that it decides whether SLA is Violated, Service Outage occurred, update configuration or satisfactory or recompense. If the SLA is available with the specified parameters, the customer will be satisfied with enhanced transparency between the stakeholders.

Conversely, if the result of SLA which is running currently on the system and the SLA which is provided by the system is different the application gives the violation as well as other notifications to the user. During that the customer has the right to terminate the contract or claim services compensation from service providers according to the available results of the comparative agent. The third type of layer includes the database. This type of agent stores the results of the signed SLA between the service provider and customers for future use. The fourth type of component is service level manager. This component contains modifications or arrangements which are performed in the SLA. When the Service provider violate the rule and when the customers asks the compensation service the modification which are performed by the service provider are refreshed by the service level manager.

The other important components are the service provider and service consumer. The service providers are the providers which avail the service to the consumer. The consumers are the customer which uses the service provided by the service provider.

The service provider may provide different services to users or customers in the form of software as a service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). The application is used to control activities which are performed in the SLA activity. The customer can be served according to the service level agreement (SLA) which is agreed by both parties. But still the process is monopolized by the Service provider. To minimize the service provider's monopolization, the research paper has a great role. The client-side measuring and monitoring SLA has great role to improve the transparency between the parties. The Client-side metering and monitoring SLA may use different parameters.

5.5 Results and Discussions

Here the result shows the service which ordered from the cloud service provider via Service Level Agreements for the client. The result shows that the availability of datacenter on the client-side machine. It contains different information just like how much service outage, how much is violated, satisfactory and updates the service. The promised availability of the service value of 99.99% divided into the following results. According to the results, the client-side measuring, and monitoring can provide this report to the cloud service provider according to their agreement among them. The promised result 99.999% on the SLA the following results displays on the client-side machine of one week's measuring datacenter. The service outage 0.192%, violation 2.154%, satisfactory 93.531% and configuration update 4.122%. Using the result which runs on the client-side machine the customer has the right to terminate the service or to compensate the service form the provider again. Besides that, the consumer can pay as use.

