A Revolution in Information Technology - Cloud Computing

Divya BHATT

University of Information Technology, Guru Gobind Singh Indraprastha University, Delhi 110075, India

(Corresponding author; e-mail: divyabhtt@gmail.com)

Abstract

What is the Internet? It is collection of "interconnected networks" represented as a Cloud in network diagrams and Cloud Computing is a metaphor for certain parts of the Internet. The IT enterprises and individuals are searching for a way to reduce the cost of computation, storage and communication. Cloud Computing is an Internet-based technology providing "On-Demand" solutions for addressing these scenarios that should be flexible enough for adaptation and responsive to requirements. The huge amount of information that resides in the Cloud for servicing various enterprises and for making enterprises secure sensitive data should reside in corporate data centers whereas the rest can reside in public data centers. The Cloud manages upgrades and provides information backup in the event of a disaster and/or a system crash. The capital and operational costs of running data centers are reduced by Cloud Computing making IT enterprises focus on strategic projects. In this paper, Cloud Computing is discussed and the various aspects of Cloud Computing outlined such as advantages, limitations, problems and solutions, applications with E-governance, emerging and future trends.

Keywords: Cloud Computing, E-governance, future trends, on-demand

Introduction

The next stage in the evolution of the Internet is Cloud Computing but definitely not synonyms with the Internet. A Cloud within Cloud Computing offers a way via which anything from computing taxes to computing infrastructure, business applications processes to personal joint working which is delivered wherever and whenever client needs [1]. Cloud Computing allows the client to access applications residing at location other than client's computer or other Internet connected devices.

The essence of Cloud Computing is that the service provider hosts the application that means they will manage software updates, handle costs of servers or development depending on how much the client pays.

Defining the Cloud

A set of hardware, networks, storage, services, and interfaces which enable the on time delivery of demanded services is a Cloud [1,2]. Over the Internet delivery of software, storage, security [3] is done by the Cloud services as per user demand.

The participants participating in the Cloud's world are:

- **End user** who doesn't have any or very little knowledge about the technology in use. The end user can be customer or client. For small businesses, the data center is the Cloud provider and for larger organizations the IT enterprises manage the inner procedure of the internal and external Cloud resources.

- **Business management** has a duty for data or services governance in the Cloud.

- **Cloud service provider** has a duty to maintain the IT assets.

Evolution of Cloud Computing is on the way and completely able to change the way IT enterprises use technology to provide service to customers, clients. IT enterprises feel that the Cloud model provides an efficient, cost effective IT service delivery.

Cloud Computing is broken down into 3 different categories:
1. Public Cloud
2. Private Cloud
3. Hybrid Cloud (combine both public and private Clouds).

The **Public Cloud** (external Cloud) computing resources are on-demand purveyed over the Internet via Web applications or Web browsers from an off-site third-party service provider.

The **Private Cloud** (internal Cloud) is Cloud Computing over private networks made exclusively for one client giving full control of data, security and service quality and they can be built and managed by a company's own organization or by a Cloud service provider.

The **Hybrid Cloud Computing** blends various public and private Clouds and introduces complexity of distribution of application across both a public and private Cloud.

Cloud's service model

The Cloud services are categorized into 3 models [4]. For example, the SaaS service provider might decide to offer separate platform services to clients. The purpose of grouping these services into 3 models is to aid in understanding the service beneath the Cloud. All these service delivery models require management and administration (including security) [5].

Realizing infrastructure as a service

Infrastructure as a Service (IaaS) is the hardware delivery (such as servers, networking technology, storage, and data center space) as a service by Cloud Computing e.g. operating systems and virtualization technology manages the resources and then installing of resources in their own data center which are paid services as per usage. For example, Amazon's Elastic Compute Cloud (Amazon EC2) provides a web interface which allows clients to access virtual devices, resources under paid user control. Amazon's EC2 is significant.

