Introduction to Cloud Computing

When you store your photos online instead of on your home computer, or use webmail or a social networking site, you are using a “cloud computing” service. If you are an organization, and you want to use, for example, an online invoicing service instead of updating the in-house one you have been using for many years, that online invoicing service is a “cloud computing” service.

Cloud computing refers to the delivery of computing resources over the Internet. Instead of keeping data on your own hard drive or updating applications for your needs, you use a service over the Internet, at another location, to store your information or use its applications. Doing so may give rise to certain privacy implications.

Cloud computing is the delivery of computing services over the Internet. Cloud services allow individuals and businesses to use software and hardware that are managed by third parties at remote locations. Examples of cloud services include online file storage, social networking sites, webmail, and online business applications. The cloud computing model allows access to information and computer resources from anywhere that a network connection is available. Cloud computing provides a shared pool of resources, including data storage space, networks, computer processing power, and specialized corporate and user applications.

Simply put, cloud computing is the delivery of computing services over the Internet. Whether they realize it or not, many people use cloud computing services for their own personal needs. For example, many people use social networking sites or webmail, and these are cloud services. Photographs that people once kept on their own computers are now being stored on servers owned by third parties. These are also examples of cloud services.

Cloud services are popular because people can access their e-mail, social networking site or photo service from anywhere in the world, at any time, at minimal or no charge. Some cloud providers may, however, use the personal information of users for advertising purposes or to learn more about the users for other reasons. The Office of the Privacy Commissioner of Canada (OPC) has been critical of some of these practices, largely because they occur without individuals fully realizing how their personal information is being used “in the cloud.” Individuals should pay careful attention to whether and how the cloud company protects their personal information. Users should also protect their own personal information by using any privacy settings that the service may offer.

History of Cloud Computing

One of the first questions asked with the introduction of a new technology is: “When was it invented?” Other questions like “When was it first mentioned?” and “What are the prospects for its future?” are also common.

When we think of cloud computing, we think of situations, products and ideas that started in the 21st century. This is not exactly the whole truth. Cloud concepts have existed for many years. Here, I will take you back to that time.

It was a gradual evolution that started in the 1950s with mainframe computing.

Multiple users were capable of accessing a central computer through dumb terminals, whose only function was to provide access to the mainframe. Because of the costs to buy and maintain mainframe computers, it was not practical for an organization to buy and maintain one for every employee. Nor did the typical user need the large (at the time) storage capacity and processing power that a mainframe provided. Providing shared access to a single resource was the solution that made economical sense for this sophisticated piece of technology.

(**Related:** Infographic: A brief history of cloud — 1950s to present day)

After some time, around 1970, the concept of virtual machines (VMs) was created.

Using virtualization software like VMware, it became possible to execute one or more operating systems simultaneously in an isolated environment. Complete computers (virtual) could be executed inside one physical hardware which in turn can run a completely different operating system.

The VM operating system took the 1950s’ shared access mainframe to the next level, permitting multiple distinct computing environments to reside on one physical environment. Virtualization came to drive the technology, and was an important catalyst in the communication and information evolution.

In the 1990s, telecommunications companies started offering virtualized private network connections.

Historically, telecommunications companies only offered single dedicated point–to-point data connections. The newly offered virtualized private network connections had the same service quality as their dedicated services at a reduced cost. Instead of building out physical infrastructure to allow for more users to have their own connections, telecommunications companies were now able to provide users with shared access to the same physical infrastructure.

The following list briefly explains the evolution of cloud computing:

- Grid computing: Solving large problems with parallel computing
- Utility computing: Offering computing resources as a metered service
- SaaS: Network-based subscriptions to applications
- Cloud computing: Anytime, anywhere access to IT resources delivered dynamically as a service

Now, let’s talk a bit about the present.

SoftLayer is one of the largest global providers of cloud computing infrastructure.

IBM already has platforms in its portfolio that include private, public and hybrid cloud solutions. The purchase of SoftLayer guarantees an even more comprehensive infrastructure as a service (IaaS) solution. While many companies look to maintain some applications in data centers, many others are moving to public clouds.

Even now, the purchase of bare metal can be modeled in commercial cloud (for example, billing by usage or put another way, physical server billing by the hour). The result of this is that a bare metal server request with all the resources needed, and nothing more, can be delivered with a matter of hours.

Cloud Service Providers

IaaS: Amazon EC2, Google Compute Engine, Azure VMs

Amazon Elastic Compute Cloud (EC2) [3] is an Infrastructure as a Service (IaaS)n offering from Amazon.com.

EC2 (TM) is a web service that provides computing capacity in the form of virtual machines that are launched in Amazon's cloud computing environment. Amazon EC2 allows users to launch instances on demand using a simple web-based interface. Amazon provides pre-configured Amazon Machine Images (AMIs) which are templates of cloud instances.

Users can also create their own AMIs with custom applications, libraries and data. Instances can be launched with a variety of operating stems. Users can load their applications on running instances and rapidly and easily increase or decrease capacity to meet the dynamic application performance requirements.

With EC2, users can even provision hundreds or thousands of server instances simultaneously, manage network access permissions, and monitor usage resources through a web interface. Amazon EC2 provides instances of various computing capacities ranging from small instances (e.g., 1 virtual core with 1EC2 compute unit, 1.7GB memory and 160GB instance storage) to extra large instances (e.g., 4 virtual cores with 2 EC2 compute units each, 15GB memory and 1690 GB instance storage).