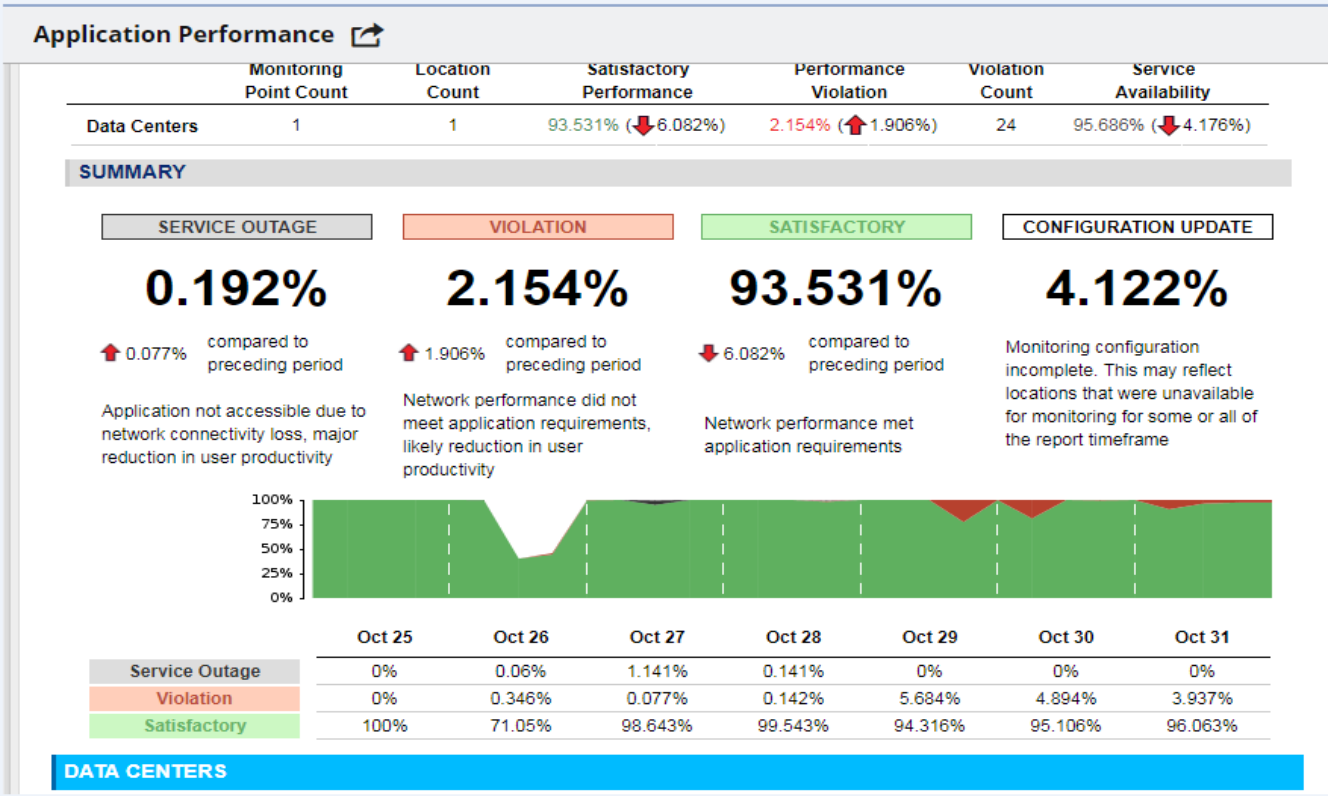


Fig 5.2: The value of Service Level Agreements of datacenter runs on client-side machine.

According to the results obtained on the client-side machine the user may ask or provide the above report to the service provider either compensate the service or to terminate the service. So, the above result gives control and negotiation power to the client. The Service Provider promised 99.99% of availability and the system reported around 93.531% satisfactory, violated result 2.154%, service outage 0.192% and configuration update 4.122%. According to the above report, the customer negotiates with the provider to compensate the service or to terminate the agreement between them.

After obtained result of the datacenter we can order other service from the Amazon web service providers. The following result shows the ordered application from the service providers.

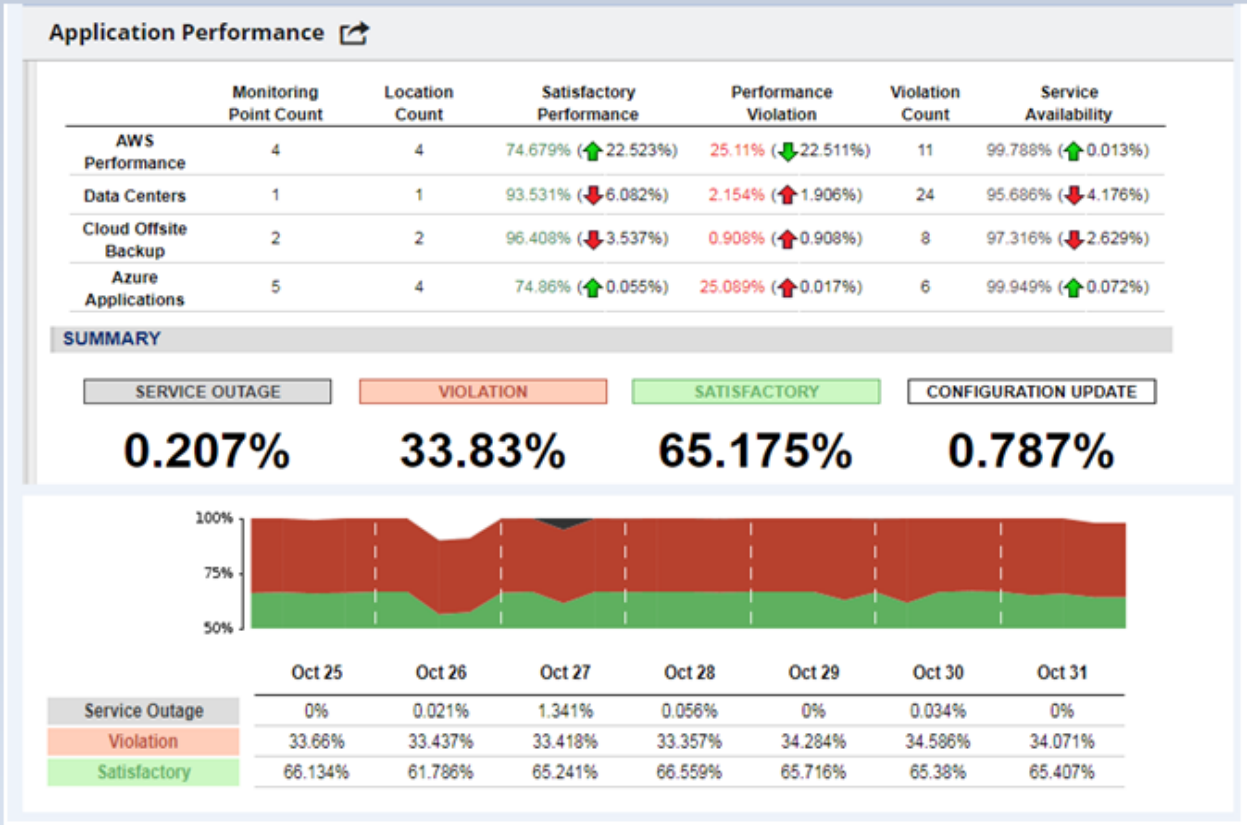


Fig 5.3: The Performance of Applications on AWS and Azure runs on the client-side machine

