Cloud Computing Models : A Survey

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Abstract

This study paper deals with various service models and deployment models provided by cloud. Cloud computing is the delivering of compute services such as databases, storage facilities, virtual machines, servers etc. Thus, cloud reduces the cost for infrastructure and maintenance, which in turn will allow the enterprises to focus on core business processes. Cloud also allows the users to pool the resources to its users effectively and efficiently. According to NIST, there are three recognized service models and three recognized deployment models. Service models include IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service). Deployment models include Public cloud, Private cloud, Community cloud and Hybrid cloud. This study paper discusses these models, along with the other models which are provided by the cloud and service providers who provide these kinds of services, in detail.

Keywords: Virtual Machines, Public Cloud, Infrastructure, Deployment Models, Service Models.

I. INTRODUCTION

Cloud computing is an internet based computing which helps in sharing various processed resources and data to computers and other devices. Cloud computing is one of the booming technologies which provides many services such as, computing, databases, storages, virtual machines, servers, analytics, machine intelligence and many more. Cloud provides these services over internet which makes it scalable and hence helps the enterprises to eliminate the capital expenditure on purchasing hardware for their organizations. According to NIST, Cloud computing is defined as "A model for enabling ubiquitous, convenient or demand network access to a shared pool of configurable computing resources that can be rapidly provisional and related with minimal management effort or service provider interaction."[4] Self-service, Rapid elasticity and scalability, reduced costs, broad network access, increased performance and productivity, reliability, service-oriented, utility-based pricing and resource pooling are some of the known features of cloud. [5] Cloud provides models for using these services for the user.

There are two types of cloud models- Service models and Deployment models. Service models are classified on the basis of the types of services provided by the cloud, whereas Deployment models are classified on the basis of how and by whom the cloud services are used. Service models are broadly classified to three types: IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service). These three models are recognized by NIST officially. There are many other known services by cloud such as MBaas (Mobile Backend as a Service), DaaS (Data as a Service), MaaS (Monitoring as a Service) etc. Deployment models include public cloud, private cloud, community cloud and hybrid cloud. There are other deployment models for cloud such as Inter cloud, Distributed cloud etc.
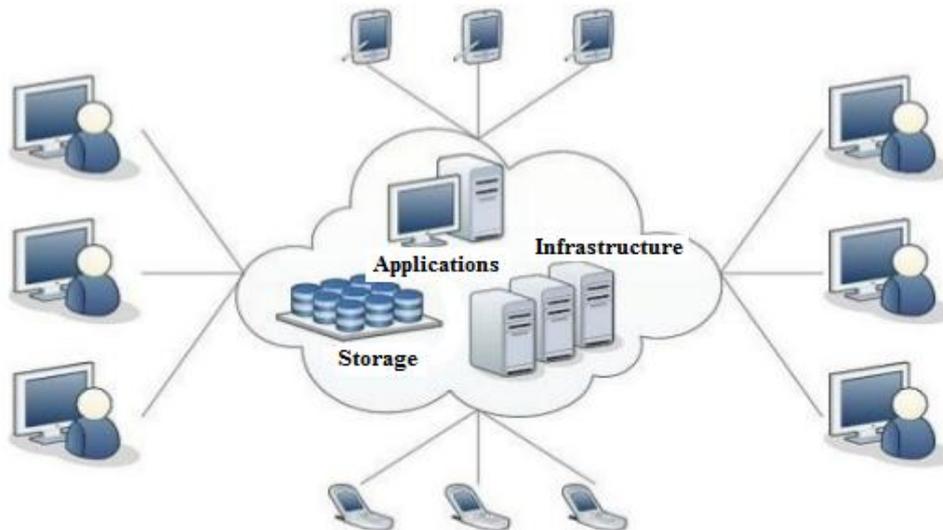

Fig : Cloud Computing Architecture

IaaS stands for Infrastructure as a Service. This service models rents the basic infrastructure facilities such as virtual machines and servers. It is the most basic service provided by the cloud. PaaS stands for Platform as a Service. This service model supplies the required on-demand environment or platform for developing, testing, deploying and maintaining software applications. It is designed to develop and test web and mobile applications easily for the developer. SaaS stands for Software as a Service. This service model provides the facility to host and manage software applications over the internet along with the necessary infrastructure and maintenances such as security and updates for the software application. A public cloud hosts the cloud services over the internet by a third party service provider and is available for public use. A private cloud is used exclusively by a single organization or a business. Hybrid cloud is a combination of both public cloud and private cloud and provides greater flexibility for the organizations. Community cloud is managed by a community or a group of organizations.

