Cloud Computing – An on Demand Service Platform

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ABSTRACT
Since computing required number of hardware and software resources which continuously changed or upgraded thus requiring customers and users to consistently pump in investments to upgrade their infrastructures. This required researchers to arrive at a solution where users and customers would have access to latest versions of hardware and software without requiring new investments. This led to the very concept of cloud computing where a customer or user pays only for the service rather than for the product [1]. This paper is a base paper that gives a brief introduction to the cloud computing, from what technologies cloud computing is derived, its components, its merits and demerits, also main challenges to the cloud computing. This paper also helps to categorize the various services provided by any cloud service provider in some categories depending upon the type of service.

Keywords
Cloud Computing, Service Models, P2P, SOA, SOAP, SaaS, PaaS, IaaS, HaaS, NaaS, CaaS etc.

1. INTRODUCTION
Cloud computing is a model for enabling easy, on-demand network access to a shared pool of configurable computing resources (e.g. servers, storage, applications, and services) that can be quickly provided and released with minimum management effort or service provider interaction [2]. These computing resources are generally offered as pay-for-use plans and hence have become attractive to cost conscious customers [3].

2. GENESIS OF CLOUD COMPUTING
Cloud computing shares its characteristics with several other computing areas and system engineering concepts [5]. Cloud computing has borrowed its basics from the following:

2.1 Cluster Computing
One way to make an application run faster is to divide its work into multiple parts then run those multiple parts simultaneously on a group of computers, Known as cluster computing [7]. Benefits of cluster computing include high performance, expandability and scalability, high throughput, high availability etc [8].

2.2 Grid Computing
Distributed computing has been implemented in many ways including grid computing in which the various computing resources and applications are put under the control of software called grid engine for dynamic allocation and optimal utilization [9].

2.3 Virtualization
Operating environment required to run any applications be it software or hardware present without the actual hardware and software being present is referred to as virtual machine and running an application on a virtual machine and giving us the experience of running the application on actual physical hardware and software environment is referred to as simulation. E.g. Citrix -farm, network devices and storage devices etc.

2.4 Client–Server Model
In client server model every computer can either act as a server or a client. A server is a computer system that selectively shares its resources. A client is a computer or computer program that contact with a server in order to make use of a resource e.g. Data, CPUs, printers, and data storage devices etc.

2.5 Peer-to-Peer Computing
In peer to peer computing network each computer can either act as a client or a server for the other computers in the network that will allow shared access to various resources e.g. files and peripherals without the need for a central server. P2P computing can also be defined as the sharing of computer services and resources by direct exchange [12]. Some of the benefits of P2P approach include, improved scalability and it will also eliminate the need for costly infrastructure [11].

2.6 Service-Oriented Architecture
Cloud computing definitely has connection with service oriented architecture which in itself was based on the same approach of sharing resources and charging the customers as per the resource utilization [13]. The domain of services was limited to reusable services which were primarily customer centric. However cloud computing widens this domain to cover maximum services even if they were not user centric. It uses protocols and technologies such as simple object access protocol (SOAP) and XML.

2.7 Utility Computing
Utility computing [4] is the packaging of computing resources, such as computation, storage and services, as a metered service. This model has the advantage of very little or no initial cost to obtain computer resources; instead, computational resources are rented. This repackaging of computing services became the foundation of the shift to "on demand" computing, software as a service and cloud computing models that further propagated the idea of computing, application and network as a service.

2.8 MapReduce
Large datasets can be produced using programming paradigm requiring just a key/value pair to generate intermediate key value pairs and a function to merge these intermediate values associated with the same intermediate key. This programming paradigm is referred to as MapReduce [16].

2.9 Autonomic Computing

Autonomic computing is a computing environment that has the ability to manage itself and can dynamically adapt to changes according to business policies and objectives. Self-managing environments can perform such activities based on situations they observe in the IT environment rather than requiring IT professionals to begin the task. These environments are self-configuring, self-healing, self-optimizing, and self-protecting [15].

3. ARCHITECTURE OF THE CLOUD COMPUTING

Cloud computing architecture refers to the components and subcomponents required for cloud computing. This section describes a layered model of cloud computing in which a cloud computing environment can be divided into four layers: the hardware/datacenter layer, the infrastructure layer, the platform layer and the application layer [6], as shown in Figure 1.