This shows the scanned result of the service provided by the provider on the client side. The above result shows violated, satisfied, service outage and update configuration within one-week report.

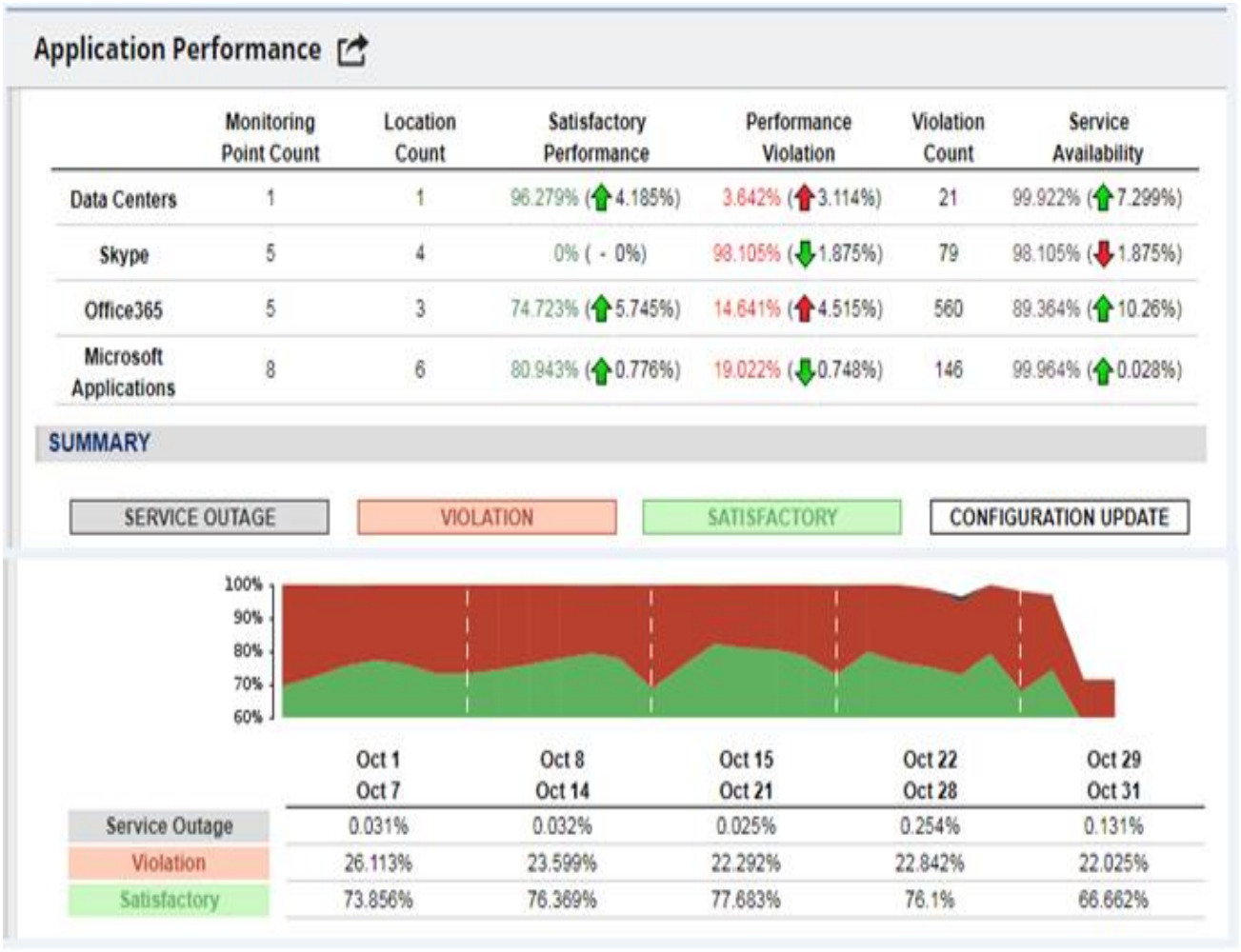


Fig 5.4: Application Performance of Amazon on the client-side machine within monthly report

Fig 5.4 shows the result based on the Service Level Agreement among the parties. Although customers can view performance of cloud service provider, after that the customer can decide which service provider provides better service. The service availability on the client-side machine the customer satisfactory 76.53%, violation 23.374% and service outage 0.096% within one moth report on the Amazon web service Applications out of 99.999% availability of the promised by the service provider.