Amazon C2 also provides instances with high memory, high CPU resources, cluster compute instances, cluster graphical processor unit (GPU) instances and high Input/Output (I/O) instances. The pricing model tor EC2 instances is based on a pay-per-use model. Users are billed based on the number on instance hours used for on-demand instances. EC2 provides the option of reserving instances by one-time payment for each instance that the user wants to reserve.

In addition to these on-demand and reserved instances, EC2 also provides spot instances that allow users to bid on unused Amazon EC2 capacity and run those instances for as long as their bid exceeds the current spot price. Amazon EC2 provides a number of powerful features for building scalable and reliable applications such as auto scaling and elastic load balancing. Figure 1.5 shows a screenshot of Amazon EC2 dashboard.

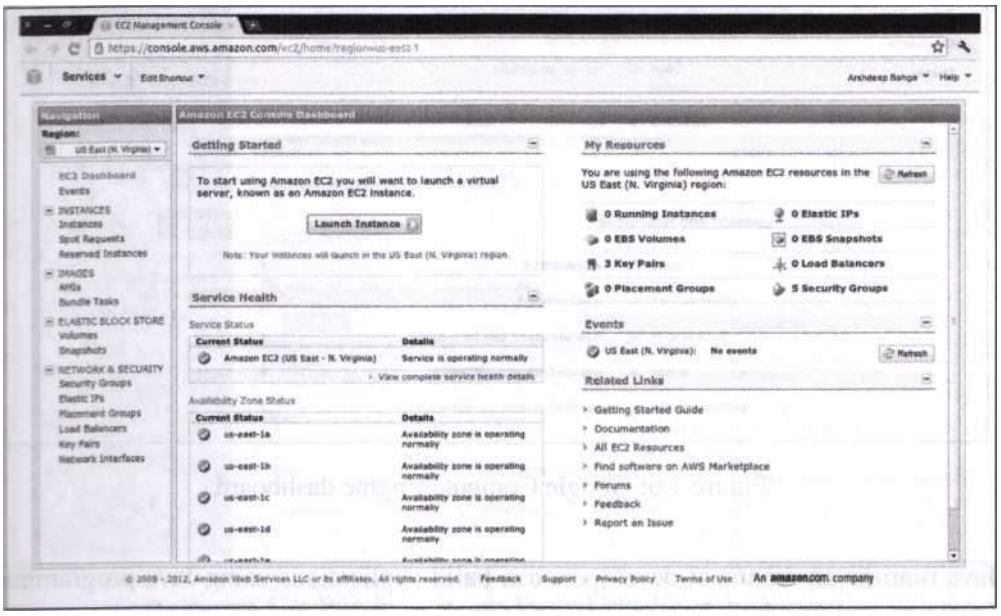

Figure 1.5: Amazon EC2 dashboard

Google Compute Engine (GCE) [4] is an IaaS offering from Google. GCE provides virtual machines of various computing capacities ranging from small instances (e.g., virtual core with 1.38 GCE unit and 1.7GB memory) to high memory machine types (e.g., 8 virtual cores with 22 GCE units and 52GB memory). Figure 1.6 shows a screenshot of Google Compute Engine dashboard.

Windows Azure Virtual Machines [83] is an IaaS offering from Microsoft. Azure VMs provides virtual machines of various computing capacities ranging from small instances (1 virtual core with 1.75GB memory) to memory intensive machine types (8 virtual cores with 56GB memory). Figure 1.7 shows a screenshot of Windows Azure Virtual Machines dashboard.

