An Effective Implementation of Load Balancing Investigation in Cloud Frameworks

[1]Sachin Gupta, [2]Dr. S.N. Panda, [3]Dr. Bharat Bhushan
[1]Ganpati Polytechnic For Engg., Ganpati's Bilaspur, Jagadhri (Ynr), Haryana, India
[2]Director Research, Centre of Excellence Chitkara University, Punjab Campus, Rajpura, Punjab, India
[3]Dept. of Computer Science & Applications, G.N. Khalsa College, Yamuna Nagar, Haryana, India

Abstract
Cloud Computing has become one of the most talked about technologies in recent times and has got lots of attention from media as well as analysts because of the opportunities it is offering. The market research and analysis firm IDC suggests that the market for Cloud Computing services was $16billion in 2008 and will rise to $42billion/year by 2012. It has been estimated that the cost advantages of Cloud Computing to be three to five times for business applications and more than five times for consumer applications. According to a Gartner press release from June 2008, Cloud Computing will be "no less influential than e-business". Cloud computing evokes different perceptions in different people. To some, it refers to accessing software and storing data in the "cloud" representation of the internet or a network and using associated services. To others, it is seen as nothing new, but just a modernization of time-sharing model that was widely employed in 1960s before the advent of relatively lower-cost computing platforms. This development eventually evolved to the client/server model and to the personal computer, which placed large accounts of computing power at people's desktops and spelled the demise of time-sharing systems. In this manuscript, we have simulated a cloud environment with different parameters including data centers, bandwidth, network speed, user bases and locations throughout the globe.

Keywords
Cloud Computing, Cloud Sim, Cloud Simulation

I. Introduction

There is a lot of discussion of what cloud computing exactly is. The U.S. National Institute of Standards and Technology (NIST) have put an effort in defining cloud computing, and as NIST"s publications are generally accepted, their definition of cloud computing will be used in this thesis. The NIST definition of cloud computing is: "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, services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."Cloud computing is the collective term for a group of IT technologies which in collaboration are changing the landscape of how IT services are provided, accessed and paid for. Some of the supporting technologies have already been available for quite some time, but it is the combination of several technologies which enables a whole new way of using IT.Cloud Computing is a term used to describe both a platform and type of application. As a platform it supplies, configures and reconfigures servers, while the servers can be physical machines or virtual machines. On the other hand, Cloud Computing describes applications that are extended to be accessible through the internet and for this purpose large data centers and powerful servers are used to host the web applications and web services.The cloud is a metaphor for the Internet and is an abstraction for the complex infrastructure it conceals. There are some important points in the definition to be discussed regarding Cloud Computing. Cloud Computing differs from traditional computing paradigms as it is scalable, can be encapsulated as an abstract entity which provides different level of services to the clients,driven by economies of scale and the services are dynamically configurable.To explain the definition in short, "convenient on-demand network access", together with "minimal management effort or service provider interaction," stands for easy and fast network access to resources that are ready to use. With a "shared pool of resources," the available computing resources of a cloud provider are combined as one big collection, to serve all users. The "rapid provisioning and releasing" of computing resources is used to quickly match available resources, with the need for those resources. This rapid provisioning prevents a lack of computing power when the need increases, while rapid release of assigned resources prevents that resources are idle while they may be required elsewhere. Defining the cloud computing with an overview of architecture, relevant technologies used and the reasons why an enterprise should adopt and avoid the cloud computing.There are many definitions of Cloud computing, a recent study noted more than 22 different definitions of cloud computing where variety of technologies in the Cloud makes the over-all picture confusing. In this section most of the available Cloud definitions (see Table 1) are gathered together to get an integrative definition as well as a minimum common denominator.