II. RELATED WORK

IlangoSriram et al[6]. go through more definitions of cloud computing and proposed the following definition:

Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for optimum resource utilization. Typically these pool of resources exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized SLAs.

Imran Ashraf [7] states that:

Cloud computing is being embraced by manyfields and is most adoptable field of information technology at the moment. Due to its pay-per-use principle it is becoming very attractive and competitive solutions for even small organizations who cannot afford to have their own hardware or software infrastructure. Moreover, it's on demand changing scalability has made it very viable solution for organizations who need to change their acquired services with the changing workload. Apart from being simple and easy to use it has other advantages over traditional framework. It works in distributed environment and serves the user according to his needs. Users just need to have internet to connect to the services and it is accessible from everywhere. It has minimized cost, improved throughput, and fast access of software and hardware resources and can scale readily and easily as required.

Eugene Gorelik[8] proposed that:

Cloud computing begin with the huge IT transformation in history, and this transformation has opened many new business opportunities. It is expected that public

clouds will provide most of the opportunities for cloud service providers. According to a recent survey conducted by Morgan Stanley, the percentage of companies using a public cloud is expected to rise to 51% though 2013.

IEEE states the use cases of the service models:

- IaaS is easily used for website hosting, where a web server and operating system stack are put on VM's, where they can easily take advantage of cloud features such as easy scaling, global availability, managed environment, geographical load balancing, special content delivery front-end or infrastructure.

- PaaS is good for deploying applications which came from an "applications container" world before like J2EE or .NET. In fact PaaS systems such as Red Hat Open Shift or Cloud Foundry from IBM or Pivotal are very much like J2EE, and Windows Azure from Microsoft is very much like .NET

- In the Mobile world SaaS is known as "an app", because the front end User Interface sits on the phone, while the back end sits in the cloud. In fact while many Mobile apps don't look like it, they are built with the reconfigurable Mobile version of a browser called Web Kit. [9]

Santosh Kumar and R. H. Goudar [10] state that Cloud Computing is the development of parallel computing, distributed computing, grid computing, and is the combination and evolution of Virtualization, Utility computing, Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS). Cloud is a metaphor to describe web as a space where computing has been pre-installed and exist as a service, data, operating systems, applications, storage and processing power exist on the web ready to be shared. To users, cloud computing is a Pay-per-Use-On-Demand mode that can conveniently access shared IT resources through the Internet.

Imran Ashraf compares the service models as:

A. IaaS: The core computing resources are hardware and software components. They lay the foundations of every computing infrastructure.

B. PaaS: Platform as a service provides a development platform toits users so that they can develop and maintain their applications and cloud specific utilities.

C. SaaS: It is different than traditional software services, where traditional software need own hardware and software components, Where SaaS makes users, independent of their own resources. [7]

KalpanaParsi and M.Laharika[11] state that:

❖ A public cloud is the obvious choice when:

➢ Public Cloud Computing is the easiest of cloud solutions to setup and maintain and is the preferred choice of most small scale and start-up enterprises, that

don't require high data security measures. These companies often don't have much capital and have less risk in losing information due to theft or security breaches.

➢ Your standardized workload for applications is used by lots of people, such as e-mail.

➢ You need to test and develop application code.

❖ A private cloud is the obvious choice when

➢ Private cloud has been adopted by industries when security is something of primary concern such as finance and health care which have some of the most rigorous compliance requirements. Your business is your data and your applications. Therefore, control and security are paramount.

➢ Your business is part of an industry that must conform to strict security and data privacy issues.

❖ A hybrid environment is best choice when.

➢ Your company wants to use a SaaS application but is concerned about security. Your SaaS vendor can create a private cloud just for your company inside their firewall. They provide you with a virtual private network (VPN) for additional security.

➢ Your company offers services that are tailored for different vertical markets. You can use a public cloud to interact with the clients but keep their data secured within a private cloud.

C Weinhardt, A Anandasivam, B Blau[12] state that:

Current trends in Cloud Computing expose a strong ambition to close these gaps and to establish existing concepts and technologies within the business world. Consequently, these trends motivate companies to incorporate innovative business models focusing on various aspects of Cloud Computing.