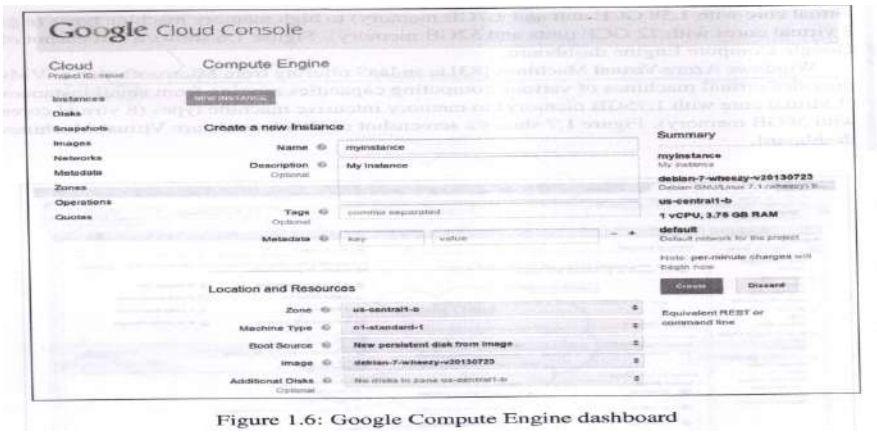

Figure 1.6: Google Compute Engine dashboard

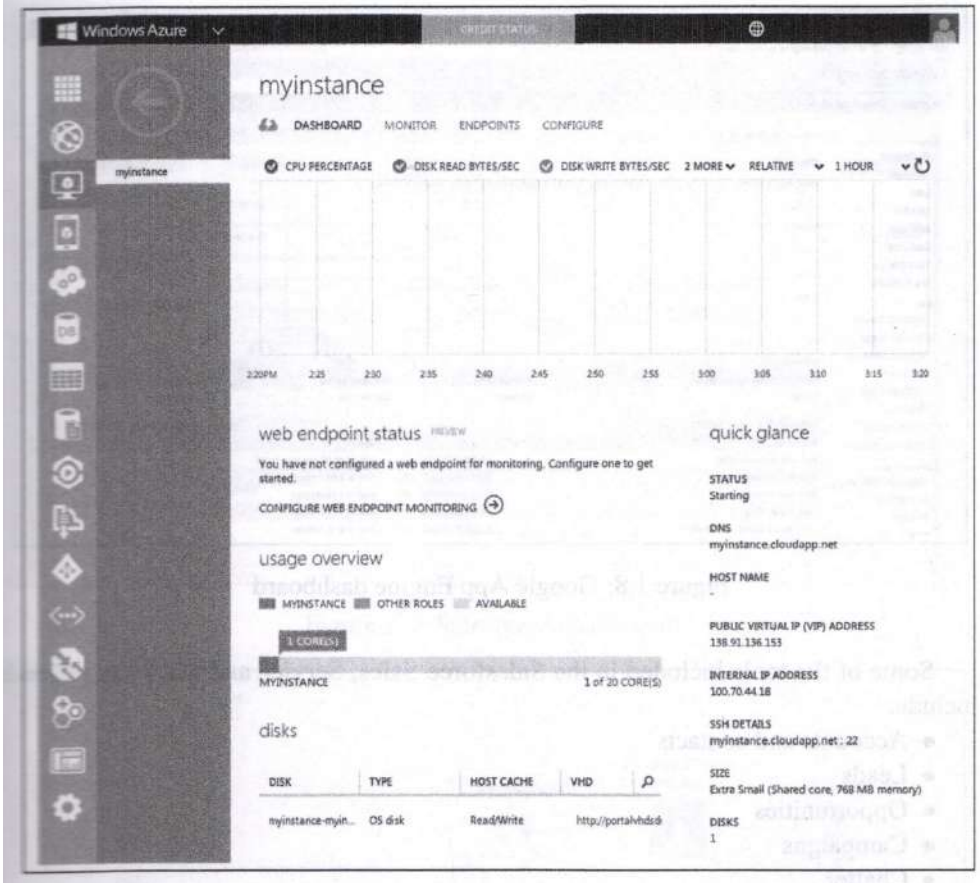

Figure 1.7: Windows Azure Virtual Machines dashboard

PaaS: Google App Engine

Google App Engine (GAE) [105] is a Platfonn-as-a-Service (PaaS) offering from Google. GAE(TM) is a cloud-based web service for hosting web applications and storing data. **GAE** allows users to build scalable and reliable applications that run on the same systems ihai power Google's own applications.

GAE provides a software development kit (SDK) for developing web applications software that can be deployed on GAE. Developers can 3e% elop and test their applications with GAE SDK on a local machine and then upload it

GAE with a simple click of a button. Applications hosted in GAE are easy to build, maintain and scale. Users don't need to worry about launching additional computing :_-'tances when the application load increases. GAE provides seamless scalability by -Lunching additional instances when application load increases. GAE provides dynamic »eb serving based on common web technologies. Applications hosted in GAE can use r.namic technologies.

GAE provides automatic scaling and load balancing capability. GAE supports applications written in several programming languages. With GAE's Java runtime environment developers can build applications using Java programming language and standard Java technologies such as Java Servlets.

GAE also provides runtime environments for Python and Go programming languages. Applications hosted in GAE run in secure sandbox with limited access to the underlying operating system and hardware. The benefit of hosting applications in separate sandboxes is that GAE can distribute web requests for applications across multiple servers thus providing scalability and security.

The pricing model for GAE is based on the amount of computing resources used. GAE provides free computing resources for applications up to a certain limit. Beyond that limit, users are billed based on the amount of computing resources used, such as amount bandwidth consumed, number of resources instance hours for front-end and back-end instances, amount of stored data, channels, and recipients emailed. Figure 1.8 shows a screenshot of GAE dashboard.

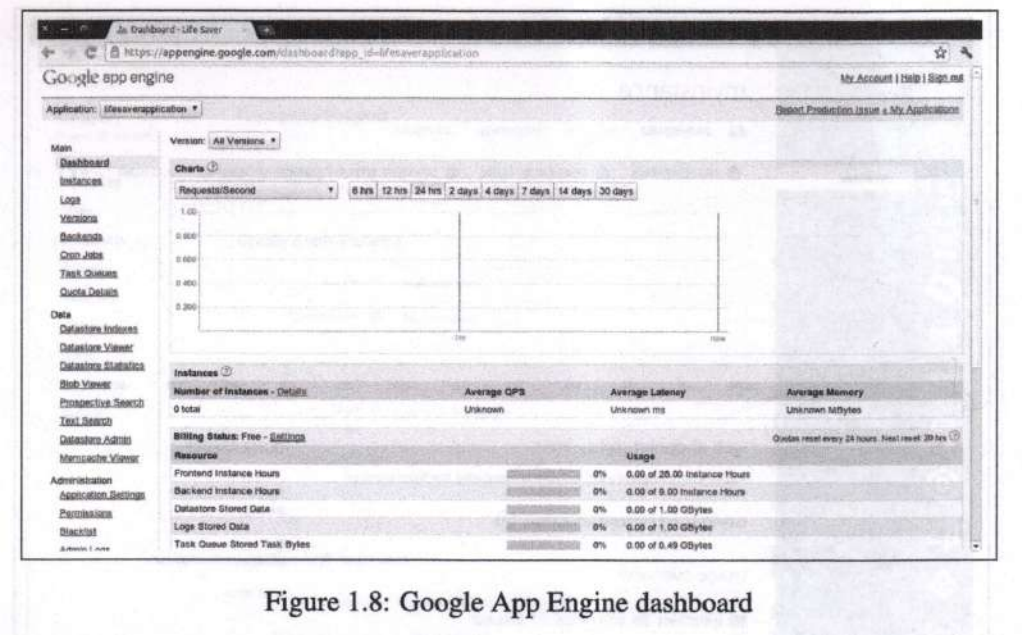

Figure 1.8: Google App Engine dashboard

1.4.3 SaaS: Salesforce

Salesforce [7] Sales Cloud(TM) is a cloud-based customer relationship management (CRM) Software-as-a-Service (SaaS) offering. Users can access CRM application from anywhere through internet-enabled devices such as workstations, laptops, tablets

and smartphones. Sales Cloud allows sales representatives to manage customer profiles, track opportunities, optimize campaigns from lead to close and monitor the impact of **campaigns.**