Fig 5.6 Show the performance of the cloud service providers of Amazon Web service and Azure Performance.

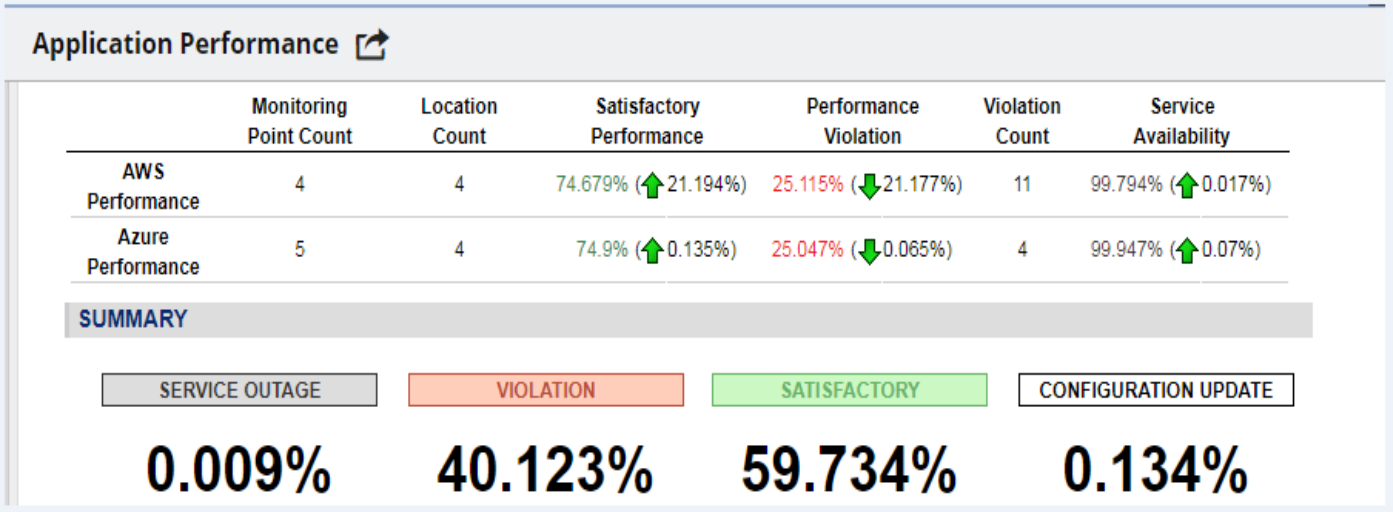
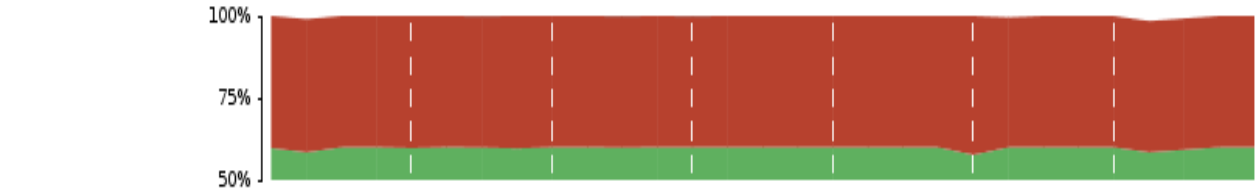


Fig 5.6: Performance of the Amazon and Azure Web service providers

In addition to the customer can measure and monitored the service which provider performance is better before they decide. Fig 5.7 shows the performance of the Amazon Web Service (AWS) within one-week period. It shows how much the service Outage, violation and Satisfaction of the customer.

