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CLOUD COMPUTING: Comparison with Grid Computing, Cloud Service Models, Architecture, Components, and Virtualization

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Abstract— Technology innovation and its adoption are two critical successful factors for any business/organization. Cloud computing is an affordable option which creates efficiency and effectiveness, reduces costs involving electricity, bandwidth, operations and hardware and does not require functional staff, in-house expertise, space, power and infrastructure. 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 computing Environment, Comparison of Cloud Computing with Grid Computing (Grid computing is an infrastructure involving collaboration of computers, databases & network resources available, to perform manipulation of intensive and large scale data set problems.) Concept of Virtualization in Cloud Computing. Readers will also discover the working with components and Architecture of cloud Computing.

Keywords— Cloud Computing vs. Grid Computing, SaaS , PaaS, IaaS , Cloud Architecture , Cloud Computing components, Characteristics of Virtualization in Cloud Computing, its application and concerns.

I. WHAT IS CLOUD?

Cloud computing 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 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.

Cloud computing should be elasticity and scalability. Figure (1) , shows six phases of computing paradigms, from dummy terminals/mainframes, to PCs, networking computing, to grid and cloud computing.

- In phase 1, many users shared powerful mainframes using dummy terminals.
- In phase 2, stand-alone PCs became powerful enough to meet the majority of users' needs.
- In phase 3, PCs, laptops, and servers were connected together through local networks to share resources and increase performance.
- In phase 4, local networks were connected to other local networks forming a global network such as the Internet to utilize remote applications and resources.
- In phase 5, grid computing provided shared computing power and storage through a distributed computing.

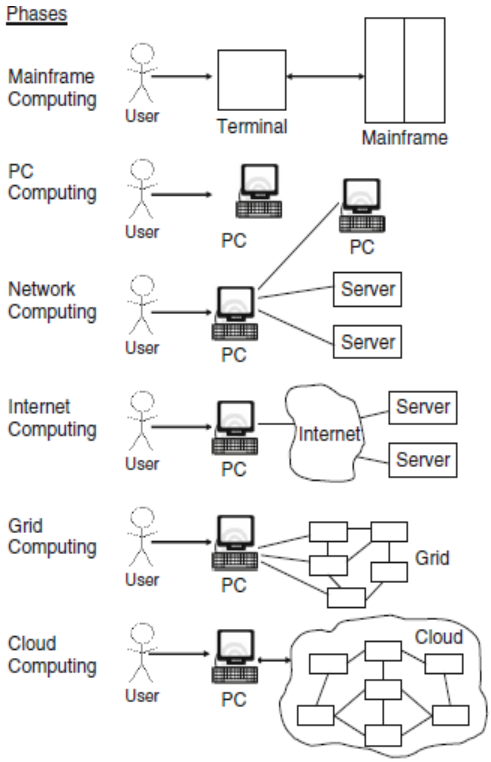

Figure (1) Six phases of computing paradigms

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. 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.

Selection and sharing of resources worldwide is the fundamental working logic behind grid computing which can be represented by Figure(2):

Figure (2) Grid computing

II. BENEFITS OF CLOUD COMPUTING

A. Reduced implementation and maintenance costs .
B. Increased mobility for a global workforce .
C. Flexible and scalable infrastructures.
D. Quick time to market .
E. IT department transformation (focus on innovation vs. Maintenance and implementation)
F. "Greening" of the data center .
G. Increased availability of high-performance applications to small/medium-sized businesses.

III. CLOUD SERVICE MODELS

- Software as a Service (SaaS):
  - Use provider's applications over a network
- Platform as a Service (PaaS) :
  - Deploy customer-created applications to a cloud
- Infrastructure as a Service (IaaS):
  - Rent processing, storage, network capacity

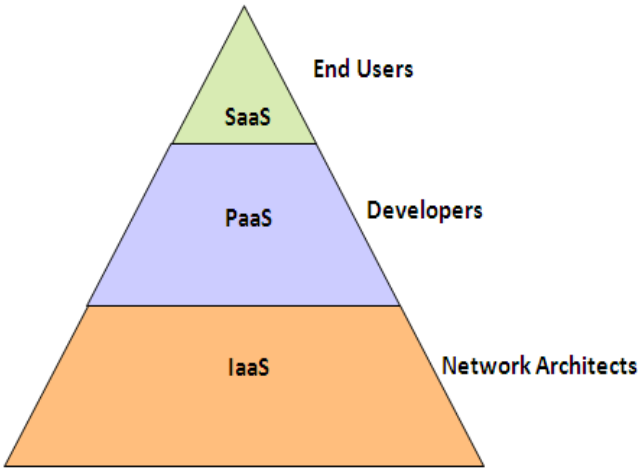

Figure (3) Cloud computing models

IV. TECHNICAL COMPONENTS OF CLOUD COMPUTING

As shown in the Figure 4, key functions of a cloud management system is divided into four layers, respectively the Resources & Network Layer, Services Layer, Access Layer, and User Layer. Each layer includes a set of functions:

- The Resources & Network Layer manages the physical and virtual resources.
- The Services Layer includes the main categories of cloud services, namely, NaaS, IaaS, PaaS, SaaS/CaaS, the service orchestration function and the cloud operational function.
- The Access Layer includes API termination function, and Inter-Cloud peering and federation function.
- The User Layer includes End-user function, Partner function and Administration function.

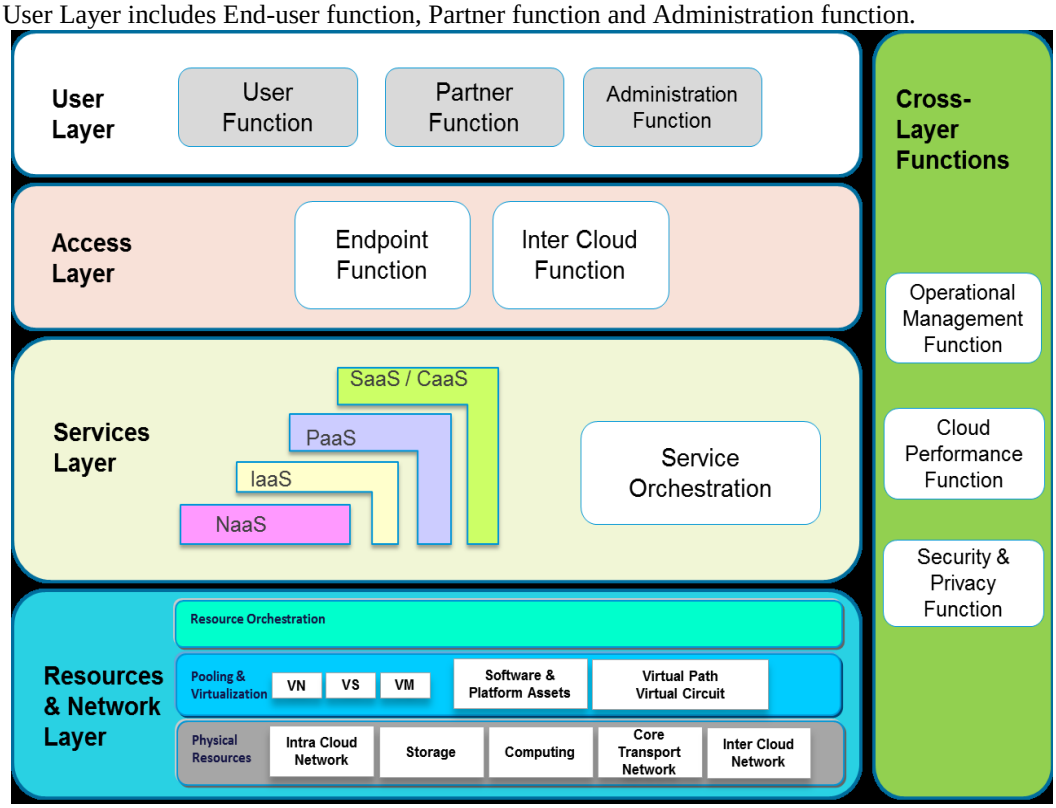

Figure (4) Cloud computing components

Other functions like Management, Security & Privacy, etc. are considered as cross-layer functions that covers all the layers. The main principle of this architecture is that all these layers are supposed to be optional. This means that a cloud provider who wants to use the reference architecture may select and implement only a subset of these layers.

V. TYPES OF CLOUD COMPUTING ENVIRONMENT

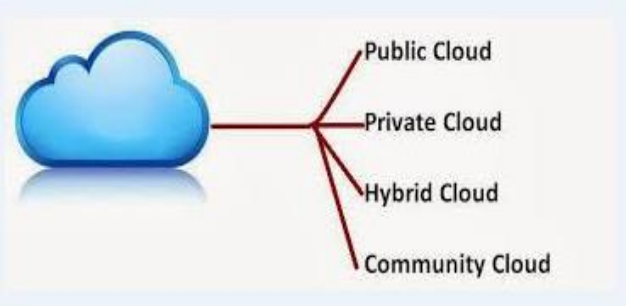

Figure (5)

PUBLIC CLOUDS:-

The cloud infrastructure is available to the public on a commercial basis by a cloud service provider. This enables a consumer to develop and deploy a service in the cloud with very little financial outlay compared to the capital expenditure requirements normally associated with other deployment options. This environment can be used by the general public. This includes individuals, corporations and other types of organizations. Typically, public clouds are administrated by third parties or vendors over
the Internet, and services are offered on pay-per-use basis. These are also called provider clouds.