Searching platform as a service

In *Platform as a Service (PaaS),* the provider delivers more than infrastructure. It delivers an integrated set of software that delivers everything a developer might need to build an application and can be viewed as an evolution of Web hosting. The PaaS provides a standard platform for operating system based provisioning, database related services, query processing. In PaaS, backup services are kept on high node for disaster recovery management. That means to develop the software a client needs, developers must focus on designing the application instead of server's compatibility, storage, and networking. These entire infrastructures will be provided by PaaS.

Considering software as a service

The *Software as a Service (SaaS)* - provider hosts business applications and delivered them as a service. The cost of the software is as *per-user* basis. The business gets the immediate benefit of reducing capital expenditures. The business gains the flexibility to test new software on a rental basis and then can continue to use and adopt the software, if it proves suitable.

Cloud components [5]

Cloud Computing is derived from several elements for providing solutions. These are:

Clients
- These are computers, mobile phones, and laptops etc. that manage the information of end users on the Cloud. The client can be a thin or thick client. Thin clients are devices (computers) that do not have internal devices whereas thick clients are devices such as regular computers that use Web browsers for getting connected with the Cloud.

Data centers
- These are a collection of servers; it could be large room of your building full of servers on the other side of world that get accessed via Internet.

Distributed servers
- The servers providing services are geographically apart, but for the client devices servers would appear to be working from the same location.

Infrastructure
- The infrastructure relies on the application and how the service provider choses to build the solution over the Cloud.

Applications
- The components that the end user wants to run/deploy. The major benefit of Cloud Computing is that client need not install, maintain or support the application. The Cloud does it.

Platform

- The name is derived from PaaS (Platform as a service) where the Cloud platform allows users (business clients, developers, clients) to deploy their applications over the Cloud platform e.g.: Force.com, Salesforce.com's proprietary PaaS service, the Google App Engine which runs off Python and the Web hosting service Mosso.

Storage

- The physical storage is expensive and IT enterprises spend billions in storage. The Cloud services have given storage "wings". The Cloud is expanding, hence accumulating more information in it and companies can concentrate on business strategies.

Processing power

- The Cloud companies are ready to expand their infrastructure, so when the customer is in need of more processing power, that should be available. The companies need not to worry about infrastructure (purchasing/costs) and also need not be concerned about power; if it is being used or if the server has gone down.

Cloud characteristics

The Cloud embodies the following basic characteristics [1,4,6]:

Elasticity and scalability

It is hard to anticipate how a customer will use a service. It depends on whether the customer will use it 3 times a year or use the application all the time. However, services should be available all the time 24*7, and be designed to provide high scale service during peak times and also during lighter zones. It should be scalable when additional users are added or when requirements change and ability to scale is achieved by providing elasticity.

Self-service provisioning

It is easy for customers to avail themselves of Cloud services; the customer simply has to request the type of service he requires. The request can be computing, storage, software process or some other resources from the service provider.

Application Programming Interfaces (APIs)

Standardized APIs are needed for Cloud services. The instruction regarding communication between 2 applications or data sources is provided by these interfaces. An easily link for the customer with a Cloud service is done by a standardized interface such that customized programming is not needed, for example a customer relationship management system with a financial management system.

Billing and metering of services

A built-in service is needed to bill customers in the Cloud environment and usage has to be metered (tracked), to calculate that bill. The free Cloud services Google's Gmail or Zoho's Internet-based office applications are tracked.

Performance monitoring and measuring

A service management environment must be included by the Cloud service provider which is an integrated approach for managing physical environments and IT systems and must be able to maintain the needed service level for organization that is, service management has to be monitored to optimize the services. It has to focus on key issues that are the performance of the system, including security and performance.

Many customers use their own monitoring tools for determining whether the service level requirements are being met.

Security

Many customers need to trust that the Cloud services are safe. To give critical data or application infrastructure to a Cloud-based service provider requires an assurance that the information has not been accidentally retrieved by another company (or hacked). The security concept should be dealt with as a serious issue in Cloud Computing as critical data resides over Cloud. The user trust can be built up if strategies regarding network behavior, user behavior, processing behavior are made [7].