Table 1: Cloud Definitions

Author / Reference	Year	Definition/Excerpt
M. Klems	2008	You can scale your infrastructure on demand within minutes or even seconds, instead of days or weeks, thereby avoiding under-utilization (idle servers) and over-utilization (blue screen) of in-house resources...
P. Gaw	2008	Using the internet to allow people to access technology-enabled services. Those services must be 'massively scalable...
R. Buyya	2008	A Cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers

R. Cohen	2008	Cloud computing is one of those catch all buzz words that tries to encompass a variety of aspects ranging from deployment, load balancing, provisioning, business model and architecture (like Web2.0). It's the next logical step in software (software 10.0). For me the simplest explanation for Cloud Computing is describing it as,"internet centric software...
J. Kaplan	2008	a broad array of web-based services aimed at allowing users to obtain a wide range of functional capabilities on a 'pay-as-you-go' basis that previously required tremendous hard- ware/software investments and professional skills to acquire. Cloud computing is the realization of the earlier ideals of utility computing without the technical complexities or complicated deployment worries...
D. Gourlay	2008	...the next hype-term...building off of the software models that virtualization enabled
D. Edwards	2008	...what is possible when you leverage web-scale infrastructure (application and physical) in an on-demand way...
B. de Haff	2008	...There really are only three types of services that are Cloud based: SaaS, PaaS, and Cloud Computing Platforms.
B. Kepes	2008	...Put simply Cloud Computing is the infrastructural paradigm shift that enables the ascension of SaaS. ... It is a broad array of web-based services aimed at allowing users to obtain a wide range of functional capabilities on a pay-as-you-go basis that previously required tremendous hardware/software investments and professional skills to acquire
K. Sheynkman	2008	Clouds focused on making the hardware layer consumable as on-demand compute and storage capacity. This is an important first step, but for companies to harness the power of the Cloud, complete application infrastructure needs to be easily configured, deployed, dynamically-scaled and managed in these virtualized hardware environments
K. Hartig	2008	..Really is accessing resources and services needed to perform functions with dynamically changing needs...is a virtualization of resources that maintains and manages itself.
P. McFedries	2008	Cloud Computing, in which not just our data but even our software resides within the Cloud, and we access everything not only through our PCs but also Cloud-friendly devices, such as smart phones, PDAs... This is utility computing powered by massive utility data centers.
Luis M. Vaquero	2009	. . . a large pool of easily usable and accessible virtualized resources (such as hard- ware, development platforms and/or services).…This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized

These definitions are based on five attributes that can be used to describe a cloud-based system. They are: Multitenancy (shared resources): Unlike previous computing models, which assumed dedicated resources (i.e., computing facilities dedicated to a single user or owner), cloud computing is based on a business model in which resources are shared (i.e., multiple users use the same resource) at the network level, host level, and application level. Scalability: cloud computing have property to scale to tens of thousands of system with bandwidth and storage also.
Elasticity: It is the property of increasing and decreasing the resources according to the users' need, as well as release the resources when they are no longer needed.
Pay as you go: One of the advantage of cloud computing is to pay according to the need or consumption like for one hour, two hour or cost per gigabyte and so on which has large impact on cost or economics. So cloud computing model provides a cheaper way for business to acquire and use the IT – capabilities. Self-provisioning of resources: Users self- provision resources like additional system and network resources.
Taking these features into account this thesis provides an encompassing definition of the Cloud. Obviously, the Cloud concept is still changing and these definitions show how the [1]Cloud is conceived today: "Cloud computing is model that makes reference to the two essential concepts: 'abstraction' and 'virtualization' to increase the capacity and capability of IT by providing on demand network access to shared pool of computing resources without investing in new infrastructure".

II. Cloud Computing Architecture

NIST (National Institute of Standards and Technology) is a well-accepted institution all over the world for their work in the field of Information Technology. This thesis presents the working definition provided by NIST of Cloud Computing. NIST defines the Cloud Computing architecture by describing five essential characteristics, three cloud services models and four cloud deployment models. Computing Service: One of the main tenets of Cloud Computing is the `as-a-Service' paradigm in which

`some' service is offered by a Service Provider (also known as a Cloud Service Provider) to a User (consumer) for use. This service can also be categorised according to the application domain of its deployment. Examples of application domains that offer services are: Financial e.g. Mint.com, Managerial e.g. Ever Note and Analytical e.g. Google Analytics. The agreed terms of use, indicating the actions that must be taken by both the provider and consumer, are described in a contract that is agreed upon before service provision. Failure to honour this agreement can lead to denial of service for the consumer or legal liability for the service provider. This contract is often described as a Terms of Service or Service Level Agreement. Moreover, as part of this agreement the service provider will provide a Privacy Policy which outlines how the user's data will be stored, managed, used and protected.

