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Core of Cloud Computing

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ABSTRACT
Advancement in computing facilities marks back from 1960's with introduction of mainframes. Each of the computing has one or the other issues, so keeping this in mind cloud computing was introduced. Cloud computing has its roots in older technologies such as hardware virtualization, distributed computing, internet technologies, and autonomic computing. Cloud computing can be described with two models, one is service model and second is deployment model. While providing several services, cloud management's primary role is resource provisioning. While there are several such benefits of cloud computing, there are challenges in adopting public clouds because of dependency on infrastructure that is shared by many enterprises. In this paper, we present core knowledge of cloud computing, highlighting its key concepts, deployment models, service models, benefits as well as security issues related to cloud data. The aim of this paper is to provide a better understanding of the cloud computing and to identify important research directions in this field
Keywords - Cloud computing, CSC, CSP, deployment model, IaaS, PaaS, private cloud, public cloud, resource provisioning, SaaS, service model, VM.

I. INTRODUCTION

The idea of providing a centralized computing service dates back to the 1960s, when computing services were provided over a network using mainframe time-sharing technology. In 1966, came the idea of computing as a public utility with a centralized computing facility to which many remote users connect over networks. In the 1960s, the mainframe time-sharing mechanism effectively utilized computing resources, and provided acceptable performance to users; however, mainframes were difficult to scale up because of increasingly high hardware costs. Accordingly, users didn't have full control over the performance of mainframe applications because it depended on how many users utilized the mainframe at a given moment. As such, with the introduction of personal computers users loved the idea of having full control of their computing resources. With the change in the semiconductor industry, personal computers became affordable, and mainframes slowly disappeared from main flow business. Client-server systems were supposed to address data-sharing challenge by providing centralized data management and processing servers. As business computing needs grew and the Internet became widely adopted, the initially simple client-server architecture transformed into more complex two-tier, three-tier, and four-tier architectures [1].

Cloud computing led to an innovative approach in the way in which IT infrastructures, applications, and services are designed, developed, and delivered. It enhances the vision of any IT asset as a utility, which can be consumed on a pay-per-use basis like water, power, and gas. Cloud computing promotes an on-demand model for IT resource provisioning where a resource can be a virtual server, a service, or an application platform [2].

Cloud computing is a type of computing that is based on the internet. It provides various hosting and delivering services over the Internet. It provides the computational resources (Server, Storage, OS and Network) to user as service, based on the demand of user. Cloud computing has gained its popularity by providing cheap and easy access to IT (Information Technology). However, despite the fact that demand for cloud based resources is increasing day by day but on the other side security is regarded as a serious issue on which work has to be done [3].

II. ROOTS OF CLOUD COMPUTING

Before cloud computing, there were many computing facilities actually available. But there was need for computing that is fast, dynamic and can enhance automatic provisioning of available computing resources (processing, networking & storage) among several tenants i.e., users. The roots of cloud computing can be tracked back in several technologies, especially in Hardware Virtualization, Internet technologies, Distributed computing and System management. Fig.1 shows the convergence of technology fields that significantly contributed to the advent of cloud computing. Following are the technologies that form base of cloud computing:

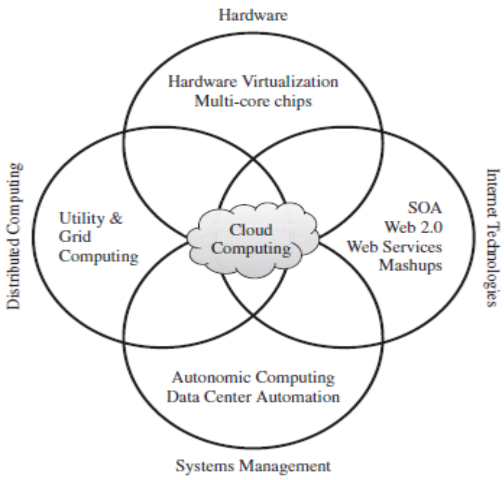

Fig. 1 Convergence of technologies

A. Mainframes to cloud

Mainframe computers were introduced in 1960's, and are very good in provisioning available physical resources among the applications. Applications use processors in time shared basis with better performance. But mainframes have slower Return on investment (ROI) as well as lower Total cost of ownership (TCO). ROI means how fast the application can generate the income. TCO means the direct and indirect cost for which an application can own the underlying physical resources. Hence, the cloud computing infrastructure uses some of the features of mainframes and the focus on improving ROI and TCO.