Salesforce Service Cloud (TM) is a cloud based customer service management SaaS. Serv ice Cloud provides companies a call-center like view and allows creating, tracking,

- uting and escalating cases. Service Cloud can be fully integrated with a company’s -.enter telephony and back office apps. Service Cloud also provides self service . _r abilities to customers. Service Cloud includes a social networking plug-in that enables social customer service where comments from social media channels can be used to answer customer questions.

Salesforce Marketing Cloud (TM) is cloud based social marketing SaaS. Marketing _ : ud allows companies to identify sales leads from social media, discover advocates, identify the most trending information on any topic. Marketing Cloud allows companies k r:o-actively engage with customers, manage social listening, create and deploy social :; -.tent, manage and execute optimized social advertisement campaigns and track the rerformance of social campaigns. Figure 1.9 shows a screenshot of Salesforce dashboard.

Some of the tools included in the Salesforce Sales, Service and Marketing Clouds include:

- Accounts and contacts
- Leads
- Opportunities
- Campaigns
- Chatter

Characteristics of Cloud Computing

Ther are five essential characteristics of cloud computing:

On-demand self service
Cloud computing resources can be provisioned on-demand by the users, without requiring interactions with the cloud service provider. The process of provisioning resources is automated.

Broad network access
Cloud computing resources can be accessed over the network using standard access mechanisms that provide platform-independent access through the use of heterogeneous client platforms such as workstations, laptops, tablets and smartphones.

Resource pooling
The computing and storage resources provided by cloud service providers are pooled to serve multiple users using multi-tenancy. Multi-tenant aspects of the cloud allow multiple users to be served by the same physical hardware. Users are assigned virtual resources that run on top of the physical resources.

Rapid elasticity
Cloud computing resources can be provisioned rapidly and elastically. Cloud resources can be rapidly scaled up or down based on demand. Two types of scaling options exist:

- **Horizontal Scaling (scaling out):** Horizontal scaling or scaling-out involves launching and provisioning additional server resources.

- **Vertical Scaling (scaling up):** Vertical scaling or scaling-up involves changing the computing capacity assigned to the server resources while keeping the number of server resources constant.
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Measured service
Cloud computing resources are provided to users on a pay-per-use model. The usage of the cloud resources is measured and the user is charged based on some specific metric. Metrics such as amount of CPU cycles used, amount of storage space used, number of network I/O requests, etc. are used to calculate the usage charges for the cloud resources.

In addition to these five essential characteristics of cloud computing, other characteristics that again highlight savings in cost include:

Performance
Cloud computing provides improved performance for applications since the resources available to the applications can be scaled up or down based on the dynamic application workloads.

Reduced costs
Cloud computing provides cost benefits for applications as only as much computing and storage resources as required can be provisioned dynamically, and upfront investment in purchase of computing assets to cover worst case requirements is avoid. This saves significant cost for organizations and individuals. Applications can experience large variations in the workloads which can be due to seasonal or other factors. For example, e-Commerce applications typically experience higher workloads in holiday seasons. To ensure market readiness of such applications, adequate resources need to be provisioned so that the applications can meet the demands of specified

workload levels and at the same time ensure that service level agreements are met.

Outsourced Management
Cloud computing allows the users (individuals, large organizations, small and medium enterprises and governments) to outsource the IT infrastructure requirements to external cloud providers. Thus, the consumers can save large upfront capital expenditures in setting up the IT infrastructure and pay only for the operational expenses for the cloud resources j^ed. The outsourced nature of the cloud services provides a reduction in the IT infrastructure management costs.

Reliability
Applications deployed in cloud computing environments generally have a higher reliability since the underlying IT infrastructure is professionally managed by the cloud service. Cloud service providers specify and guarantee the reliability and availability levels for their cloud resources in the form of service level agreements (SLAs). Most cloud providers promise ***9***9.99***%*** uptime guarantee for the cloud resources, which may often be expensive to achieve with in-house IT infrastructure.

Multi-tenancy
The multi-tenanted approach of the cloud allows multiple users to make use of the same shared -e-ources. Modem applications such as e-Commerce, Business-to-Business, Banking and Financial, Retail and Social Networking applications that are deployed in cloud computing environments are multi-tenanted applications. Multi-tenancy can be of different forms:

- **Virtual multi-tenancy:** In virtual multi-tenancy, computing and storage resources are shared among multiple users. Multiple tenants are served from virtual machines (VMs) that execute concurrently on top of the same computing and storage resources.
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- **Organic multi-tenancy:** In organic multi-tenancy every component in the system architecture is shared among multiple tenants, including hardware, OS, database servers, application servers, load balancers, etc. Organic multi-tenancy exists when explicit multi-tenant design patterns are coded into the application.