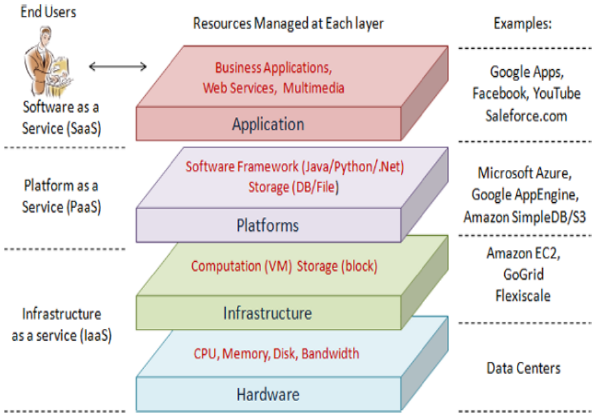

Figure 1 Cloud Computing Architecture [6]

3.1 The Hardware Layer

This layer is responsible for managing the physical resources of the cloud, including servers, routers, switches, power and cooling systems. In practice, the hardware layer is typically implemented in data centers. A data center usually contains thousands of servers that are organized in racks and interconnected through switches, routers or other fabrics [6].

3.2 The Infrastructure Layer

This layer is also known as the virtualization layer, the infrastructure layer creates a pool of storage and computing resources by partitioning the physical resources using virtualization technologies such as Xen [6], KVM [6] and VMware [6]. Typically services in this layer are such as Elastic Computing Cloud of Amazon [22].

3.3 The Platform Layer

Built on top of the infrastructure layer, the platform layer consists of operating systems and application frameworks. The purpose of this layer is to minimize the burden of deploying applications directly into VM containers [6]. The typical services in this layer are Google App Engine [22] and Azure from Microsoft [22].

3.4 The Application Layer

At the top level of the hierarchy application layer is there consists of the actual cloud applications. Different from traditional applications, cloud applications can provide the automatic-scaling feature to achieve better performance, availability and lower operating cost. Examples of SaaS include the Customer Relationship Management (CRM) [22] from Salesforce, which was developed based on the force.com (a PaaS in Salesforce). Services provided by Google on-line office such as documents, spreadsheets, presentations all are examples of SaaS[22].

Cloud computing architecture is modular in which each layer is loosely coupled with the layers above and below it. This modular architecture allows cloud computing to support a wide range of application requirements while reducing management and maintenance overhead and this modularity of architecture allows each layer to evolve separately [6].

4. SERVICE MODELS

Clouds offer services that can be grouped into the following categories:

4.1 Infrastructure as a Service (IaaS) or Hardware as a Service (HaaS)

IaaS offers the hardware so that any organization can put whatever they want onto it. Rather than to purchase servers, racks, and having to pay for the datacenter space for them, the service providers rent these resources.

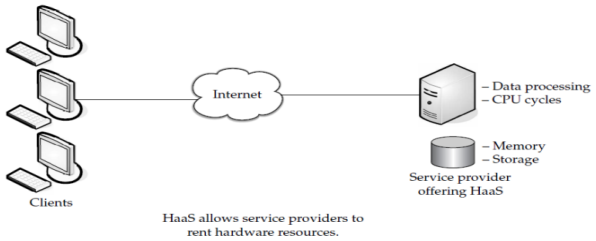

Figure 2 Infrastructure as a Service

Examples of IaaS providers include Amazon EC2 [20], GoGrid [6] and Flexiscale [6].

4.2 Platform as a Service (PaaS)

PaaS supplies all resources required to build applications and services completely from the internet, without having to download or install software.

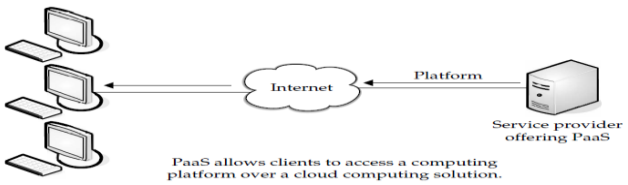

Figure 3 Platform as a service

PaaS services include application design, development, testing, deployment and hosting. PaaS providers include Google App Engine [10], Microsoft Windows Azure [6] and Force.com [6].

4.3 Software as a Service (SaaS)

SaaS is the model in which an application is hosted as a service to customers. Customers can access these services through internet. When the software is hosted off-site, the customer does not have to maintain it. The service provider does all the patching, upgrades. Also to keep the infrastructure running, only the service provider is responsible.