Advantages of Cloud Computing

Cloud Computing has a number of advantages from a user's point of view:

1. Lower cost: Being an online service, Cloud Computing provides access to applications using a browser while applications are stored on distributed servers. It is lower cost for the user and owners.

2. Free access: Access of applications from any location makes users independent.

3. More storage area: As Cloud Computing is distributed process, it maintains a storage den. It provides more storage than personal storage.

4. Flexibility: Cloud Computing provides a tension-free environment by upgrading, managing,

installing software on its own. It provides a download free zone.

5. Mobility: The user can connect to the Cloud from any location.

6. Ease of sharing: This is key component of Cloud Computing. The information, resources and hardware sharing for instant delivery.

7. Data safety: The files/data are safe unless the hard drive get stolen.

8. Availability: There are several copies which can be owned as per user demand.

9. Copyright convenience: Responsibility for all aspects of licensing, maintenance and authorization.

10. Synchronization: Different experts from different issues, projects and locations.

11. Rapid elasticity: migrating from one platform to another.

12. Location independent resources.

13. On-demand self-sufficient service and ubiquitous network access

Limitations with Clouds

It is not possible that Cloud Computing is error-free and it may not be the best solution ever needed in computing trends. The limitations of Cloud Computing should be known, so that, they can be removed [3].

1. Security: Major decisions in IT fields are taken on the basis of security risk. Hence, Cloud Computing should be dynamic in providing privacy, data integrity, management and other issues. The Intranet, Extranet, Internet and DMZ boundaries are getting blurred and need security challenges like authentication, Cloud vendor reliability etc.

2. Unstructured programming: In Cloud Computing, each Cloud has its own programming support, data storage interfaces and programming syntax. The standardization of methods and interfaces are needed.

3. Consistency insurance: The data and code, both are replicated over the Cloud and it is very crucial to maintain consistency in data. Most Cloud vendors provide data stores that do not support relational models. Hence, can lead to unneeded joins, bad code and other problems for developers.

Major problems with Cloud Computing

• There is risk of hacking in Cloud Computing. The risk is not only for stored data but also for mishandling of transmitting data over the Clouds.

• Sharing of documents Could be affected by masquerading i.e. your shared data can be accessed by anyone else.

• Cheap energy needed for data storage centers as each center requires a large amount of energy.

• The real benefit of Cloud dissipates into the ether if geographical and political borders fracture the Cloud into groupings.

Emerging trends in Cloud Computing [6,9]

• Enterprises are building their own Clouds e.g. IBM "Blue Cloud", Microsoft "Azure", Google "GooG", Salesforce "Successforce". The data centers in the private Clouds are managed by third parties (Amazon.com) and by IT staff. In a virtual environment these private Clouds are managed centrally.

• Cloud Computing diverts the important points of IT enterprises by taking the burden of technological implementation into its Cloud. This helps enterprises to concentrate on their business process, developing new technologies. This will improve the quality of projects and will save a lot of time.

• The security procedures that physically safeguard data are developing. The thinking of keeping data in one place is not favorable for growing enterprises.

• Cloud Computing is not limited to providing software and hardware help but also consultancy, on-demand services such as Salesforce's Successforce which helps clients to get Salesforce consultancy or connect them to their partners Accenture, Deloitte, the online tax preparation service which is provided by Tango of HandR Block, and NetSuite which provides on-demand service to clients by collaborating with NetSuite partners.

• The personal computer has become slimmer with fewer or no applications. The only thing needed will be a Web-browser in it for connecting to heavy-lifting Cloud services.

• With huge databases, the Cloud will become a knowledge pool.

• In future, human intelligence will be incorporated into the Cloud and new horizons will open for Artificial Intelligence making Cloud the "IT THING".

• Green Technology is emerging with the help of Cloud Computing as fewer natural resources will be utilized.