Pros & Cons of cloud computing

Pros:-

1) Cost:

Well with all the required software and even hard drives accessible from the cloud, the budget of the business is greatly reduced. There are no infrastructure costs or other Capex (capital expenses). End to expensive servers, routers, etc. When the business is having less or very optimum investment then cloud is the right option. However the expense in cloud scenario is “all or nothing” policy.

2) Easy to learn and use:

If you have used Gmail, Google Docs, then cloud is nothing new to you. Since the staff would be a well expertise in Gmail and other basic cloud concepts, no special training is required; thereby satisfying the time and the cost constraint. Obviously, now there would no need to hire experienced expensive IT professionals, since this application is a trouble-free one.

3) Flexibility:

Documents, software, hard drive, storage equipment, etc anything can be accessed from anywhere through cloud; hence no need for the staffs to be office to do the work. Moreover this allows staff to work at anytime thus increasing staff morale.

4) Maintenance:

No more software updates, reinstalling of applications or even sorting out of software problems since these problems would be sorted out remotely, thus the employee can concentrate more on his/her own work.

Cons:-

1) Security:

Security is the X-Factor for any business. Just imagine your data being visible to all, or maybe your business strategies visible to all? Negative point, right? That’s what the scenario in cloud computing is; your data will be shared with other companies on the same platform. Of course your cloud vendor will have a higher level of security than the one you have in-house. Still regarding security cloud can’t be rated excellent.

2) Intellectual property (IP) issues:

There can be a bit chaos as most cloud providers will have different requisites and conditions regarding tenure of the data. To overcome this demerit, you must have read the fine print and understand things like when can you access your data, what happens

3) Wireless connections:

Connecting to wireless devices is not the easiest task to do. This problem is for small scale industries rather than larger business since larger companies have well structured network thus making wireless connections easy. Sometimes certain softwares are designed to relate to certain PCs alone in that case even usage of software maybe a problem.

4) Performance and Reliability:

Since everything you access is online, there might be a risk in CIA parameters (Confidentiality, Integrity, and Availability). Moreover the speed of your process depends on the speed of the network (when there is network traffic, the speed of our process may collapse). Additionally there can be noise in the media if any major application is down. In order to overcome this you must review the SLA (Service Level Agreement).

Benefits of Cloud Computing

The following are some of the possible benefits for those who offer cloud computing-based services and applications:

• **Cost Savings** — Companies can reduce their capital expenditures and use operational expenditures for increasing their computing capabilities. This is a lower barrier to entry and also requires fewer in-house IT resources to provide system support.

• **Scalability/Flexibility** — Companies can start with a small deployment and grow to a large deployment fairly rapidly, and then scale back if necessary. Also, the flexibility of cloud computing allows companies to use extra resources at peak times, enabling them to satisfy consumer demands.

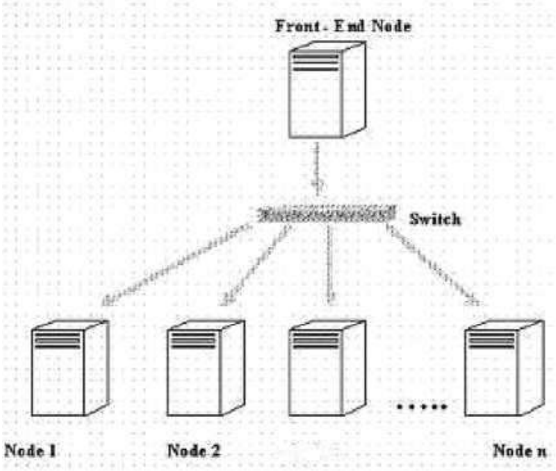
• **Reliability** — Services using multiple redundant sites can support business continuity and disaster recovery.

• **Maintenance** — Cloud service providers do the system maintenance, and access is through APIs that do not require application installations onto PCs, thus further reducing maintenance requirements.

• **Mobile Accessible** — Mobile workers have increased productivity due to systems accessible in an infrastructure available from anywhere.

Cluster Computing Cluster computing is a type of computing in which several nodes are made to run as a single entity .The various nodes involved in cluster are normally connected to each other using some fast local area networks. There are mainly two reasons of deploying a cluster instead of a single computer which are performance and fault tolerance. An application desires high computation in terms of response time, memory and throughput especially when we talk about real time applications. Cluster computing provides high computation by employing parallel programming, which is use of many processors simultaneously for a number of or a single problem.

Another reason is fault tolerance which is actually the ability of a system to operate gracefully even in the presence of any fault. As the clusters are the replicas of similar components, the fault in one component only affects the cluster's power but not its availability . So, users always have some components to work with even in the presence of fault.



Here Fig. 1 shows the general concept of cluster computing according to which several nodes merge together and are presented as a single interface/node to the user.

Advantages of Cluster Computing Manageability: It takes a lot of effort, cost and money to manage a large number of components. But, with cluster, large numbers of components are combined to work as a single entity. So, management becomes easy.

Single System Image: Again, with cluster, user just gets the feel that he is working with a single system, but actually he is working with a large number of components. He need not worry about that components, he only needs to manage a single system image.

High Availability: As all the components are replicas of each other, so if one component goes down because

of ay technical reason, then some other component can takes its place, and user can continue to work with the system [9].

B. Disadvantages of Cluster Computing

(1) *Programmability Issues:* This might be the case if the components are different in terms of software from each other, and then there may be issues when combining all of them together as a single entity.

(2) *Problem in Finding Fault:* Because we are dealing with a single entity, so problem may arise when finding out fault that which of the component has some problem associated with it.

(3) *Difficult to handle by a Layman:* As cluster computing involves merging different or same components together with different programmability, so a non-professional person may find it difficult to manage.