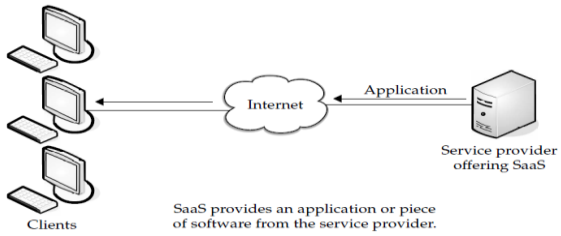

Figure 4 Software as a Service

Examples of SaaS providers include Salesforce.com [6], Rackspace [6], SAP Business ByDesign [19].

4.4 Network as a Service (NaaS)

Network connectivity being an important component of communication for internet applications so, obviously optimization of resource allocations considering network services and computing resources is vital to success of the application. Therefore providing network connectivity between a client and a cloud or between two clouds is considered as a services and the term network as a service is defined as a part of the cloud computing just as IaaS, PaaS and SaaS.

4.5 Communication as a Service (CaaS)

It is an extension of SaaS by adding an additional control layer based on session protocol thereby facilitating communications applications to run on the cloud as a service referred to as CaaS.

5. DEPLOYMENT MODELS

Each company chooses a deployment model for a cloud computing solution based on their specific business, operational, and technical requirements. There are mainly following four deployment models:

5.1 Public Cloud

Public clouds are run by third parties. Applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks (Figure 5).

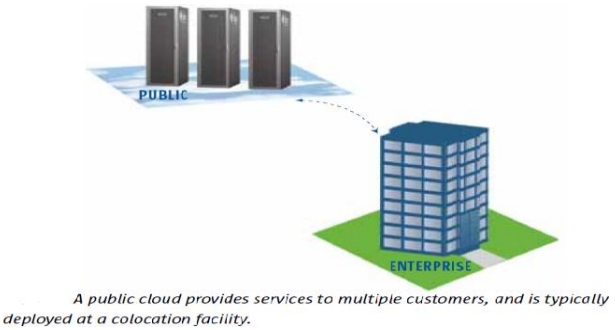

Figure 5 Public Cloud [18]

Public cloud provides a way to reduce customer risk and cost by providing temporary and flexible extension to the enterprise infrastructure [18]. Public clouds are mostly hosted away from customer premises. Example: Amazon, Google Apps, Windows Azure [19], force.com [14].

5.2 Private Cloud

Private clouds are made for the exclusive use of one client, providing the full control over quality of service, data and security (Figure 6).

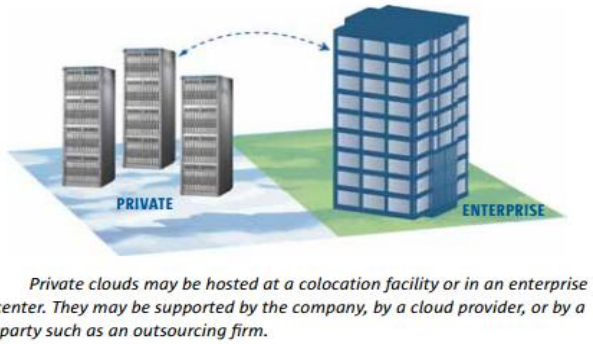

Figure 6 Private Cloud [18]

The company has its own infrastructure and has control over the deployment of applications on this infrastructure [18]. Example: eBay [19].

5.3 Hybrid Cloud

Hybrid cloud is a combination of both public and private cloud models (Fig. 7). It has the ability to strengthen a private cloud with the resources of public cloud. This facility can be used to maintain the levels of service quality at the time of rapid workload fluctuations.

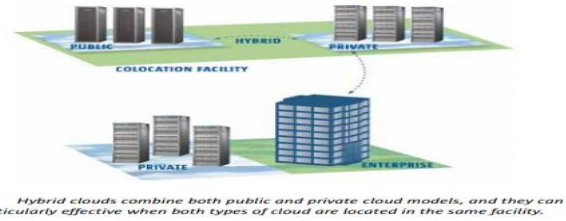

Figure 7 Hybrid cloud [18]

This type of cloud also can be used to handle planned workload spikes [18]. There are not many hybrid clouds in use today, though initial initiatives such as the one by IBM and Juniper already introduce base technologies for their realization [19].

5.4 Community Cloud

Individual communities or organizations rather than creating their private clouds should opt for Community clouds by sharing their infrastructure for a specific common goal. E.g. research community or NGOs with common concerns (security, compliance etc.).The costs are spread over fewer users confined to the community than a public cloud where the set of users is very vast (but more than a private cloud), so only limited cost savings can be achieved. Community Clouds are very limited owing to the limitations mentioned above.