A. Cloud Service Delivery Models

The services offered are often categorised using the SPI Service Model. This model represents the different layers/levels of service that can be offered to users by service providers over the different application domains and types of cloud available. Clouds can be used to provide as-a-Service: software to use, a platform to develop on, or an infrastructure to utilise.

B. The Software- As- a- Service Model

Conventional way of utilising software involved the customer loading the software onto his own hardware after paying license fee (a capital expense, known as CapEx). For other support services the customer could also purchase a maintenance agreement. The customer was afraid with the compatibility of operational systems, patch installations, and compliance with license agreements. In a SaaS model, there is no requirement for purchase software, but rather rents it for use on a pay as you grow model (an operational expense, known as OpEx). In some cases, the service is free for limited use. Typically, the purchased service is complete from a hardware, software, and support perspective. The user accesses the service through any authorized device [R2, H1, T1]

C. The Platform- As- a- Service Model

Pass is also a variation of saas model where the development environment is offered as a service. In paas solution the development tool is hosted in cloud which is accessed via browser and can built web applications without installing any tool on their own system and can then deploy those applications without any administrative skills.

D. The Infrastructure- As- a- Service Model

In the traditional hosted application model, the vendor provides the entire infrastructure for a customer to run his applications. Often, this entails housing dedicated hardware that is purchased or leased for that specific application whereas Iaas model offers the various computing services as provided in utility computing. In this model we pay for the processing power, disk space and so on which is actually consumed by us. Iaas is typical a service associated with cloud computing including physical computing resources, location, data partitioning, scaling, security, backup and so on. [2] Examples are Amazon EC2, S3, suns' cloud services etc. Various features that should be available for Iaas system includes:

E. Scalability

The ability to scale infrastructure requirement. Pay as you go: The ability to purchase the infrastructure required at any specific time. Best- of- breed technology: Ability to access the best suitable service and solutions for a fraction of cost . [3]Cloud Deployment Models: In cloud computing environment, the most fundamental aspect is how services are delivered? Which mainly dependent on cloud deployment models (provides hosting environment). There are three primary types of cloud computing which are available to service consumer: Public Clouds: A public cloud is hosted, operated, and managed by third party vendor from one or more data centres. The service is offered to multiple customers over common infrastructure. In a public cloud, security management and day- to- day operations are relegated to third party vendor, who is responsible for the public cloud service offering. Hence, the customer of the public cloud service offering has a low degree of control and oversight of the physical and logical security aspects of a private cloud. There are a few challenges listed below that are preventing wide scale adoption of public clouds.Security: The biggest roadblock is the potential security issues due to multitenant nature of public clouds. There is security and privacy concerns with sharing same physical hardware with unknown parties that need to addressed.

E. Reliability and Performance

Performance and availability of the applications are important criteria defining the success of an enterprise's business. However, the fact that organizations lose control over IT environment and important success metrics like performance and reliability, and are dependent on factors outside the control of the IT organizations makes it dangerous for some mission critical applications.

F. Vendor Lock-in

Cloud computing services offered by different vendors are not governed by any standards as of today. Depending on the vendor, the applications have to undergo changes to adapt to the service. Leveraging Existing Investment: Most large organizations that have already invested in their own data centers would see a need to leverage those investments as an important criterion in adopting cloud computing. Corporate Governance and Auditing: Performing governance and auditing activities with the corporate data abstracted in the public cloud poses challenges that are yet to be addressed.

G. Maturity of the Solutions

Some of the PaaS offering like AppEngine offer limited capabilities like only a subset of JDO API.