III. GRID COMPUTING

Grid computing is the segregation of resources from multiple sites so as to solve a problem that can't be solved by using the processing of a single computer . It employs use of multiple clusters that are loosely coupled, heterogeneous and are geographically dispersed. Here individual user gets access to the resources (like processors, storage, data etc.) on demand with little or no knowledge of the fact that where those resources are physically located. For example, we use electricity for running air-conditioners, televisions etc. through wall sockets without concerned about the fact that from where that electricity is coming and how it is being generated . It is more popularly known as a collection of servers that are bound together to attack a single problem. Grid computing is concerned about sharing, collecting, hosting and providing services to various consumers

Fig. 2: Grid computing concept

Here Fig. 2 shows the general concept of grid computing which shows that various resources are segregated from across the globe or geographically dispersed locations towards a central location i.e. the grid system.

Advantages of Grid Computing Access to Additional Resources: In addition to CPU and other storage resources, a grid can also provide other resources as well.

Resource Balancing: A grid incorporates large number of systems into a single system image. For applications that are grid enabled, grid performs the resource balancing by scheduling grid jobs on machines that are showing low utilization.

(3) Reliability: The systems in grid are cheap and geographically dispersed. If, for example, there is power or cooling failure at one site, then that will not affect the other site, thus high reliability will be there specially in *. Disadvantages of Grid Computing*

(1) *Not Stable:* Grid software and standards are not stable in comparison to other computing. Its standards are still evolving .

(2) *High Internet Connection Required*: Gathering and assembling various resources from geographically dispersed sites require high internet connection which results in high monetary cost.

(3) *Different Administrator Domains:* Sometimes political issues arise when sharing resources among different domains. Some additional tools are required for having proper syncing and managing among different environments like cfengine, opsware etc.

IV. CLOUD COMPUTING

Cloud computing is the new computing paradigm which provides large pool of dynamical scalable and virtual resources as a service on demand. The main principle behind cloud computing model is to offer computing, storage, and software as a service or as a utility. We just need internet to use these utilities. Buyya et al. (2009) have defined it as follows: “Cloud is a parallel and distributed computing system consisting of a collection of inter-connected and virtualized 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.”

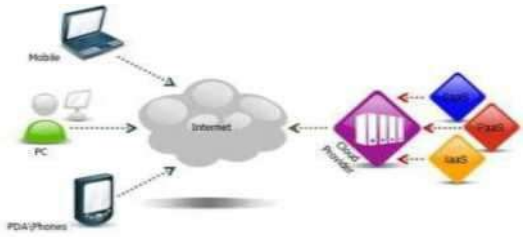


Fig. 3: Cloud computing concept

Here Fig. 3 shows that how users can connect to the cloud services provided by cloud service provider using any device over the internet. Cloud infrastructure includes scalable resources in storage, network, and compute. It also contain virtualized infrastructure and provide these services to the users over internet.

Cloud computing cuts the operational and capital costs and allow the IT departments to focus on strategic projects instead of keeping the datacenter running. It provides the services on Infrastructure level, Platform level, and Software level. It provides many features such as speed, scalability of resources, parallel processing, just pay the used resources, choose another technology at any time to further work, 24/7 availability of services, device and location independent, provides reliability and security etc

Cloud has five essential features such as rapid elasticity, measured services, on-demand self-service, resource pooling, and board network access as shown in Fig. 4.

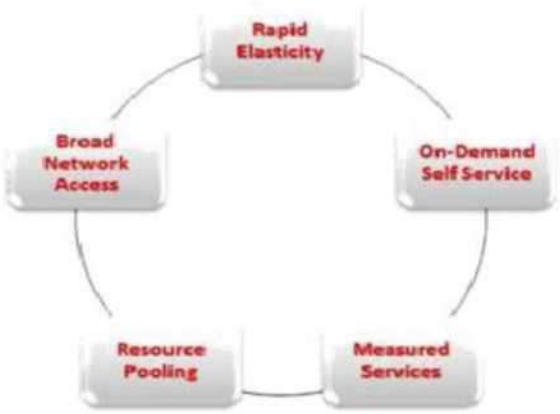


Fig. 4: Five features of cloud computing

A. *Advantages of Cloud Computing*

(1) *Shared Resources:* Cloud computing share resources to provide the services to multiple users. That's why it can easily provide the facility like scale up and scale down the resources on demand.

(2) *Pay-As-You-Go:* Users just need to pay only for those resources which are used by them. They can demand for more resources if they required latter on and they can also release their resources after use.

(3) *Better Hardware Management:* It is easy for cloud service provider to manage the hardware easily because all computers run the same hardware [7].

(4) *Save CAPEX and OPEX of Users:* New technologies are developing very rapidly. Organizations need to use new technologies to fulfill the requirements of their customers. But changing the technologies is very costly. With the help of cloud computing, users don't need to purchase the physical infrastructure and spend money on maintaining it. They can use any technology as per their requirement.

B. *Disadvantages of Cloud Computing*

(1) *Less Reliability:* Cloud Computing is less reliable because it used to share the resources with multiple users. So there is possibility to steal the data of a user or data of one organization may mix with the data of another organization. For example, In 2007 Microsoft and Yahoo! released some search data to the US Department of Justice as part of a child pornography case. A disgruntled employee could alter or destroy the data using his or her own access credentials. If cloud storage system is not reliable, no one wants to save the data on an unreliable system .

(2) *Internet:* The main requirement for users to use the services of cloud computing is internet. Users required high speed of internet connection. Unavailability of internet would cause unavailability of data.