III. SERVICE MODELS

Cloud supports XaaS (Everything as a Service), but offers its services as three major service models recognized as IaaS, PaaS and SaaS. Now we discuss these models in detail.

1. Infrastructure as a Service(IaaS)

This service model delivers computer infrastructure as a service. This service is made available as a platform for virtualized machines. Unlike, traditional hardware machines which require special maintenance and limited flexibility, cloud makes these machines easily available virtually on the internet with flexible specifications and improved performance, optimized according to the requirements of the customer.

Developers can run the platforms necessary for their software development and run them. This service also makes it easy for the customer to create instance for his required virtual machine simple and easy. In most of the cloud services provided by various service providers, setting up of virtual machines can be done with no or less cost. Cloud provides this virtualization feature in the form of containers. A direct virtual machine needs a hypervisor on its hardware above the kernel for efficient virtualization whereas containerization doesn't need a hypervisor which saves the processor efficiency and improves its performance. And also, container size is flexible i.e., it can be changed dynamically, hence eliminates over-provisioning. Generally, these virtual machines are installed as a form disk images, object, load balancers or IP addresses which can be dynamically installed on the cloud and also ensure the security of the virtual machine by allotting the virtual instance with a unique host address each time installed. These virtual instances are pre-installed on large pools of equipment called data centers. These virtual machines are billed by the service providers on the utility computing basis.

The general virtual components which can be offered by IaaS are-

1. Computer Hardware

2. Computer Networks (such as routers, firewalls, load balancers etc.)

3. Internet Connectivity (using optical carriers)

4. Platform virtualization environment for running client-specified virtual machines.

5. Service level agreements.

Advantages of IaaS are:

1. Readily available environment, customized for client, promotes efficient IT services.

2. Maintenance such as software updates, latest versions can be readily available on the internet.

3. Reduces the maintenance cost for the hardware which is quite expensive.

4. Data stored on the virtual machine is secured and can be recovered in case of any failure of host allocation.

5. Can accommodate many virtual instances as per the demand.

6. Virtual instances can be rented for machines like servers, operating systems, networks as a fully outsourced service.

Some of the IaaS service providers are:

1. Amazon Elastic Cloud Compute (EC2) service from Amazon Web Services by Amazon.

2. Google Compute Engine from Google Cloud Services by Google.

3. Windows Azure Virtual Machines from Windows Azure by Microsoft.

4. IBM Smart Cloud Enterprise by IBM.

5. HP Enterprise Converged Infrastructure from HP.

2. Platform as a Service(PaaS)

This service model delivers platforms for building and running web-based applications. It provides all the facilities required to support the complete software development life cycle. This service basically delivers a computing platform for the customer who includes operating system, programming platforms, web servers, databases etc. Since everything is run on internet, there is no need to worry about the infrastructure and minimum requirements for the platform. This model can hence eliminates the worry of incompatibility of software environment on the machine, since hardware specifications required by the platform are met by the cloud service provider directly, thus providing powerful and unlimited computing power. Anyone with an internet connection can now develop powerful and efficient applications without worrying about the infrastructural and cost issues. The traditional on premise models were expensive and complex, which required specific, set of hardware and software specifications. For every problem statement, there is a different business solution, which meant different set of hardware and software specifications. This situation used to force the developers to change the application every now and then. Enormous electricity power was also required to run the hardware. With the entry of PaaS model of cloud, application development became quick, cost effective and efficient. PaaS provides infrastructure along with the workflow facilities required for the software development. It also provides application services for the software development such as security, storage, database integration, instrumentation etc. Another characteristic of PaaS models is the integration of web and mobile applications and services with the databases using Simple Object Access Protocol.

PaaS consists of three main components

1. Stack- consisting of all the backend implementation components such as language virtual machine, servers, databases load balancers, caching mechanisms etc.

2. Deployment Machinery- consisting of scripts and services for deploying the developed applications on the internet.

3. User Experience- consisting of all the frontend components such as user interface, customized abstraction, flexibility to choose the environments and design.

Advantages of Paas are:

1. Can develop and deploy agile applications.

2. Can focus on the important resources for the enterprise without worrying about the cost of infrastructure.

3. The platforms provided by a PaaS provider are revised editions which are updated time to time, thus applications can be built using best technologies.