H. Private Clouds

To overcome all above challenges enterprises adopt the private clouds which is managed or owned by an organization to provide the high level control over cloud services and infrastructure. In other words private cloud is built specifically to provide the services within an organization for maintaining the security and privacy. As such, a variety of private cloud patterns have emerged: Dedicated: Private cloud hosted within a customer- owned data center or at a collection facility, and operated by internal IT departments. Community: Private clouds located at the premises of third party; owned, managed, and operated by a vendor who is bound by customer SLAs and contractual clauses with security and compliance requirements. Managed: Private cloud infrastructure owned by customer and managed by a vendor. Hybrid clouds: This model comprised both the private and public cloud models where organisation might run non- core application in a public cloud, while maintaining core applications and sensitive data in- house in a private cloud

III. Relevant Technologies in Cloud Computing

[4]Cloud computing isn't so much technology as it is the combination of many pre-existing technologies. These technologies have matured at different rates and in different contexts, and were not designed as a coherent whole; however, they have come together to create a technical ecosystem for cloud computing. Key technologies that enabled cloud computing are described as follow; they include virtualization, Web service and service-oriented architecture, service flows and workflows, and Web 2.0 and mashup. Cloud Access Devices: The range of access devices for the cloud has expanded in recent years. Home PCs, enterprise PCs, network computers, mobile phone devices, custom handheld devices, and custom static devices (including refrigerators) are all online. Interestingly, the growth of the iPhone and the Proliferation of applications available from its App Store illustrate an improvement in terms of access to the cloud. This greater access is resulting in greater use and growth of services within the cloud Web Service and Service Oriented Architecture: Web Services and Service Oriented Architecture (SOA) are not new concepts; however they represent the base technologies for cloud computing. [5]Cloud services are typically designed as Web services, which follow industry standards including WSDL, SOAP, and UDDI. A Service Oriented Architecture organizes and manages Web services inside clouds. A SOA also includes a set of cloud services, which are available on various distributed platforms. SOA and cloud computing are related, specifically, SOA is an architectural pattern that guides business solutions to create, organize and reuse its computing components, while cloud computing is a set of enabling technology that services a bigger, more flexible platform for enterprise to build their SOA solutions. In other words, SOA and cloud computing will coexist, complement, and support each other. There have been several initiatives at attempting bridging SOA and cloud computing but service oriented cloud computing architecture (SOCCA) is a 4-layer architecture that firstly supports both SOA and cloud computing and allow an application to run on different cloud and interoperate with each other. It supports easy application migration from one cloud to another and service redeployment to different clouds by separating the roles of service logic provider and service hosting/cloud provider. It promotes an open platform on which open standards, ontology are embraced. Browsers and Thin Clients: Users of multiple device types can now access applications and information from wherever they can load a browser. Indeed, browsers are becoming increasingly sophisticated. Enterprise applications, such as SAP and Oracle, can be accessed through a browser interface—a change from when a client (a so-called "fat") application needed to be loaded onto the desktop. The general population has become more familiar with the browser function and can use a discrete application, where the context is intuitive, without requiring training or user guides.

[6]Virtualization: The advantage of cloud computing is the ability to virtualises and share resources among different applications with the objective for better server utilization. In non-cloud computing three independent platforms exist for three different applications running on its own server. In the cloud, servers can be shared, or virtualized, for operating systems and applications resulting in fewer servers (in specific example two servers). Virtualization technologies include virtual machine techniques such as VMware and Xen, and virtual networks, such as VPN. Virtual machines provide virtualized IT-infrastructures on-demand, while virtual networks support users with a customized network environment to access cloud resources. Service Flow and Workflows: The concept of service flow and workflow refers to an integrated view of service-based activities provided in clouds. Workflows have become one of the important areas of research in the field of database and information systems. Data centers and server farms: Cloud-based services require large computing capacity and are hosted in data centers and server farms. These distributed data centers and server farms span multiple locations and can be linked via internetworks providing distributed computing and service delivery capabilities. [7]A number of examples today illustrate the flexibility and scalability of cloud computing power. For instance, Google has linked a very large number of inexpensive servers to provide tremendous flexibility and power. Amazon's Elastic Compute Cloud (EC2) provides virtualization in the data center to create huge numbers of virtual instances for services being requested. Salesforce.com provides SaaS to its large customer base by grouping its customers into clusters to enable scalability and flexibility. High-speed Broadband Access: A critical component of the cloud is the broadband network, which offers the means to connect components and provides one of the substantial differences from the utility computing concept of 30 years ago. Broadband access is now widely available, especially in global metropolitan areas. Nearly pervasive wireless access (e.g., Wi-Fi, cellular, emerging WiMAX) is available, which has established mobile devices as entry points to the IT resources of the enterprise and the cloud. Web 2.0 and Mashup: Web 2.0 is a new concept that refers to the use of Web technology and Web design to enhance creativity, information sharing, and collaboration among users. On the other hand, Mash up is a web application that combines data from more than one source into a single integrated storage tool. Both technologies are very beneficial for cloud computing. Storage Devices: Decreasing storage costs and the flexibility with which storage can be deployed have changed the storage landscape. The fixed direct access storage device (DASD) has been replaced with storage area networks (SANs), which have reduced costs and allowed more flexibility in enterprise storage. SAN software manages integration of storage devices and can independently allocate storage space on demand across a number of devices. Key [8]Drivers to Adopting the Cloud:This section further articulates the cloud's impact on IT users. To compare client/server computing and cloud computing, Table 2 illustrates some of benefits cloud computing offers: lower IT costs,faster time to go live and reduced complexity.

