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Cloud Computing: Types, Architecture, Applications, Concerns, Virtualization and Role of IT Governance in Cloud

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Abstract: Technology innovation and its adoption are two critical successful factors for any business/organization. Cloud computing is a recent technology paradigm that enables organizations or individuals to share various services in a seamless and cost-effective manner. This paper describes cloud computing, a computing platform for the next generation of the Internet. The paper defines clouds, types of cloud Provides, Comparison of Cloud Computing with Grid Computing, applications and concerns of Cloud Computing , Concept of Virtualization in Cloud Computing. Readers will also discover the working, Architecture and Role of I.T Governance in Cloud Computing.

Keywords: Cloud Computing vs. Grid Computing , SaaS , PaaS, IaaS , Cloud Architecture , Cloud Computing Applications and Concerns , Virtualization , Understanding IT Governance in Cloud Computing

I. What Is Cloud?

Cloud computing[1] is a term used to describe both a platform and type of application. A cloud computing platform dynamically provisions, configures, reconfigures, and deprovisions servers as needed. Servers in the cloud can be physical machines or virtual machines. Advanced clouds typically include other computing resources such as storage area networks (SANs), network equipment, firewall and other security devices.

Cloud computing[2] also describes applications that are extended to be accessible through the Internet. These *cloud applications* use large data centers and powerful servers that host Web applications and Web services. Anyone with a suitable Internet connection and a standard browser can access a cloud application.

A. Definition

A cloud is a pool of virtualized computer resources. A cloud can:

- Host a variety of different workloads, including batch-style back-end jobs and interactive, user-facing applications.
- Allow workloads to be deployed and scaled-out quickly through the rapid provisioning of virtual machines or physical machines.
- Support redundant, self-recovering, highly scalable programming models that allow workloads to recover from many unavoidable hardware/software failures
- Monitor resource use in real time to enable rebalancing of allocations when needed.

B. Cloud Computing vs. Grid Computing

Cloud computing environments support grid computing by quickly providing physical and virtual servers on which the grid applications can run.

Cloud computing should not be confused with grid computing[3]. Grid computing involves dividing a large task into many smaller tasks that run in parallel on separate servers. Grids require many computers, typically in the thousands, and commonly use servers, desktops, and laptops. Clouds also support nongrid environments, such as a three-tier Web architecture running standard or Web 2.0 applications. A cloud is more than a collection of computer resources because a Cloud provides a mechanism to manage those resources. Management includes provisioning, change requests, reimaging, workload rebalancing, deprovisioning, and monitoring.

II. TYPES OF CLOUD PROVIDERS

A. Software as a Service (SaaS)

SaaS clients rent usage of applications running within the Cloud‟s provider infrastructure, for example SalesForce. The applications are typically offered to the clients via the Internet and are managed completely by the Cloud provider. That means that the administration of these services such as updating and patching are in the provider‟s responsibility. One big benefit of SaaS[4] is that all clients are running the same software version and new functionality can be easily integrated by the provider and is therefore available to all clients.

B. Platform as a Service (PaaS)

PaaS[4] Cloud providers offer an application platform as a service, for example Google App Engine. This enables clients to deploy custom software using the tools and programming languages offered by the provider. Clients have control over the deployed applications and environment-related settings. As with SaaS, the management of the underlying infrastructure lies within the responsibility of the provider.

C. Infrastructure as a Service (IaaS)

IaaS[4] delivers hardware resources such as CPU, disk space or network components as a service. These resources are usually delivered as a virtualization platform by the Cloud provider and can be accessed across the Internet by the client. The client has full control of the virtualized platform and is not responsible for managing the underlying infrastructure.

D. Storage as a service

Storage as a service (STaaS) is a business model in which a large service provider rents space in their storage infrastructure on a subscription basis. The economy of scale in the service provider's infrastructure allows them to provide storage much more cost effectively than most individuals or corporations can provide their own storage, when total cost of ownership is considered. Storage as a Service is often used to solve offsite backup challenges**.** Critics of storage as a service point to the large amount of network bandwidth required to conduct their storage utilizing an internet-based service.

E. Security as a service

Security as a service (SECaaS) is a business model in which a large service provider integrates their security services into a corporate infrastructure on a subscription basis more cost effectively than most individuals or corporations can provide on their own, when total cost of ownership is considered. These security services often include authentication, anti-virus, anti-malware/spyware, intrusion detection, and security event management, among others.