• Cloud economics involves paying only for what you use. Cloud economics 101: matches elastic applications to Cloud platforms and moving transient apps in and out so their costs are constantly returning to zero. Cloud economics 201: designs and optimizes applications to take advantage. Cloud economics 301: knows when and which Cloud to be used for optimum profitability. Earlier efforts of Amazon Web Service's Spot Instances and Enomaly's SpotCloud for showing the way and the Cloud Price Calculator for normalize costs.

• Autodesk's Project Cumulus and the ISVs queuing up behind GreenButton are showing the way as both these companies know how to put a Cloud behind applications and in so doing deliver game-changing productivity. Such moves leverage Cloud economics and may disrupt supercomputing.

• Cloud Computing not only will help enterprises gain insight from information. It will help to derive revenue from it too. Services like: Windows Azure DataMarket will help enterprises leverage data sources more easily and become one of those providers themselves. The Associated Press, Dun & Bradstreet and ESRI are appropriate models.

• Cloud security will be proven not only by the providers alone, as it is shared effort, hence, security will be addressed by both client and provider.

• The Berlin-based company Zimory's open-technology can get connected with large number of Clouds and thousands of machines can be scaled-up [9].

• In the field of Cloud Computing, Abiquo [9] with promising startup boasts including hyper-peak support portfolio with leading vendors such as Microsoft, Citrix, VMware and Zend, the firm bids a permission-based hierarchy that enables enterprises to forge public, private or hybrid Clouds sweeping data centers on- and off-premises. It provides a support system to remove the vendor lock-in problem.

• The recent entrant in the market of Cloud NephoScale [9] is a public Cloud infrastructure platform offering pay-by-the-hour servers, object-based storage, and dedicated on-demand servers.

E-governance and Cloud Computing [10,11]

The technology using the Internet, remote servers for maintaining applications and data is Cloud Computing. It allows the process of business applications from remote places. It helps in storing personal files, accessing them and managing them e.g. Yahoo mail, Gmail. Only an Internet connection is needed. Companies and the Indian Government are most affected by Cloud Computing. Hence, Cloud technology can be utilized for providing doorstep services for the common man with the help of E-governance. E-governance applications include Indian Railway, Indian Bank services and ATMs. The E-governance deals with citizens/public in two ways: Internet economy and Interaction. The Internet economy deals with taxes, addition of revenues, space utilization and interaction deals with G2G, G2B B2B etc.

• SaaS can be used for E-governance (G2B, G2G, G2E, G2C) and provide applications such as Job-Portal, Service-help desk, Municipal management systems, E-court, E-police, District management systems.

• PaaS database, backup services can be provided efficiently and provide dynamic OS, query service, workflow service for providing database services, backup services, and efficient management for disaster recovery.

• IaaS can allow various clients to utilize storage, hardware utility and the network. The application designers can focus on features and utility of application instead of worrying about scalability.

Cloud Computing dimensions for E-governance include:

1. Vertical Dimension: healthcare, land records, passport database and other services provided by the government to the citizen of the country.

2. Horizontal Dimension: public access and participation, policy publications, public grievance and procedures.

E-governance challenges can be overcome with Cloud Computing as it allows for sharing of large resources and making strategies. Cloud

Computing can help in monitoring or analyzing large amounts of data detection and fraud. By keeping services of the provider accountable we can control corruption. The processes of E-governance such as application migration of any citizen, recovering lost data, taking back ups, minimizing pollution etc. can be improved. Moreover, with the help of Cloud Computing lots of resources can be saved such as air-conditioners power, electricity, paper resources that make it Green Technology.

Some of the E-governance challenges and benefits of Cloud Computing [12]:

1. Scaling of data: to manage the large amount of data of E-governance, databases should be scalable. The Cloud databases should be considered as On-high demand, high-end scalability.

2. Audit and log: it deals with content traceability. With this service, corruption in government can be controlled, as a process audit and security audit can be done periodically. Clouds can help in analyzing huge amount of data and fraud detection.