Table 2: Traditional IT v/s Cloud Computing: A customer's Perspective

Traditional IT	Cloud Computing
High upfront IT investments for new builds	low upfront IT investments: pay- as –you grow model
High cost of reliable infrastructure	Reliable built into the cloud architecture
High complexity of IT environment	Modular IT architecture environments
Complex infrastructure	No infrastructure

The following subsection describe a number of reasons to move operations towards cloud computing. Economy of Scalability and on-demand services: Most development projects have a sizing phase during which one attempts to calculate the storage, processing power and memory requirements during development, testing, and production. It is often difficult to make accurate estimates; under- or overestimating these calculations is typical. The lead time for acquiring the equipment to support these estimates can sometimes be lengthy, thus adding to the time necessary to complete the

project. With the flexibility that cloud computing solutions offer, companies can acquire computing and development services as needed and on demand, which means development projects are less at risk of missing deadlines and dealing with the unknown. Cloud computing provides resources and services for users on demand. Open standards: Some capabilities in cloud computing are based on open standards for building a modular architecture that can grow rapidly and can change when required. Open source software is defined as computer software that is governed by a software license in the public domain, or that meets the definition of open source, which allows users to use, change, and improve the software. Table 3 illustrates several of these open standards, which are currently used in cloud computing.

Table 3: Cloud Computing Standards

APPLICATIONS	Communications: HTTP, XMPP Security: OAuth, OpenID, SSL/ TLS Syndication: Atom
CLIENT	Browsers: AJAX Offline:' HTML5
IMPLEMENTATIONS	Virtualization: OVF
PLATFORM	Solution stacks: LAMP
SERVICE	Data: XML, JSON Web services: REST

User-centric interface: Cloud interfaces are location independent and can be accesses by well-established interfaces such as Web services and Internet browsers.

[9]Guaranteed Quality of Service (QoS): Cloud computed can guarantee QoS for users in terms of hardware/CPU performance, bandwidth, and memory capacity.

Autonomous system: The cloud computing systems are autonomous systems managed transparently to users. However, software and data inside clouds can be automatically reconfigured and consolidated to a simple platform depending on user's needs.

Pricing: Cloud computing does not require up-from investment. No capital expenditure is required. Users pay for services and capacity as they need them. Pricing for cloud platforms and services is based on three key dimensions: (i) storage, (ii) bandwidth, and (iii) compute.

Storage is typically measured as average daily amount of data stored in GB over a monthly period.

Bandwidth is measured by calculating the total amount of data transferred in and out of platform service through transaction and batch processing. Generally, data transfer between services within the same platform is free in many platforms. Compute is measured as the time units needed to run an instance, or application, or machine to servicing requests. Table 4 compares pricing for three major cloud computing platforms.