(3) *Non-Interoperability:* If user stored data in one cloud then later on he/she can't move it to another cloud service provider because there is non-interoperability between cloud based systems .

Cluster Computing	Grid Computing	Cloud Computing
Characteristics of Cluster computing 1:Tightly coupled systems 2: Single system image 3: Centralized Job management & scheduling system	Characteristics of Grid Computing 1: Loosely coupled (Decentralization) 2: Diversity and Dynamism 3: Distributed Job Management & scheduling	Characteristic of cloud computing 1: Dynamic computing infrastructure 2: IT service-centric approach 3: Self-service based usage model 4: Minimally or self-managed platform 5: Consumption-based billing

behaves like a single system view and resources are managed by centralized resource manager.	has its own resource manager and behaves like an independent entity	entity
The computers in the cluster are normally contained in a single location or complex.	Grid are inherently distributed by its nature over a LAN, metropolitan or WAN	Clouds are mainly distributed over MAN
More than 2 computers are connected to solve a problem	A large project is divided among multiple computers to make use of their resources.	It does just the opposite. It allows multiple smaller applications to run at the same time.
Areas of cluster computing 1. Educational resources 2. Commercial sectors for industrial promotion 3. Medical research	Areas of Grid Computing 1. Predictive Modeling and Simulations 2. Engineering Design and Automation 3. Energy Resources Exploration 4. Medical, Military and Basic Research 5. Visualization	Areas of cloud Computing 1.Banking 2.Insurance 3.Weather Forecasting 4.Space Exploration 5.Software as a service 6.PaaS 7.Infrastructure- as -a-Service
Commodity computers	High-end computers (servers, clusters)	Commodity computers and high-end servers and network attached storage
Size or scalability is 100s	Size or scalability is 1000s	Size or scalability is 100s to 1000s
One of the standard OSs (Linux, Windows)	Any standard OS (dominated by Unix)	A hypervisor (VM) on which multiple OSs run
Single Ownership	Multiple Ownership	Single Ownership
Dedicated, high-end with low latency and high bandwidth Interconnection Network	Mostly Internet with high latency and low Bandwidth Interconnection Network	Dedicated, high-end with low latency and high Bandwidth Interconnection Network
Traditional login/password- based. Medium level of privacy depends on user privileges.	Public/private key pair based authentication and mapping a user to an account. Limited support for privacy.	Each user/application is provided with a virtual machine. High security/privacy is guaranteed. Support for setting per-file access control list (ACL).
Membership services	Centralized indexing and	Membership services

Potential for building 3rd party or value-added solutions is limited due to rigid architecture	Potential for building 3rd party or value-added solutions is limited due to strong orientation for scientific Computing	High potential - can create new services by dynamically provisioning of compute, storage, and application services and offer as their own isolated or composite Cloud services to users

The legal issues that arise in cloud computing are wide ranging. Significant issues regarding privacy of data and data security exist, specifically as they relate to protecting personally identifiable information of individuals, but also as they relate to protection of sensitive and potentially confidential business information either directly accessible through or gleaned from the cloud systems (e.g., identification of a company's customer by evaluating traffic across the network).

Additionally, there are multiple contracting models under which cloud services may be offered to customers (e.g., licensing, service agreements, on-line agreements, etc.). The appropriate model depends on the nature of the services as well as the potential sensitivity of the systems being implemented or data being released into the cloud. In this regard, the risk profile (i.e., which party bears the risk of harm in certain foreseeable and other not-so-foreseeable situations) of the agreement and the cloud provider's limits on its liability also require a careful look when reviewing contracting models.

Additionally, complex jurisdictional issues may arise due to the potential for data to reside in disparate or multiple geographies. This geographical diversity is inherent in cloud service offerings. This means that both virtualization of and physical locations of servers storing and processing data may potentially impact what country's law might govern in the event of a data breach or intrusion into cloud systems. Jurisdictional matters also determine the country's law that is applicable to data and information that may be moved geographically among data centers around the world at any given point in time.

Finally, commercial and business considerations require some attention. What happens to customer information, applications, and data when a cloud provider is acquired? What are the implications for that same set of information, applications, and data when a cloud provider is files bankruptcy or ceases to do business? All of these issues will be explored.

Distinguishing Cloud Computing from Outsourcing and Provision of Application Services Cloud computing is different from traditional outsourcing and the application service provider (ASP) model in the following ways:

In general, outsourcers tend to take an entire business or IT process of a customer organization and completely run the business for the benefit of the customer.

Though the outsourcer may provide services similar to those by multiple customers, each outsourcing arrangement is highly negotiated, and the contract is typically lengthy and complex. Depending on the nature of the outsourcing, the software belongs to the customer, and software sublicense rights were transferred to the outsourcer as part of the arrangement.

The customer's systems are run on the customer's equipment, though it is usually at an offsite location managed by the outsourcer. Pricing is typically negotiated for each outsourced relationship.

The outsourcer's ability to scale to meet customer demand is a slow, and also negotiated, process. The location of the data and processing is known, predetermined, and agreed to contractually. In the ASP model, the service provided is a software service. The software application may have been used previously in-house by the customer, or it may be a new value-added offering.

DATA PRIVACY AND SECURITY ISSUES

Data Breach Notification Requirements

Generally speaking, data breach is a loss of unencrypted electronically stored personal information. This information is usually some combination of name and financial information (e.g., credit card number, Social Security Number).

A breach can occur in many ways—for example, by having a server compromised, loss of a thumb drive, or theft of a laptop or cell phone. Avoidance of a data breach is important to both cloud providers and users of cloud services because of the significant harm, both to the user and to the provider, when a breach occurs.