6. CHARACTERISTICS OF CLOUD COMPUTING

Cloud computing exhibits the following key characteristics:

6.1 Broad Network Access

Broad network access means that the hosted application can be accessed through any network based device. E.g. laptop,

desktop, smartphone, tablet device etc. Broad network access is accomplished by using the built-in web browser. The advantage of this setup is that client devices can be much less powerful as "thin-clients".

6.2 Rapid Elasticity

This means the service can be quickly scaled, often automatically [26], such that the capacity appears infinite to the consumer.

6.3 Multi-Tenancy

In a cloud environment, services owned by multiple providers are co-located in a single data center. The performance and management issues of these services are shared among service providers and the infrastructure providers. The layered architecture of cloud computing provides a natural division of responsibilities. The owner of each layer only needs to focus on the specific objectives associated with this layer.

6.4 Shared Resource Pooling

By using the concept of resource pooling multiple organizations can share the underlying physical cloud infrastructure. This increases the purchasing power for these companies because they can access to a larger pool of resources rather than procuring the physical or virtual infrastructure themselves.

6.5 Maintenance

System maintenance is done by the cloud service providers. As the access is through APIs that's why installation of application on PCs is not required. This will result in reducing maintenance requirements [25].

6.6 Cost Savings

By using cloud computing based services and applications companies can reduce their capital expenditures [23] and use operational expenditures for increasing their computing capabilities. But, there is a major issue of improving energy efficiency because it has been estimated that the cost of powering and cooling accounts for 53% of the total operational expenditure of data centers [21].

7. MAIN CHALLENGES/ISSUES TO CLOUD COMPUTING

Though cloud computing is on the edge of becoming a reality, but still there are several issues and challenges, few of them are described below:

7.1 Monitoring

Monitoring for cloud systems is active research topic in cloud computing. With the enormous size of the cloud data centers and the large number of nodes supporting any cloud offering, hardware and software failures become an unavoidable reality, for which a robust monitoring system must be in place to allow the cloud services to actively react to failures [5].

7.2 Compliance

Numerous regulations applicable to the storage and use of data require regular reporting and audit trails. The data centers maintained by cloud providers as well as the customer's requirements may also be subject to compliance requirements [17].

7.3 Availability of Service

The goal of availability for cloud computing systems (including applications and its infrastructures) is to ensure its users that they can use them at any time, at any place [17].

7.4 Legal Issues

Worries stick with safety measures and confidentiality of individual all the way through legislative levels [17].

7.5 Privacy

Information stored in the cloud is looked after by the provider, meaning that consumers share control over their information with the provider. This creates a range of privacy and security issues, as well as legal concerns as to who owns and has access to the information [24]. Well-known security issues such as data loss, phishing, botnet (running remotely on a collection of machines) pose serious threats to organization's data and software [27].

7.6 Accountability

If the cloud fails, can the user access their information from somewhere else? Or if they decide to move clouds. For example, migrate from Google to Yahoo, can their data be transferred? By relying on cloud computing, the user is entrusting all of their information to a service provider. If the cloud fails, who is responsible for recovering that lost information, and for any costs or damages incurred by that loss [24]?

7.7 Service Level Agreement

Although cloud consumers do not have control over the underlying computing resources, they are required to ensure the quality, availability, reliability, and performance of these resources when customers have migrated their core business functions onto their entrusted cloud. In other words, it is necessary for customers to obtain guarantees from providers on service delivery. Typically, these are provided through Service Level Agreements (SLAs) negotiated between the providers and consumers.

7.8 Billing

As the services are provided to the users on demand because of this determination of the costs involved in using cloud services is a difficult task. Budgeting and assessment of the cost will be very difficult unless the provider has some good and comparable benchmarks to offer.

7.9 Interoperability

Each cloud offering has its own way on how cloud clients, users and applications interact with the cloud. This leads to the "Hazy Cloud" phenomenon. This phenomenon badly obstructs the development of cloud ecosystems by forcing vendor locking, which prevents the users to choose from alternative vendors/offerings simultaneously in order to optimize resources at different levels within an organization [27].

8. CONCLUSION

In this paper we have discussed the various technologies related to cloud computing, its architecture, service models, deployment models, merits of cloud computing, various challenges and Issues in the cloud computing. Although, Cloud Computing has emerged as a major technology to provide services over the Internet in easy and efficient way still there are many areas like energy management, security of data, cloud monitoring etc. that need the attention of the researchers to make the cloud computing technology more advantageous.

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