Table 4: Pricing Comparison for Major Cloud Computing Platforms

RESOURCE	UNIT	Amazon	Google	Microsoft
Stored Data	GB per month	$0.10	$0.15	$0.15
Storage Transaction	Per 10K requests	$0.10	$0.10	$0.10
Outgoing Bandwidth	GB	$0.10 - $0.17	$0.12	$0.15
Incoming Bandwidth	GB	$0.10	$0.10	$0.10
Compute Time	Instance Hours	$0.10 - $1.20	$0.10	$0.12

Barriers to Cloud Computing Adoption in Enterprise: Though each cloud computing platform has its own strength, one thing should be noticed is that no matter what kind of platform there is lots unsolved issues. For example, continuously high availability, dealt mechanisms of cluster failure in cloud environment, consistency guaranty, synchronization in different clusters in cloud platform, interoperation and standardization, the security of cloud platform and data in transmission and so on are all among the issue to be better solved .Control: Some IT departments are concerned because cloud computing providers have a full control of the platforms. Cloud computing providers typically do not design platforms for specific companies and their business practices.

[10]Performance: The major issue in performance can be for some intensive transaction-oriented and other data-intensive applications, in which cloud computing may lack adequate performance. Also, users who are at a long distance from cloud providers may experience high latency and delays.

Bandwidth Costs: With cloud computing, companies can save money on hardware and software; however they could incur higher network bandwidth charges. Bandwidth cost may be low for smaller Internet-based applications, which are not data intensive, but could significantly grow for data-intensive applications. Political Issues Due to Global Boundaries: In the cloud computing world, there is variability in terms of where the physical data resides, where processing takes place, and from where the data is accessed. Given this variability, different privacy rules and regulations may apply. Because of these varying rules and regulations, by definition politics becomes an element in the adoption of cloud computing, which is effectively multijurisdictional. Reliability: Cloud computing still does not always offer round-the-clock reliability. There were cases where cloud computing services suffered few-hours outages. In the future, we can expect more cloud computing providers, richer services, established standards, and best practices. Security: Because cloud computing represents a new computing model, there is a great deal of uncertainty about how security at all levels (e.g., network, host, application, and data levels) can be achieved. That uncertainty has consistently led information executives to state that security is their number one concern with cloud computing. The subsequent chapters present a detailed examination of those concerns to determine whether they are grounded. Privacy: The ability of cloud computing to adequately address privacy regulations has been called into question. Organizations today face numerous different requirements attempting to protect the privacy of individuals' information, and it is not clear (i.e., not yet established) whether the cloud computing model provides adequate protection of such information, or whether organizations will be found in violation of regulations because of this new model.Connectivity and Open Access: The full potential of cloud computing depends on the availability of high-speed access to all.Such connectivity, rather like electricity availability, globally opens the possibility for industry and a new range of consumer products. Connectivity and open access to computing power and information availability through the cloud promotes another era of industrialization and the need for more sophisticated consumer products. [11] Interoperability: The interoperability and portability of information between private

clouds and public clouds are critical enablers for broad adoption of cloud computing by the enterprise. Many companies have made considerable progress toward standardizing their processes, data, and systems through implementation of ERPs. This process has been enabled by scalable infrastructures to create single instances, or highly integrated connections between instances, to manage the consistency of master and transaction data and produce reliable consolidated information. Even with these improved platforms, the speed at which businesses change may still outpace the ability of IT organizations to respond to these changes. SaaS applications delivered through the cloud provide a low-capital, fast-deployment option. Depending on the application, it is critical to integrate with traditional applications that may be resident in a separate cloud or on traditional technology. The standard for interoperability is either an enabler or a barrier to interoperability, and permits maintenance of the integrity and consistency of a company's information and processes.

IV. Simulation and Results

In this simulation, we have used CloudSim for load balancing algorithm and scheduling. The simulations depicts different parameters including bandwidth, data centers, regions and their associated aspects.In the simulation, we have used 5 data centers in the different locations of the world. 6 different user bases are deployed for execution and results fetching.The service broken policy is used as Closes Data Center.