PRIVATE CLOUDS:-

The cloud infrastructure has been deployed, and is maintained and operated for a specific organization. The operation may be in-house or with a third party on the premises. This cloud computing environment resides within the boundaries of an organization and is used exclusively for the organizations benefits. These are also called internal clouds. They are built primarily by IT departments within enterprises who seek to optimize utilization of infrastructure resources within the enterprise by
provisioning the infrastructure with applications using the concepts of grid and virtualization.

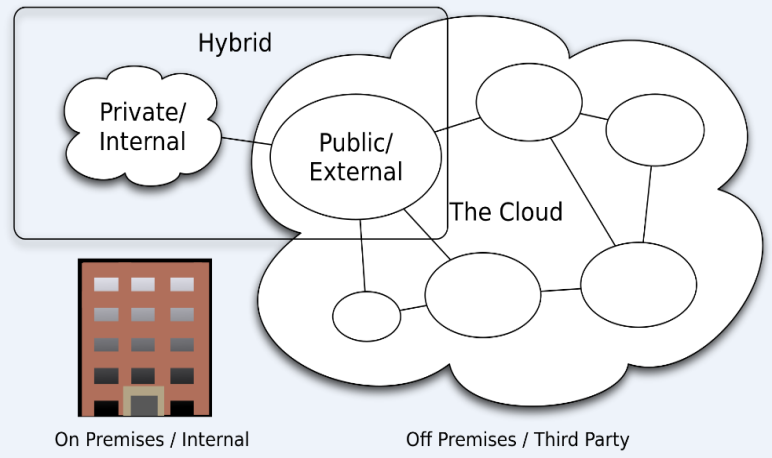

Figure (6) Shows private, public and hybrid clouds

HYBRID CLOUDS:-

This is a combination of both private (internal) and public (external) cloud computing environments. The cloud infrastructure consists of a number of clouds of any type, but the clouds have the ability through their interfaces to allow data and/or applications to be moved from one cloud to another. This can be a combination of private and public clouds.

COMMUNITY CLOUD:-

The cloud infrastructure is shared among a number of organizations with similar interests and requirements. This may help limit the capital expenditure costs for its establishment as the costs are shared among the organizations. The operation may be in-house or with a third party on the premises.

VI. 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.

Figure (6) Working of cloud computing

In a cloud computing system, there's a significant workload shift. 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 systems 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.

VII. CLOUD COMPUTING ARCHITECHTURE

When talking about a cloud computing system 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 .As shown in the figure(7):

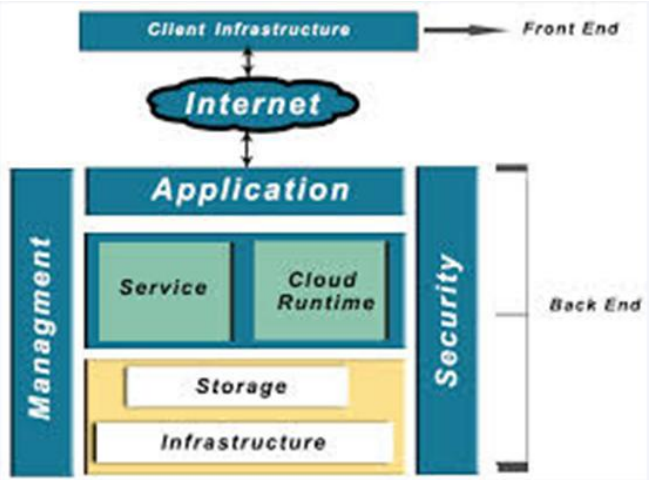

Figure (7) Cloud computing architechture

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.

VIII. CLOUD COMPUTING APPLICATIONS

The applications 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.

IX. CLOUD COMPUTING CONCERNS:

Perhaps the biggest concerns 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.

X. CHARECTERISTIC OF VIRTUALIZATION IN CLOUD COMPUTING

Any discussion of cloud computing typically begins with virtualization. *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 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:

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.

XI. 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. We 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. We discussed the characteristics, applications and various forms of Virtualization.

ACKNOWLEDGMENT

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