4. Maximizes the productivity and minimized the development time.

5. Doesn't require the developer to know the backend processes of the platform environment of the cloud.

Some of the PaaS service providers are:

1. Google App Engine by Google Cloud services from Google.

2. Windows Azure PaaS services by Windows Azure from Microsoft.

3. Amazon Elastic BeanStalk by Amazon Web Services from Amazon.

4. Openshift by Red Hat from Linux.

5. Engine Yard run on Amazon Web Services by Amazon.

3. Software as a Service(SaaS)

This service model provides the access to the application services and databases. Cloud providers take care of the infrastructure and platforms required to run the software applications on the Internet. It is sometimes referred to as 'on-demand software', which can be used after paying the subscription fees. In this model, cloud users directly install the subscribed applications on the cloud and directly access the software from their cloud clients. The cloud users need not manage the necessary infrastructure or the platforms required to run the software application. Some of the SaaS applications are Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), accounting and other business software, which are mainly non-core-competency software. Most of the companies today opt for SaaS solutions, which don't require the employee to know the infrastructure, background logics and platform details to run the application. Instead he can just install the application on the cloud and run the application as a browser based service on the Internet. The present day advancements in cloud make it easier for the customer to use these SaaS applications anywhere at any time. These applications can be used on a web browser or a program interface without having to manage the specifications of the software. These applications have limited user-specific configuration settings which abstract most of the complex background details, making it easier for the user to deploy these applications.

Features of SaaS-

1. Can manage applications on a strong network and access to licensed software at low costs.

2. Follows Multitenancy model.

3. Customer specific enhancements of the software.

Advantages of SaaS are:

1. Easily available software reduces the time required for the application development.

2. Increases the availability of the applications globally.

3. Data consistency and compatibility across the company/organization/enterprise.

4. These applications are scalable and flexible.

5. The updated versions of the SaaS software are looked after by the service providers.

Some of the SaaS service providers are:

1. Salesforce CRM from Salesforce.

2. Oracle CRM from Oracle On-Demand from Oracle.

3. SAP ERP and SAP CRM by SAP Business By Design from SAP.

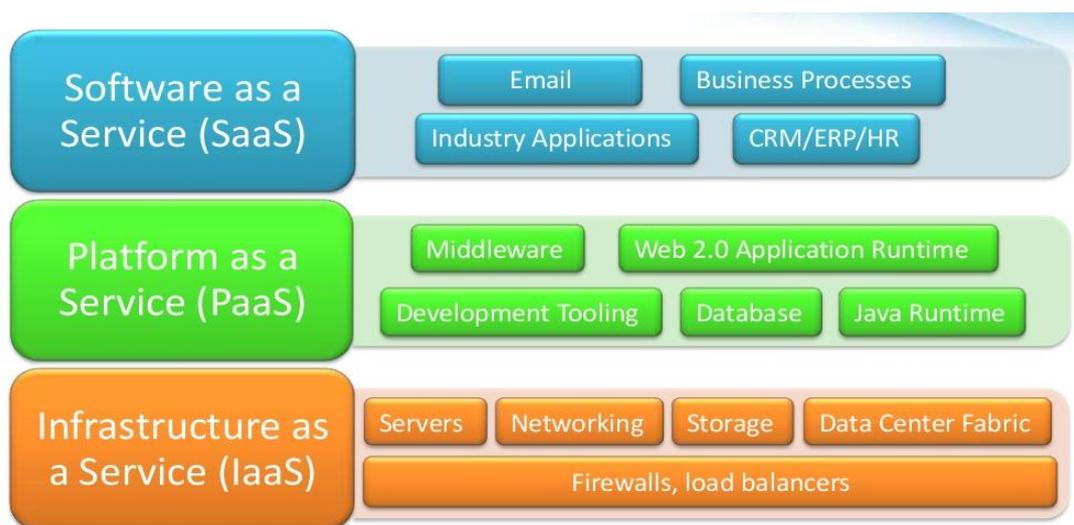4. SaaS applications and services from Cloud9 Analytics.

Fig : Service models and Services

Apart from these three service models, there are other service models of the cloud. Some of them are:

4. Communication as a Service(CaaS)

This service model is responsible for managing hardware and software required for communication services such as Voice over IP (VoIP), Instant Messaging (IM), Collaboration and Video conferencing capabilities using fixed and mobile devices. This service model offers guaranteed Quality of Service (QoS), flexibility and expandability of small or medium -sized businesses which cannot afford the cost for devices or modes. This model allows the user/customer to select the types of communication services which are to be deployed by the organization for their core business processes. Network Capacity and feature sets can be changed dynamically, so that these small or medium-sized businesses can keep their pace with premium enterprises in the market. This service model needs little to no management, hence alleviates the cost for maintenance and operations overhead. It also allows the customer to pay for the required communication services easily. Forrester Research is one of the vendors which provide CaaS solutions.