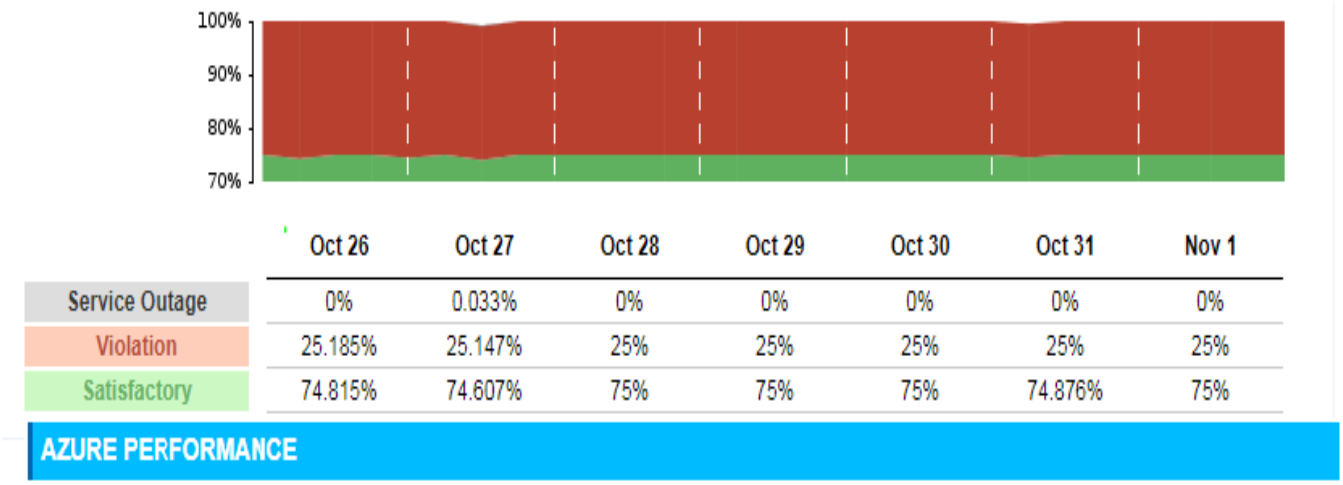


	Oct 26	Oct 27	Oct 28	Oct 29	Oct 30	Oct 31	Nov 1
Service Outage	0%	0.027%	0.026%	0.012%	0%	0%	0%
Violation	40.22%	40.151%	40%	40%	40%	40.488%	40%
Satisfactory	59.533%	59.822%	59.974%	59.988%	60%	59.413%	59.409%

AWS PERFORMANCE

Fig 5.7 The Performance of the Amazon Web service within one-week period

Besides, customers can also measure the performance of different service providers. Fig 5.8 shows the performance of the Azure web service provider. Based on the result, the customer can decide which service provider is the best.



	Oct 26	Oct 27	Oct 28	Oct 29	Oct 30	Oct 31	Nov 1
Service Outage	0%	0.033%	0%	0%	0%	0%	0%
Violation	25.185%	25.147%	25%	25%	25%	25%	25%
Satisfactory	74.815%	74.607%	75%	75%	75%	74.876%	75%

Fig 5.8: The Performance of the Azure service provider with in one-week report on the client-side machine

Using the above one week result the customer can view and decide which cloud service provider best. They can also view how much is the service outage, violated and Satisfactory within one-week period. According to the above reports from 99.99% promised SLA around 25.1% of the result is violated. The satisfactory result of the client side is around 74.899 % from the promised result of 99.999% which is written in the Service Level Agreement.