B. Hardware virtualization

Virtualization term was coined in late 1960's, but actually it was implemented in 1990's. As the name suggest, virtual means logical. The available physical resources like processing, networking and storage have to be shared as a pool of logical resources among several virtual machines. Virtual machine (VM) is the logical implementation of the physical system, having virtual resources like processing, networking and storage. Various applications are deployed in the virtual machines.

Virtualization is defined as a technique that allows sharing single physical instance among several tenants or users. The virtualized platform forms the basis for many cloud computing platforms. Virtualization technology examples are Xen, KVM, VMware, etc. The number of applications running per physical system is called utilization of the system. Thus, the utilization of the physical system increases, as the number of VMs increases and hence the number of application deployed on the VM also increases.

C. Distributed computing

Cluster computing and Grid computing are the examples of distributed computing and forms the base for Cloud computing.

Computing actually means provisioning the available resources like processing, networking and storage across many applications. Cluster computing is the infrastructure of homogenous machines connected in LAN to solve a specific problem. Here the homogenous machine means the machines with same configurations. As these machines are connected in LAN at a location, they are also referred as tightly coupled systems. Grid computing is the infrastructure of heterogeneous machines connected over internet to solve a specific problem. Here the heterogeneous machine means the machines with different configurations. As these machines are connected over internet across geographical areas, they are also called loosely coupled systems.

Utility computing is the computing infrastructure which is used on pay-per-use basis and in utility, location of the source of computing infrastructure is abstracted from the user. Examples of utility computing are electricity, telephone, etc. Cloud computing also should exhibit the characteristics of utility computing, cluster computing and grid computing.

D. Internet technologies

With the advancement in computing, accessing the computing infrastructure over internet from distant places needs updating internet technologies. In current era, widely used internet technologies were Simple Object Access Protocol (SOAP) and Representational State Transfer (REST). Traditionally, internet technologies used were Distributed Component Object Model (DCOM), Common Object Request Broker Architecture (CORBA), and Web Services Definition Language (WSDL). The user sitting at a distant place can access the computing infrastructure or applications over internet following these internet technology standards. Service Oriented Architecture (SOA) is an architecture that allows the communication between two or more applications (or services). Service here means web services that are collection of functions that are well defined, well contained enhancing better communication between the end points. Generally, we can say web services as a technology which allows the connections over internet.

III. CLOUD COMPUTING MODEL

The question is, inspite of many computing technologies available, why there is a need for Cloud computing? In cloud computing, the concept of utility computing and virtualization plays vital role. In order to say a computing infrastructure as cloud computing, it should exhibit utility and virtualization features. Buyya et al. [5] have defined it as follows: "Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualised computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements (SLA) established through negotiation between the service provider and consumers."

A. Service model

Cloud service providers (CSP) offers resources to the Cloud service consumers (CSC) on demand, hence the cloud computing services are divided into three classes, namely: (1) Infrastructure as a Service, (2) Platform as a Service, and (3) Software as a Service.

a. Infrastructure as a Service (IaaS)

IaaS can be defined as a cloud computing service model that offers resources such as computing, storage and networking to the clients on pay-per-use basis. The cloud infrastructure enables on demand provisioning of servers running different flavors of operating systems. In short, in IaaS client don't feel need to purchase a new physical server, instead it can lease the IaaS service from cloud services providers (CSPs). This minimizes the cost as the client is only paying for the time he uses the service. Examples of IaaS are EC2 (Elastic compute cloud) by Amazon, Compute engine service by Google cloud, etc.

b. Platform as a Service (PaaS)

PaaS can be defined as a cloud computing service model that offers environment to the clients on pay-per-use basis, so that the client can develop and deploy applications. To use PaaS tool, client necessarily need not know about how many processors and what amount of memory is required. Traditionally license of the platform has to be paid and then application can be developed and deployed. But, with the introduction of PaaS service much of cost cutting can be achieved and it is performance effective also. Examples of PaaS are Google app engine by Google cloud, Open shift and Cloud Foundry.

c. Software as a Service (aaS)

SaaS can be defined as a cloud computing service model that offers application to the client who can access the application through web portal on pay-per-use basis. Traditional desktop applications such as word processing and spreadsheet can now be accessed as a service in the Web. This model of delivering applications alleviates the burden of software maintenance for customers and simplifies development and testing for providers. Example of SaaS are Salesforce.com, that offers business productivity applications (CRM) that reside completely on their servers, allowing customers to customize and access applications on demand.