F. Data as a service

Data as a service, or DaaS, is a cousin of software as a service. Like all members of the "as a Service" (aaS) family, DaaS is based on the concept that the product, data in this case, can be provided on demand to the user regardless of geographic or organizational separation of provider and consumer. Additionally, the emergence of service-oriented architecture (SOA) has rendered the actual platform on which the data resides also irrelevant. This development has enabled the recent emergence of the relatively new concept of DaaS. Data provided as a service was at first primarily used in web mashups, but now is being increasingly employed both commercially and, less commonly, within organisations such as the UN.

G. Test environment as a service

Test Environment as a service (TEaaS**)**, sometimes referred to as "on-demand test environment," is a test environment delivery model in which software and its associated data are hosted centrally (typically in the (Internet) cloud) and are typically accessed by users using a thin client, normally using a web browser over the Internet.

H. Backend as a service

Backend as a service (BaaS), also known as "mobile backend as a service" (MBaaS), is a model for providing web and mobile app developers with a way to link their applications to backend cloud storage while also providing features such as user management, push notifications, and integration with social networking services. These services are provided via the use of custom software development kits (SDKs) and application programming interfaces (APIs). BaaS is a relatively recent development in cloud computing, with most BaaS startups dating from 2011 or later. The global BaaS market had an estimated value of $216.5 million in 2012

III. How Cloud Computing Works

Let's say you're an executive at a large corporation. Your particular responsibilities include making sure that all of your employees have the right hardware and software they need to do their jobs. Buying computers for everyone isn't enough -- you also have to purchase software or software licenses to give employees the tools they require. Whenever you have a new hire, you have to buy more software or make sure your current software license allows another user. It's so stressful that you find it difficult to go to sleep on your huge pile of money every night.

Soon, there may be an alternative for executives like you. Instead of installing a suite of software for each computer, you'd only have to load one application. That application would allow workers to log into a Web-based service which hosts all the programs the user would need for his or her job. Remote machines owned by another company would run everything from e-mail to word processing to complex data analysis programs. It's called cloud computing, and it could change the entire computer industry.

In a cloud computing system, there's a significant workload shift [5]. Local computers no longer have to do all the heavy lifting when it comes to running applications. The network of computers that make up the cloud handles them instead. Hardware and software demands on the user's side decrease. The only thing the user's computer needs to be able to run is the cloud computing system's interface software, which can be as simple as a Web browser, and the cloud's network takes care of the rest. There's a good chance you've already used some form of cloud computing. If you have an e-mail account with a Web-based e-mail service like Hotmail, Yahoo! Mail or Gmail, then you've had some experience with cloud computing. Instead of running an e-mail program on your computer, you log in to a Web e-mail account remotely. The software and storage for your account doesn't exist on your computer -- it's on the service's computer cloud.

IV. Cloud Computing Architecture

When talking about a cloud computing system[5], it's helpful to divide it into two sections: the front end and the back end. They connect to each other through a network, usually the Internet. The front end is the side the computer user, or client, sees. The back end is the "cloud" section of the system. The front end includes the client's computer (or computer network) and the application required to access the cloud computing system. Not all cloud computing systems have the same user interface. Services like Web-based e-mail programs leverage existing Web browsers like Internet Explorer or Firefox. Other systems have unique applications that provide network access to clients.

On the back end of the system are the various computers, servers and data storage systems that create the "cloud" of computing services. In theory, a cloud computing system could include practically any computer program you can imagine, from data processing to video games. Usually, each application will have its own dedicated server.

A central server administers the system, monitoring traffic and client demands to ensure everything runs smoothly. It follows a set of rules called protocols and uses a special kind of software called middleware. Middleware allows networked computers to communicate with each other. Most of the time, servers don't run at full capacity. That means there's unused processing power going to waste. It's possible to fool a physical server into thinking it's actually multiple servers, each running with its own independent operating system. The technique is called server virtualization. By maximizing the output of individual servers, server virtualization reduces the need for more physical machines.