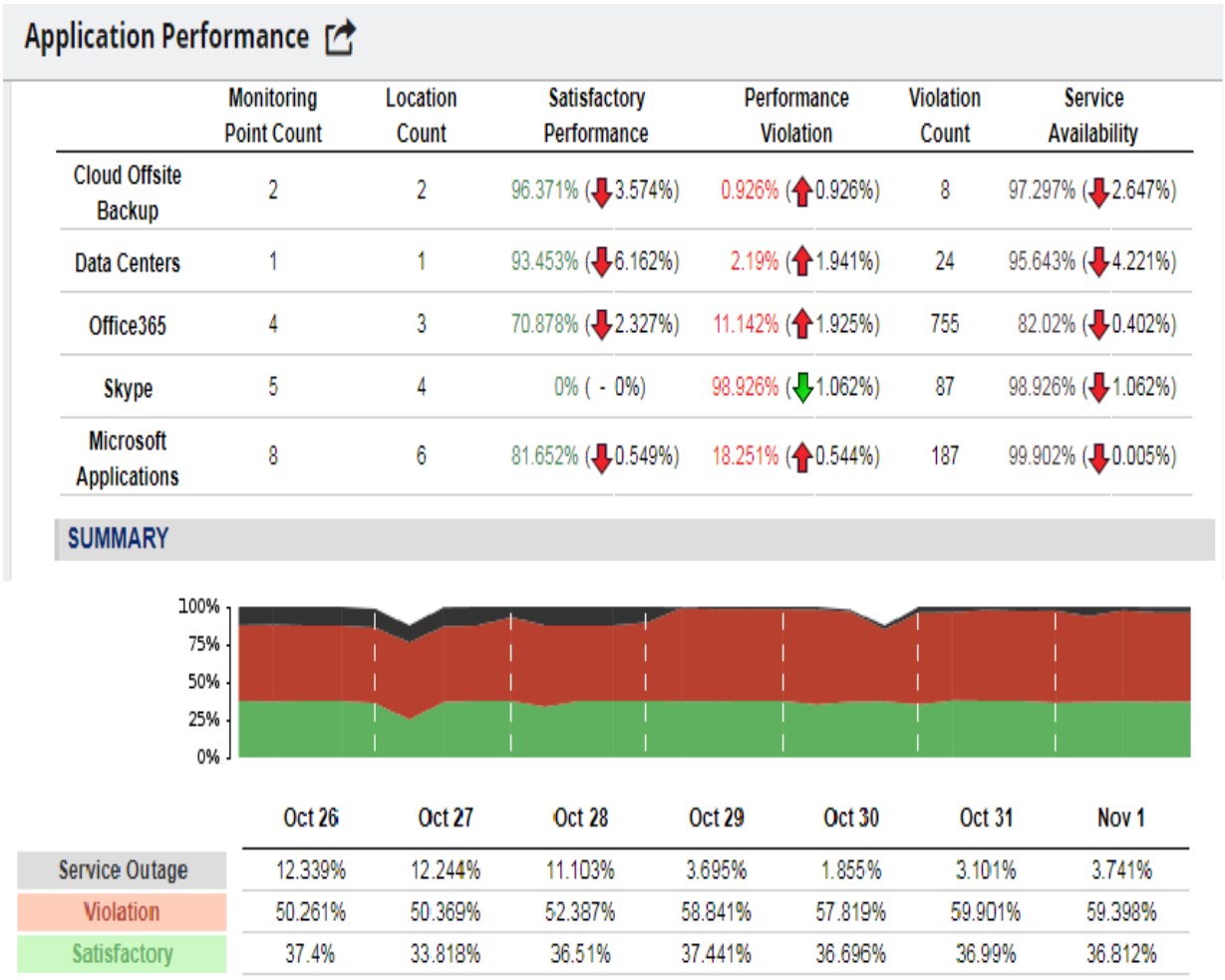


Fig 5.9: The Application Performance on the Azure Platform with one-week report

Using the results shown in Fig 5.9 the cloud consumer can also decide which cloud provider it can use. According the above report the Azure cloud service provider almost failed the promised result on the SLA. According to the report the service Outage is 6.868%, violated result is 55.568% and the satisfaction result is 36.524%. Besides that, the customer has the right to terminate the service or to compensate the violated and service outage.

The following summary of the service Level Agreement are displayed on the user or customer side. According to the Service level Agreement between the customer and Service Provider the following reports run on the client-side machine.