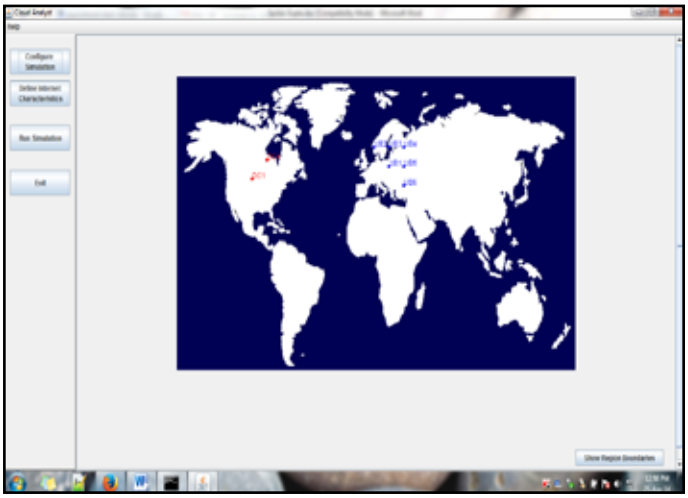


Fig. 1: Users Base in Different Regions of the Globe

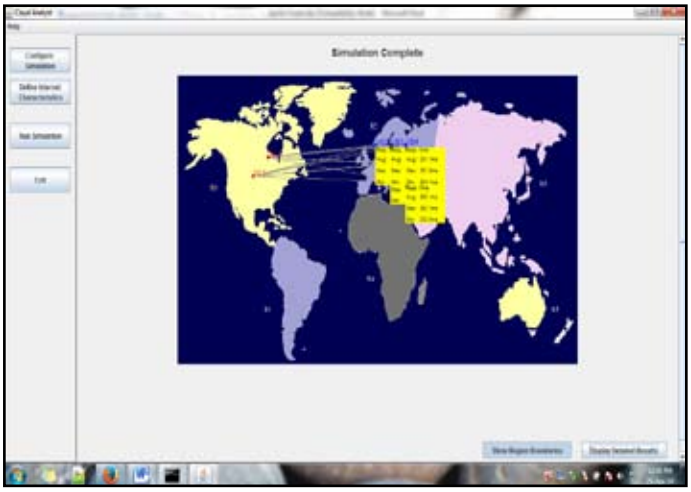
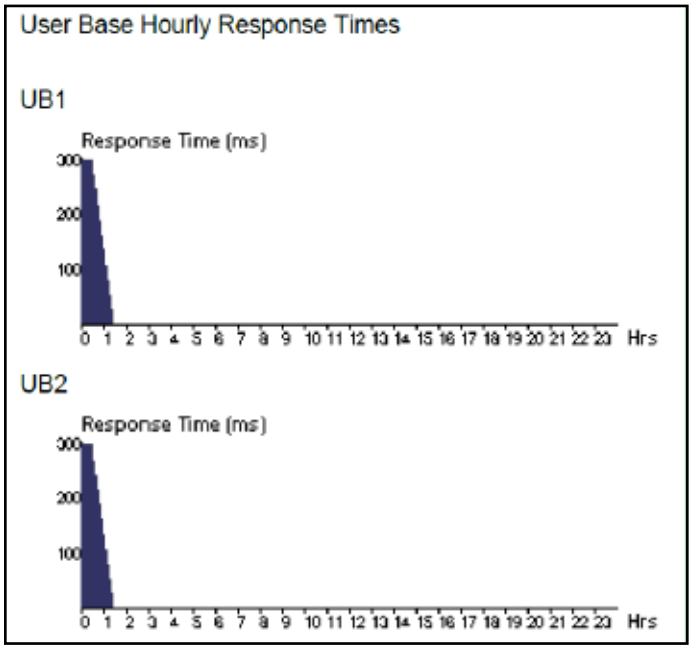