B. Deployment model

Cloud service models are defined on the basis of the type of service offered, but cloud deployment model are defined on the basis where the cloud is deployed. Cloud can be deployed within the premise of organization or outside the premise of organization. The deployment models are as follows

a. Private cloud

The cloud infrastructure created within the private network of the organization is referred to as private cloud. The organization's private network is segmented from public network i.e. internet by firewall. In private cloud, various departments of the organization are connected over intranet. The performance of this cloud is good and latency of accessing the cloud service is low, as the cloud is deployed in private network and private network uses the strength of bandwidth for accessing service. Fig. 2 shows the private cloud. Privacy and security are not the major concerns in private cloud as this cloud is not publicly available to others. Examples of private cloud are Openstack, Eucalyptus, Opennimbus, etc.

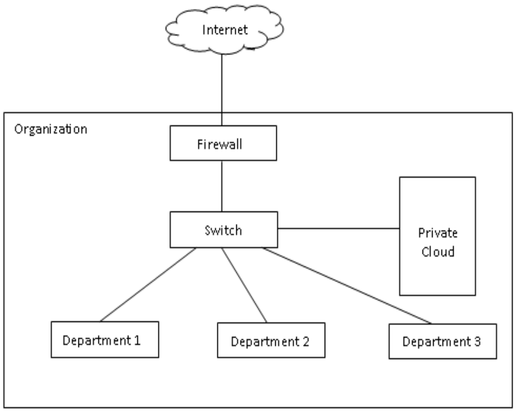

Fig. 2 Private cloud

b. Public cloud

The cloud infrastructure created outside the private network of the organization is referred to as public cloud. The organization's private network is segmented from public network i.e. internet by firewall. This cloud is deployed outside the organization's firewall over internet. The performance of this cloud depends on the internet speed as cloud is deployed on internet. Privacy and security are the major concerns in public cloud as this cloud is publicly available and attackers can compromise the cloud. Fig. 3 shows the public cloud. So, privacy and security algorithms play vital role in public cloud to provide security to the cloud. Examples of private cloud are Amazon, Google, Microsoft, etc.

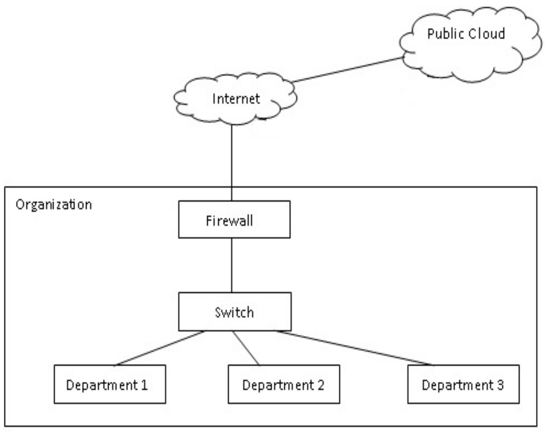

Fig. 3 Public cloud

c. Hybrid cloud

Hybrid cloud is a cloud infrastructure created by combination of private and public cloud. There are two cases when the organization goes for hybrid cloud, one is when it feels the on premise private cloud space falls short then it goes for hybrid cloud and second is when public cloud data is critical and not to be shared with other geographical location then it goes for hybrid cloud serving the need.

IV. DESIRED FEATURES IN CLOUD COMPUTING

Certain features [4] that should be exhibited by cloud computing inorder to fall different from existing computing facility are as follows:

A. Self service

Consumers of cloud computing services expect on-demand, nearly instant access to resources. To support this expectation, clouds must allow self-service access so that customers can request, customize, pay, and use services without intervention of human operators through web browser.

B. Per-usage metering and billing

Cloud computing allows users to request and use only the necessary amount service. Services must be priced on a short term basis (e.g., by the hour), allowing users to release resources as soon as they are not needed. So, clouds must implement features to allow efficient trading of service such as pricing, accounting, and billing. Metering should be done accordingly for different types of service (e.g., storage, processing, and bandwidth) and usage promptly reported, thus providing greater transparency.

C. Elasticity

Cloud computing gives the illusion of infinite computing resources available on demand. Therefore users expect clouds to rapidly provide resources in any quantity at any time. In particular, it is expected that the additional resources can be (a) provisioned automatically, when an application load increases and (b) released when load decreases i.e., scale up and down.