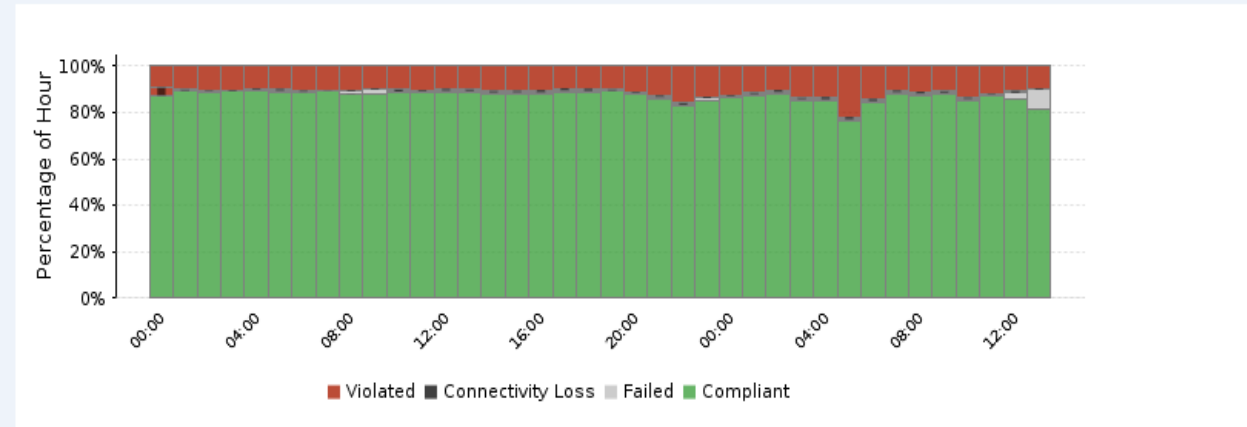


Fig 5.10: Service Level Compliance for 24 hours

According to Fig 5.10 the Service Level Agreement (SLA) on client-side results are obtained. The Violated result is around 9.1%, connectivity loss 0.91%, failed 5.1% and Compliance 84.4% on the client-side machine.

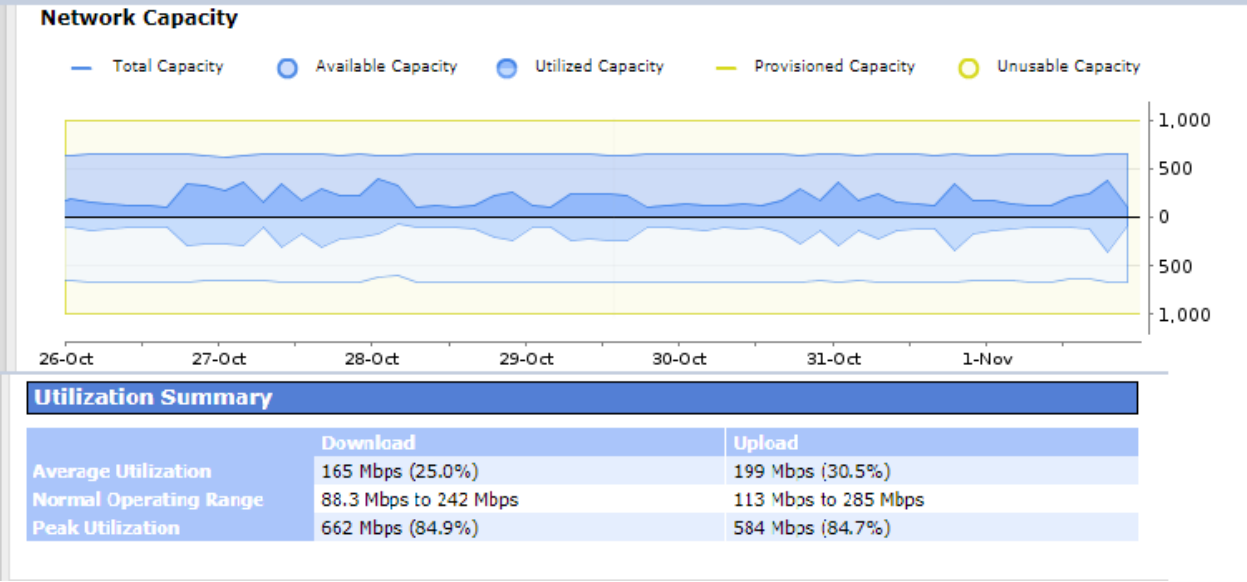
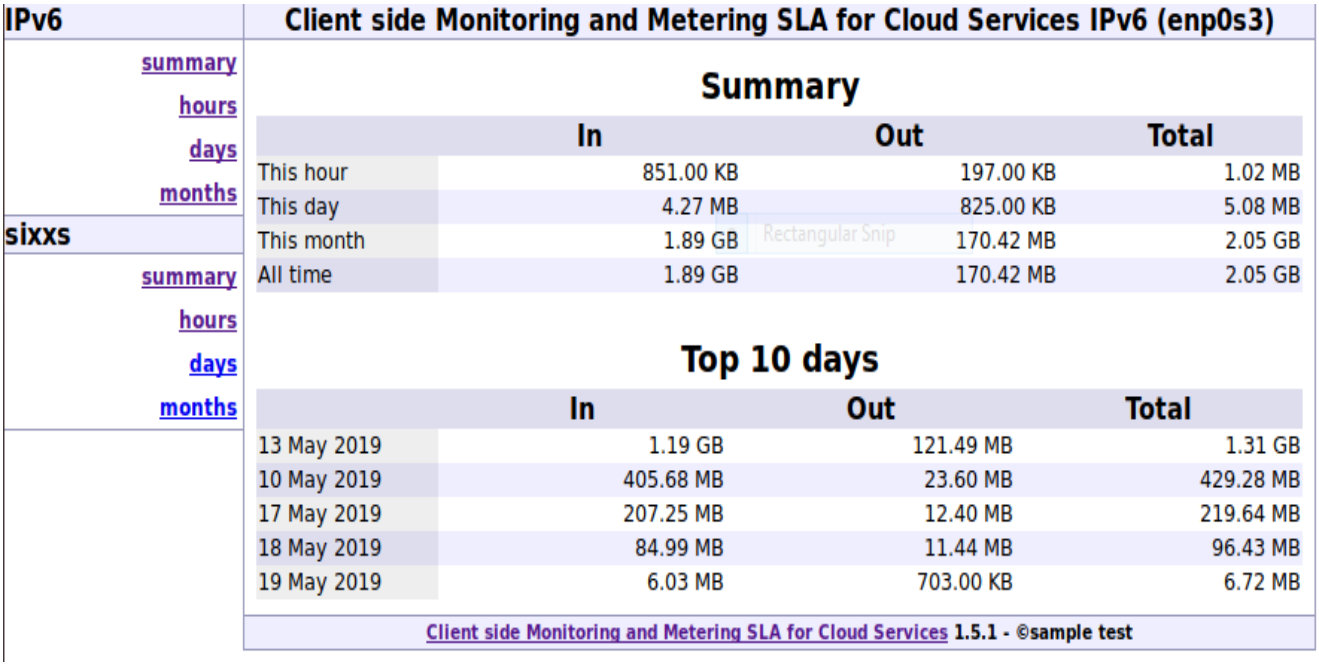