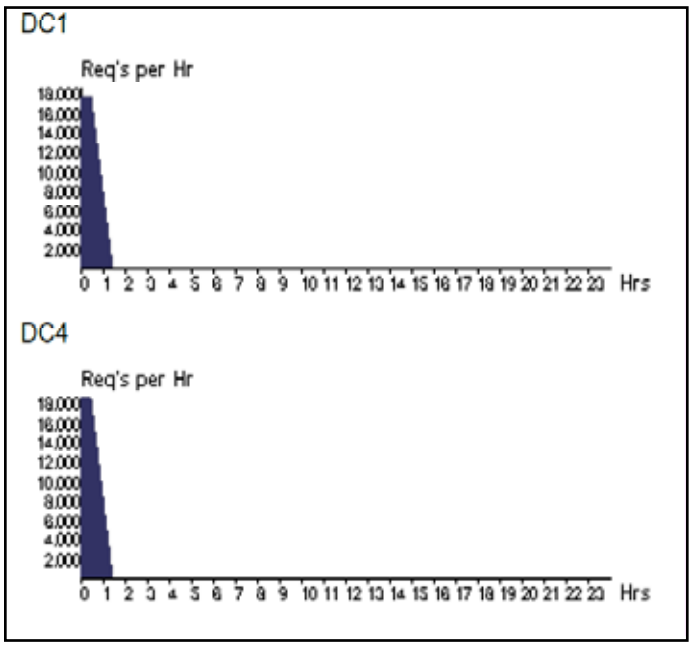
Fig. 2: Overall Response Time Summary

	Avg(ms)	Min(ms)	Max(ms)
Overall	300.01	225.14	366.07
response time			
Data center processing time	0.36	0.02	0.69

Response Time by Region

Userbase	Avg (ms)	Min(ms)	Max(ms)
UB1	300.85	225.14	364.63
UB2	298.95	231.14	361.63
UB3	299.00	232.64	366.07
UB4	301.09	234.12	361.63
UB5	300.04	225.14	363.15
UB6	300.14	232.64	363.11





Cost

Total Virtual Machine Cost($)	1.00
Total Data Transfer Cost($)	0.38
Grand Total	1.39

Data Center	VM Cost $	Data Transfer Cost $	Total $
DC4	0.50	0.20	0.70

V. Summary

Cloud computing is a novel, fast, growing and emerging technology that is becoming more popular with in last few years. But the lack of single or standard architecture of cloud computing, greater advancement and their open shared nature because of virtualization concept are responsible for the violation of security polices and laws as well as degrades their computing reputation and performance. We have simulated a cloud environment and different user bases are implemented. The simulation and deployment is done using Cloud Sim simulator. In simulation, different parameters are aspects are measured including cost and requests per hour.

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Sachin Gupta is working as a Principal in Ganpati Group of Institution, Bilaspur, Jagadhri, Yamuna Nagar, Haryana, India from 01-08-2007. He is pursuing Ph.D. in Computer Applications from Punjab Technical University, Jalandhar, Punjab, India. He has Published Two research papers in International Journal of Computing and Business Research & Two presented and published in UGC Sponsored One day National Seminar.

Dr. S.N.Panda, Ph.D. in Computer Science & Applications From Deptt. of Computer Science, Kurukshetra University Kurukshetra, Haryana (India). He is Currently working as Director Research, Centre of Excellence,Chitkara University, Punjab Campus, Rajpura, Punjab. He has published 52 national/international journals and has published 3 books. He has a Membership in 24 Academic bodies and 03 non-academic bodies. He has 21 years of teaching experience and 8 years of research experience and he is supervising 8 Ph.D. students, 01Ph.D. student has been awarded the degree and 2 Ph.D. students has submitted the thesis.

Dr. Bharat Bhushan received his Doctorate from Kurukshetra University, Kururkshetra. the M Sc (Physics), from Panjab Univ. Chandigarh and M.Sc. (Comp. Sc.), MCA degrees from Guru Jambeshwar University. Respectively. Presently working as Head, Department of Computer Science and Applications, Guru Nanak Khalsa College, Yamuna Nagar (affiliated to Kurukshetra University, Kurukshetra-Haryana, India) and senior most teacher of computer science in Haryana since 1984. He has very vast experience in the field of teaching and research. He is a member of Board of Studies of Computer Science, Kurukshetra University and member of Advisory Board of educational programme (EDUSAT) launched by Govt. of Haryana to impart online education. He has published more than 34 research papers in International and national journals of repute. His research interest includes Software engineering, web mining,, mobile ad hoc networks and Simulation Experiments.