Some of the communication features provided by CaaS are:

1. Chat

2. Multimedia Conferencing

3. Real-time interfacing

4. Software based telephones

5. Video Conferencing

6. Unified messaging and mobility.

5. Data as a Service(DaaS)

This service model provides data on demand to the customers, without any constraint of geographical or organizational distance between the customer and the service provider. This service primarily was started by web mashups in 2015, and now an extensively used feature by organizations such as UN. The primary reason for this service model to come into existence is the increasing costs for combined software and data customer packages, and the necessary EAI (Enterprise Application Integration) middleware, which act as an interface between the software and data. This service model separates the data cost and data usage from the cost of the software or the environment required to run it, making itself attractive to the customers. The pricing for this model is done either on the basis of the volume of the data required or the type of the data required. Hence, now customers can easily access the business data on the cloud platform with an existing data center. This service

model ensures the agility in accessing data, quality of data provided and also cost effective for the enterprises. Advancements are made on this service model to launch it as Big Data as a Service (BDaaS). Oracle and Informatica Cloud are some of the vendors who provide DaaS solutions.

6. Disaster Recovery as a Service(DRaaS)

It is also referred to as Recovery as a Service (RaaS), which provides protection of the application or data in the cloud at the times of natural or human disaster or interruption in the service at any location, and also ensuring the full recovery of the application or data to the customer when needed. The customer can pay for this service only when needed, which makes this service more efficient than the traditional sites for data recovery. This service model uses sandboxes for its implementation. These sandboxes contain RaaS protected copy of the application or data which is accessible to no one but the system administrator. The protected applications can be tested and deployed in the sandbox without causing interruption to the main application running in the cloud. And thus at the time of any sudden disaster or calamity, then the customer can pay for this service and use it, and discard once using it. We can also use this service by replicating and hosting of physical or virtual servers. With this service model, data and applications are secured and also the time for recovery from the traditional sites is reduced. Veeam and IBM DRaaS and Consulting, are some of the vendors who provide DRaaS solutions.

7. Mobile Backend as a Service(MBaaS)

It is also referred as Backend as a Service (BaaS), which delivers a model for the web and mobile applications developers for linking their applications to the backend cloud storage. It also provides application interfaces for other services such as push notifications, integration with social networking services and user management, in the backend. Most of the service providers who provide BaaS solutions focus on providing SDKs and APIs for web and mobile application development compatible with operating systems and web languages such as iOS, Android, Windows, Blackberry, HTML 5 and others. This service, though a commercial service, also gives open source options to the user. Customer can pay for the set of APIs and SDKs as a package which are required for developing his/her own web/mobile based application exclusively. This service model reduces the burden of extensive and complex coding on the developer, because of availability of APIs readily in the cloud. Efficient applications can be developed since these APIs are lighter in weight and also powerfully developed. Developers can easily abstract the server side infrastructure while using this service model. Firebase from Google, MBaaS services from Windows Azure, and Kumulos, are some of the vendors who provide MBaaS solutions.

8. MaaS (Monitoring as a Service)

It is a service which is mean to monitor a certain part of an application, server or any other IT device. This service helps in monitoring many other applications and services running within the cloud. Online state monitoring is the most common service of MaaS model. This state monitoring service continuously monitors and tracks the instances, networks, applications deployed within the cloud. This service is mainly used by organizations to regulate and monitor their security, server logs, and integrity of their systems. For maintaining the confidentiality, integrity and availability of IT assets and this is done by a strong security team. MaaS provides real time monitoring services to the organizations, and immediate incident response across a strong security infrastructure. This service model is based on Security Operations Centers (SOCs) []. This kind of model improves customer security infrastructure, and quickly detects threats. These monitoring services also keep a log of events happening within the cloud and hence can report to the customer in case of any log-in failures. Flexibility and scalability is offered to all the available instances in the cloud effectively. Amazon Web Services and Monitis are some of the vendors who provide MaaS solutions.

IV. DEPLOYMENT MODELS

There are four major deployment models of cloud recognized by NIST.