If a cloud computing company has a lot of clients, there's likely to be a high demand for a lot of storage space. Some companies require hundreds of digital storage devices. Cloud computing systems need at least twice the number of storage devices it requires to keep all its clients' information stored. That's because these devices, like all computers, occasionally break down. A cloud computing system must make a copy of all its clients' information and store it on other devices. The copies enable the central server to access backup machines to retrieve data that otherwise would be unreachable. Making copies of data as a backup is called redundancy**.**

V. Cloud Computing Applications

The applications [6,7] of cloud computing are practically limitless. With the right middleware, a cloud computing system could execute all the programs a normal computer could run. Potentially, everything from generic word processing software to customized computer programs designed for a specific company could work on a cloud computing system.

Why would anyone want to rely on another computer system to run programs and store data? Here are just a few reasons:

- Clients would be able to access their applications and data from anywhere at any time. They could access the cloud computing system using any computer linked to the Internet. Data wouldn't be confined to a hard drive on one user's computer or even a corporation's internal network.
- It could bring hardware costs down. Cloud computing systems would reduce the need for advanced hardware on the client side. You wouldn't need to buy the fastest computer with the most memory, because the cloud system would take care of those needs for you. Instead, you could buy an inexpensive computer terminal. The terminal could include a monitor, input devices like a keyboard and mouse and just enough processing power to run the middleware necessary to connect to the cloud system. You wouldn't need a large hard drive because you'd store all your information on a remote computer.
- Corporations that rely on computers have to make sure they have the right software in place to achieve goals. Cloud computing systems give these organizations company-wide access to computer applications. The companies don't have to buy a set of software or software licenses for every employee. Instead, the company could pay a metered fee to a cloud computing company.
- Servers and digital storage devices take up space. Some companies rent physical space to store servers and databases because they don't have it available on site. Cloud computing gives these companies the option of storing data on someone else's hardware, removing the need for physical space on the front end.
- Corporations might save money on IT support. Streamlined hardware would, in theory, have fewer problems than a network of heterogeneous machines and operating systems.

VI. Cloud Computing Concerns

Perhaps the biggest concerns[8] about cloud computing are security and privacy. The idea of handing over important data to another company worries some people. Corporate executives might hesitate to take advantage of a cloud computing system because they can't keep their company's information under lock and key.

The counterargument to this position is that the companies offering cloud computing services live and die by their reputations. It benefits these companies to have reliable security measures in place. Otherwise, the service would lose all its clients. It's in their interest to employ the most advanced techniques to protect their clients' data. Privacy is another matter. If a client can log in from any location to access data and applications, it's possible the client's privacy could be compromised. Cloud computing companies will need to find ways to protect client privacy. One way is to use authentication techniques such as user names and passwords. Another is to employ an authorization format -- each user can access only the data and applications relevant to his or her job.

Some questions regarding cloud computing are more philosophical. Does the user or company subscribing to the cloud computing service own the data? Does the cloud computing system, which provides the actual storage space, own it? Is it possible for a cloud computing company to deny a client access to that client's data? Several companies, law firms and universities are debating these and other questions about the nature of cloud computing.

How will cloud computing affect other industries? There's a growing concern in the IT industry about how cloud computing could impact the business of computer maintenance and repair. If companies switch to using streamlined computer systems, they'll have fewer IT needs. Some industry experts believe that the need for IT jobs will migrate to the back end of the cloud computing system.

VII. Characteristics Of Virtualization In Cloud Computing

Any discussion of cloud computing typically begins with virtualization [9]. *Virtualization* is using computer resources to imitate other computer resources or whole computers. It separates resources and services from the underlying physical delivery environment.

*A. **Characteristics***

Virtualization has three characteristics that make it ideal for cloud computing:

1) Partitioning: In virtualization, many applications and operating systems (OSes) are supported in a single physical system by *partitioning* (separating) the available resources.

2) Isolation: Each virtual machine is isolated from its host physical system and other virtualized machines. Because of this isolation, if one virtual-instance crashes, it doesn't affect the other virtual machines. In addition, data isn't shared between one virtual container and another.

3) Encapsulation: A virtual machine can be represented (and even stored) as a single file, so you can identify it easily based on the service it provides. In essence, the encapsulated process could be a business service. This encapsulated virtual machine can be presented to an application as a complete entity. Therefore, encapsulation can protect each application so that it doesn't interfere with another application.