3. New instances, duplication and migration: the architecture of Cloud Computing provides excellent features for creation of an instance of any application that reduces the deploy time of a new application.

4. Disaster recovery: avoid data loss and make services available "round the clock". Cloud virtualization technology provides backup and restoring facilities besides this it offers seamless migration from one platform to another as compared to other data centers.

5. Better governance: for better governance data center usage, peak loads, consumption levels, power usage along with time are major factors needed to be monitored for good resource utilization. Cloud offers Business Intelligence infrastructure that seamlessly integrates with different frameworks like MAPREDUCE (Apache Hadcoop).

6. Policy management: dealing with different citizens, understanding their needs along with infrastructure and data center, policies need to be imposed in day to day processes. Cloud Computing helps in policy implementation in data center with respect to security, application deployment etc.

7. New migration: co-existing with new versions or co-locating with them.

8. System integration: Cloud architecture is built on the SOA feature that provides an on-demand user service.

Conclusions and future scope

Cloud Computing provides attractive capabilities, environments, and operating systems solutions. This paper discusses the concept of Cloud Computing in detail and provides information of trends, areas to be answered, categories of Cloud, and models for Cloud Computing (IaaS, PaaS, SaaS). Cloud Computing needs to be applied fully for the benefit of every citizen in day to day life. Cloud Computing is becoming a synonym for Green computing as it reduces paper work and power consumption. Cloud Computing has become a non-restrictive platform for many applications. But there are many issues that need to be addressed but this is still set to revolutionize the way we use the Internet.

This paper tries to conclude Cloud Computing on the basis of its theory (broadly). In the future, the practical view of Cloud Computing will be studied and researched. The practical view will have case studies of some leading companies in this field such as Microsoft, Amazon to get insight into the Cloud Computing world.

References
[1] Cloud computing, Available at: http://en.wikipedia.org/wiki/Cloud_Computing.
[2] Cloud Computing Terminology, Thinking Out Cloud, Available at: http://gevaperry.typepad.com/main/2008/08/new-cloud-compu.html, accessed August 2008.
[3] Assessing the Security Risks of Cloud Computing, Gartner, Inc., Available at: http://cloud.ctrls.in/files/assessing-the-security-risks.pdf, accessed June 2008.
[4] A short introduction to cloud platform-An Enterprise-oriented View, Microsoft Corporation, CHAPPELL & ASSOCIATES, Available at: http://www.davidchappell.com/CloudPlatforms--Chappell.pdf, accessed August 2008.
[5] D Pant and MK Sharma. Cloud Computing. *CSI Communications* 2009; **32**, 10-3.
[6] How Cloud & Utility Computing Are Different, at Giga-Om, Available at:

http://gigaom.com/2008/02/28/how-cloud-utility-computing-are-different/, accessed February 2008.

[7] T Li-qin and L Chuang. Evaluation of User Behavior Trust in Cloud Computing, *In*: Proceedings of the 2010 International Conference on Computer Application and System Modeling, Taiyuan, China. 2010, p. 567-72.

[8] C Roman. 15 Cloud Computing Companies to Watch, Available at: http://cloudtimes.org/15-cloud-computing-companies-to-watch/, accessed May 2011.

[9] Security Guidance for Critical Areas of focus in Cloud Computing, Cloud Security Alliance, Available at:

http://www.cloudsecurityalliance.org/guidance/csaguide.pdf, accessed December 2009.

[10] J Marijn and A Cresswell. Enterprise architecture integration in E-government. *In*: Proceedings of the 38th Annual Hawaii International Conference on System Sciences, Hawaii. 2005, p. 3-6.

[11] R Heek. *Implementing Managing E-Government*. Vistaar Publications, 2006.

[12] M Pokhrael and J Sou Park. Cloud Computing: Future solutions for e-Governance. *In*: Proceedings of the 3rd International Conference on Theory and Practice of Electronic Governance, Bogota, Colombia. 2009, p. 409-10.