1. Public cloud

This deployment model of cloud renders all its applications and services available and open to public use, over a network. These services may be free most of the times. The user can meet his needs for little or no cost sometimes. These clouds can be used by anyone, a single user or an organization. Some of the known public clouds are Amazon Web Services, Google AppEngine, Windows Azure, IBM Blue Cloud, etc.

2. Private cloud

This deployment model of cloud is operated by a single organization. It can be managed by the organization itself, or by a third party service provider, located internally or externally. This kind of cloud is preferred by the businesses with dynamic needs and which require direct control to the work environment. Some of the private clouds are Amazon Private Cloud by Amazon Web Services, SUSE Open Stack Private Cloud, etc.
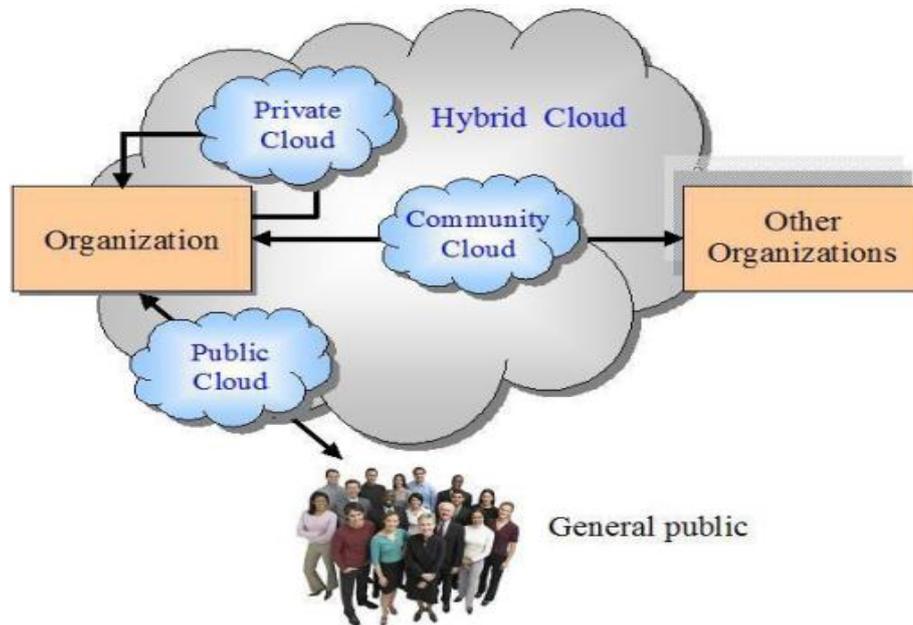
Fig : Deployment Models

3. Community cloud

This deployment cloud is operated by a community of group of organizations which share common concerns such as storage or security. These clouds can also be hosted and managed, both internally and externally. This model of cloud follows multi-tenant infrastructure. Some of the community clouds are Salesforce and QTS DataCenters.

4. Hybrid cloud

This deployment cloud is a combination of two or more clouds (public, private or community). In this model, the privacy of the organization along with the availability for multi-tenancy with the ability to connect with other organizations is satisfied. For example, an organization uses a private cloud to store its client-sensitive data, uses community cloud to connect with other similar organizations and uses a public cloud that connect a business intelligence tool to a software application. Some of the hybrid clouds are RackSpace and SoftLayer.com.

Other deployment clouds are like :

1. Distributed cloud

If a cloud computing platform is distributed across different locations on different machines, then that kind of cloud model is called distributed model. There are two types of distributed clouds- public resource cloud and volunteer cloud. This model can provide fast and responsive communication services globally.

2. Inter Cloud

It is known as cloud of clouds. Here each cloud can use the computational capacity and other infrastructure resources of other clouds simultaneously for generating effective and productive solutions. Cisco uses Inter Cloud.

3. Multi Cloud

It is the use of multiple cloud computing resources under a single heterogeneous architecture. These kinds of clouds are used to minimize the loss of data or any other component in the cloud. This kind of cloud improves overall performance of the cloud.

V. CONCLUSION

Cloud Computing can be beneficial to all those embryonic businesses which are in the stage of development. The services and deployment models provided by cloud form the basic functionality of cloud. Cloud computing, thus, provides the benefits of resources at economical scale, with flexibility, scalability and multi-tenancy. Cloud can be the platform for executing all the crucial and core business processes.

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