B. Applications of virtualization

Virtualization can be applied[10] broadly to just about everything that you could imagine:

- Memory
- Networks
- Storage
- Hardware
- Operating systems
- Applications

What makes virtualization so important for the cloud is that it decouples the software from the hardware. *Decoupling* means that software is put in a separate container so that it's isolated from operating systems.

C. Forms of virtualization

To understand how virtualization helps with cloud computing, you must understand its many forms. In essence, in all cases, a resource actually emulates or imitates another resource. Here are some examples:

1) Virtual memory: Disks have a lot more space than computer memory. Therefore, with virtual memory, the computer frees valuable memory space by placing information it doesn't use often into disk space. PCs have *virtual memory*, which is a disk area that's used like memory. Although disks are very slow in comparison with memory, the user may never notice the difference, especially if the system does a good job of managing virtual memory. The substitution works surprisingly well.

2) Software: Companies have built software that can emulate a whole computer. That way, one computer can perform as though it were actually 20 computers. The application consolidation results can be quite significant. For example, you might be able to move from a data center with thousands of servers to one that supports as few as a couple of hundred. This reduction results in less money spent not only on computers, but also on power, air conditioning, maintenance, and floor space.

VIII. Understanding It Governance In Cloud Computing

Governance is about making good decisions regarding performance predictability and requiring accountability. This is the case whether you're governing your own data center or thinking about the cloud. At its most basic, *governance* is about applying policies relating to using services. It's about defining the organizing principles and rules that determine how an organization should behave.

Before diving in, take a step back and look at the IT governance process in general because many of the same principles are relevant to the cloud environment[11]. IT manages a complex infrastructure of hardware, data, storage, and software environments. The data center is designed to use all assets efficiently while guaranteeing a certain service level to the customer. A data center has teams of people responsible for managing everything from the overall facility, workloads, hardware, data, software, and network infrastructure.

In addition to the data center itself, your organization may have remote facilities with technology that depends on the data center. IT management has long-established processes for managing and monitoring individual IT components, which is good.

IT governance does the following:

- Ensures that IT assets (systems, processes, and so on) are implemented and used according to agreed-upon policies and procedures.
- Ensures that these assets are properly controlled and maintained.
- Ensures that these assets are providing value to the organization (actually supporting your organization's strategy and business goals).

IT governance, therefore, has to include the techniques and policies that measure and control how systems are managed. However, IT doesn't stand alone in the governance process. In order for governance to be effective, it needs to be holistic. It is as much about organizational issues and how people work together to achieve business goals as it is about any technology. Therefore, the best kind of governance occurs when IT and the business are working together.

A critical part of governance is establishing organizational relationships between business and IT, as well as defining how people will work together across organizational boundaries.

How does IT governance typically work? IT governance usually involves establishing a board made up of business and IT representatives. The board creates rules and processes that the organization must follow to ensure that policies are being met. This might include

- Understanding business issues such as regulatory requirements or funding for development
- Establishing best practices and monitoring these processes
- Responsibility for things like programming standards, proper design, reviewing, certifying, and monitoring applications from a technical perspective, and so on.

A simple example of IT governance in action is making sure that IT is meeting its obligations in terms of computing uptime. This uptime obligation is negotiated between the business and IT, based on the criticality of the application to the business.

IX. Conclusion:

In today's global competitive market, companies must innovate and get the most from its resources to succeed. This requires enabling its employees, business partners, and users with the platforms and collaboration tools that promote innovation. Cloud computing infrastructures are next generation platforms that can provide tremendous value to companies of any size. Cloud Computing provides Software, Platform, Infrastructure, Storage, Security, Data, Test Environment etc. as a service.

Clients would be able to access their applications and data from anywhere at any time. Data wouldn't be confined to a hard drive on one user's computer or even a corporation's internal network. It would also bring hardware costs down. You would not need a large hard drive because you would store all your information on a remote computer. However the biggest concerns about cloud computing are security and privacy. The idea of handling over important data to another company worries some people. Corporate executives might hesitate to take advantage of a cloud computing system because they can't keep company's information under lock and key.

I also discussed the Concept of Virtualization in Cloud Computing as any discussion of cloud computing typically begins with the virtualization. Virtualization is using computer resources to imitate other computer resources or whole computers. I discussed the characteristics, applications and various forms of Virtualization.

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