Fig 5.11: Shows the Service which is available on the Client-side on daily basis

Ubuntu operating system is popular to simulate SLA agreement threshold and instant throughput, Up/downtime, Latency/delay and Response time.



IPv6

summary
hours
days
months

sixxs

summary
hours
days
months

Client side Monitoring and Metering SLA for Cloud Services IPv6 (enp0s3)

Summary

	In	Out	Total
This hour	851.00 KB	197.00 KB	1.02 MB
This day	4.27 MB	825.00 KB	5.08 MB
This month	1.89 GB	170.42 MB	2.05 GB
All time	1.89 GB	170.42 MB	2.05 GB

Top 10 days

	In	Out	Total
13 May 2019	1.19 GB	121.49 MB	1.31 GB
10 May 2019	405.68 MB	23.60 MB	429.28 MB
17 May 2019	207.25 MB	12.40 MB	219.64 MB
18 May 2019	84.99 MB	11.44 MB	96.43 MB
19 May 2019	6.03 MB	703.00 KB	6.72 MB

Client side Monitoring and Metering SLA for Cloud Services 1.5.1 - ©sample test

Fig 5.12: Shows simulated service level agreement and instant latency of users

CHAPTER SIX

CONCLUSIONS AND FUTURE WORKS

6.1 Conclusions

This research study is an effort to explore the new knowledge of client-side measuring and monitoring of Service Level Agreement (SLA) over cloud services. As described in literature review Service Level Agreements are monopolized by the Service Provider. That means there is no clear transparency between the two parties i.e. between the service provider and service consumer. Since the study focused on the Client-side measuring and monitoring on the Service Level Agreement over the cloud service, it has given special emphasis on the client-side measuring and monitoring of the services according to the Service Level Agreement. The client-side measuring and monitoring SLA provides a convenient condition between the service provider and the service consumer. Client-side measuring, and monitoring mechanism provides reports that run on the client machines according to the Service Level Agreement (SLA) between the parties. According to the reports generated by the client machine, the consumer may have no complain to pay the payment. Besides, it also has shown that the transparency between the provider and service consumer increases.

This thesis has shown a new way of monitoring cloud applications. With the result of one week of monitoring, the Amazon Web Service alone reached approximately 74.899% of uptime, but there is no sign of the Amazon Web Service reporting to the customer. So, the studies obtained are important for the decision making for the selection of best cloud providers. The actual monitoring tool can also be important for companies who either try to reach high availability or want to compare different cloud providers.

6.3 Future Works

It is believed that the outcome of this research will serve as inspirations for future works in the following areas:

- In this study, the Client-side metering and monitoring prototype, which is designed, developed and tested over cloud platform, used the free trial tool and technology. Therefore, it is recommended for the future research to do similar experiments on different cloud providers and in a much longer period. This tool can evaluate how much availability difference should cloud service provider's promise and can evaluate if they report the correct accessibility and availability of uptime.
- Furthermore, the researcher recommends redesigning and developing a full-future client-side metering and monitoring SLA for all the cloud service providers and more than one month.

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