D. Customization

In a multi-tenant cloud, there is difference in user requirements. Thus, resources rented from the cloud must be highly customizable. In the case of infrastructure services, customization means allowing users to deploy specialized virtual appliances and to be given privileged (root) access to the virtual servers. Other service classes (PaaS and SaaS) offer less flexibility and are not suitable for general-purpose computing [5], but still are expected to provide a certain level of customization.

V. CHALLENGES AND RISKS IN CLOUD COMPUTING

Inspite of many advantages of this new paradigm cloud computing, there are some challenges [5] and risks that should be considered by providers, developers and end users before making any move towards it. The challenges and risks are as follows:

A. Security, privacy and trust

Public clouds are created over internet, hence, they are always exposed to attackers. Security is a challenge inorder to make cloud computing as secure as in house IT systems. At the same time, existing, technologies can be leveraged, such as data encryption, VLANs, and firewalls. Cloud is used to store massive data of third parties, so the trust toward providers is fundamental to ensure the desired level of privacy for applications hosted in the cloud [5]. When data are moved into the Cloud, providers may choose to locate them anywhere on the planet. The physical location of data centers determines the set of laws that can be applied to the management of data. For example, specific cryptography techniques could not be used because they are not allowed in some countries. Similarly, country laws can impose that sensitive data, such as patient health records, are to be stored within national borders.

B. Data lock-in and standardization

A major concern of cloud computing users is about having their data locked-in by a certain provider [5]. Users may want to move data and applications out from a provider that does not meet their requirements. However, in their current form, cloud computing infrastructures and platforms do not employ standard methods of storing user data and applications. Consequently, they do not interoperate and user data are not portable. The answer to this concern is standardization. In this direction, there are efforts to create open standards for cloud computing. The Cloud Computing Interoperability Forum (CCIF) was formed by organizations such as Intel, Sun, and Cisco in order to "enable a global cloud computing ecosystem whereby organizations are able to seamlessly work together for the purposes for wider industry adoption of cloud computing technology." The development of the Unified Cloud Interface (UCI) by CCIF aims at creating a standard programmatic point of access to an entire cloud infrastructure [5].

C. Availability, fault tolerance and disaster recovery

User expects some of the services from providers after user's application are moved to the cloud. These expectations include availability of the service, its overall performance, and what measures are to be taken if anything goes wrong to the cloud. SLAs, which include QoS requirements, must be ideally set up between customers and cloud computing providers to act as warranty. An SLA specifies the details of the service to be provided, including availability and performance guarantees [5]. Additionally, metrics must be agreed upon by all parties, and penalties for violating the expectations must also be approved.

D. Resource management and energy efficiency

One important challenge faced by providers of cloud computing services is the efficient management of virtualized resource pools. Physical resources such as CPU cores, disk space, and network bandwidth must be sliced and shared among virtual machines. These virtual machines need to be allocated on physical hosts. For VM allocations dimensions such as number of CPUs, amount of memory, size of virtual disks, and network bandwidth. Dynamic VM mapping policies may leverage the ability to suspend, migrate, and resume VMs as an easy way of preempting low-priority allocations in favor of higher-priority ones. Migration of VMs also brings additional challenges such as detecting when to initiate a migration, which VM to migrate, and where to migrate [5].

Another challenge concerns the outstanding amount of data to be managed in various VM management activities. Such data amount is a result of particular abilities of virtual machines, including the ability of traveling through space (i.e., migration) and time (i.e., checkpointing and rewinding), operations that may be required in load balancing, backup, and recovery scenarios. Data centers consumer large amounts of electricity. According to a data published by HP [6], 100 server racks can consume 1.3MWof power and another 1.3 MW are required by the cooling system, thus costing USD 2.6 million per year. Besides the monetary cost, data centers significantly impact the environment in terms of CO2 emissions from the cooling systems.

In addition to optimize application performance, dynamic resource management can also improve utilization and consequently minimize energy consumption in data centers. This can be done by judiciously consolidating workload onto smaller number of servers and turning off idle resources.

VI. CONCLUSION

Cloud computing is a new paradigm of computing facility that promises to provide more flexibility, less expensive, and more efficiency in IT services to end users. Firstly this paper presents an introduction to cloud computing and discuss about on the different types of service models such IaaS, PaaS and SaaS. The paper also discuss about deployment models such as private cloud, public cloud and hybrid cloud. Towards the end, desired features and challenges cloud may face are elaborated

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