From the user's viewpoint, if personal information is compromised, there is a risk of identity theft and of credit or debit card fraud. From the provider's viewpoint, financial harm, potential for lawsuits, Federal Trade Commission

(FTC) investigations, loss of customers, and damage to reputation are all likely results of when a data breach occurs. Data breaches can be expensive.

Financial losses from lawsuits, customer claims, protecting reputation, FTC settlements, and other costs for the most serious U.S. data breaches have exceeded US $1 billion.

Almost all 50 states in the United States now require notification of affected persons (i.e., residents of the individual state), upon the occurrence of a data breach. As of this writing, the European Union was considering data breach legislation.

Given the breadth of various laws across most of the United States, a breach generally results in a company notification of persons across the country when their information has been compromised. Because of these laws, business customers have attempted to materially expand the contractual obligations of their providers and shift the risk of harm to the provider, the holder of the personal information.

Over time, as more mission-critical information migrates into the cloud, cloud providers may have to assume more risk for treatment of personal information in a manner consistent with the obligations of non-cloud providers. For purposes of data breach law, data in the cloud are treated no differently than any other electronically stored information. Cloud providers that have had their systems compromised will be required to notify affected persons and will have to coordinate with the cloud users who provided the data in order to do so.

U.S. Federal Law Compliance

Gramm_Leach_Bliley Act: Financial Privacy Rule. The Gramm_Leach_ Bliley Act (GLB) [3] requires, among other things, that financial institutions implement procedures to ensure the confidentiality of personal information and to protect against unauthorized access to the information. Various United States government agencies are charged with enforcing GLB, and those agencies have implemented and currently enforce standards [4].

As part of the requirement to prevent unauthorized access to information, financial institutions must take steps to protect information provided to a service provider. A service provider under GLB may be any number of individuals or companies that provide services to the financial institution and would include a cloud provider handling the personal information of a financial institution’s customers.

The implications to the cloud provider that is providing services to financial institutions are that the cloud provider will, to some degree, have to (1) comply with the relevant portions of GLB by demonstrating how it prevents unauthorized access to information, (2) contractually agree to prevent unauthorized access, or (3) both of the above.
The Role of the FTC: Safeguards Rule and Red Flags Rule. At the United States federal level, the Federal Trade Commission (FTC) working under the auspices of the FTC Act has been given authority to protect consumers and their personal information.

The Safeguards Rule [5] mandated by GLB and enforced by the FTC requires that all businesses significantly involved in the provision of financial services and products have a written security plan to protect customer information. The plan must include the following elements [6]:

Designation of one or more employees to coordinate its information security program;
Identification and assessment of the risks to customer information in each relevant area of the company’s operation, and evaluation of the effectiveness of the current safeguards for controlling these risks; Designing and implementing a safeguards program, and regularly monitoring and testing it;

Selection of service providers that can maintain appropriate safeguards; and Evaluation and adjustment of the program in light of relevant circumstances, including (a) changes in the firm’s business or operations or
(b) the results of security testing and monitoring.

In 2007, as part of the Fair and Accurate Credit Transaction Act of 2003 (FACT) [7], the FTC promulgated the Red Flag Rules[1] (these rules were scheduled to go into effect in November 2009, but have been delayed several times).

Challenges in the cloud computing

The challenges of cloud computing includes the following:

1) Dynamic scalability: The compute nodes are scaled up and down dynamically by the application according to the response time of the user's queries. The scheduling delays involved are real concern which leads to the need of effective and dynamic load management system.

2) Multi-tenancy: When the number of applications running on the same compute node increases, it will reduce the amount of bandwidth allocated to each application which may lead to performance degradation.

3) Querying and access: Scalable provenance querying and secure access of provenance information are open problems for both grid and cloud environment.

4) Standardization: As every organization has their own APIs and protocols used which makes the user data or vendor lock-in. Thus integration and interoperability of all the services and application is a challenge.

5) Reliability and fault-tolerance: Tools for testing the ap- plication against fault tolerance and compute failures are required which help in developing a reliable system.

6) Debugging and profiling: Parallel and remote debugging has always been a problem for developing HPC programs and is an issue in cloud computing also.

7) Security and Privacy: The user has no idea where data is stored and who will use it as there are more hackers than developers.

8) Power: Though cloud computing offers many type of services finally to meet the needs of users, enormous amount of power is consumed. An autonomic energy aware resource management is very much required.

Overview of Mobile cloud Computing

Mobile Cloud Computing (MCC) is a combination of Cloud computing and mobile networks. It is a technique or model in which mobile applications are built, powered and hosted using cloud computing technology. The mobile computing means to access shared data or infrastructure through portable devices like PDA, smart phone, tablet and so on. Mobile uses the cloud for both application development as well as hosting. The most of application in mobile is cloud based application
i.e. IE, social networking apps like facebook apps, that accessible through cloud (internet). It provides the user to interface the data and services on the cloud platform.

Benefits of Mobile Cloud Computing:

1] Extended Battery lifetime:

Computation offloading migrates large computations and complex processing from resource limited devices to resourceful machine. Remote application executions can save energy significantly.

2] Improving data storage capacity and processing power:

Mobile Cloud Computing enables mobile users to store access large data on the cloud. The running cost for computation intensive application is reduce. The data is stored on the cloud not in mobile application.

3] Improving reliability and availability:

Mobile Cloud Computing can be designed as a comprehensive data security model for both service providers and users. Protect copyrighted digital contents in clouds. Provide security services such as virus scanning, malicious code detection, authentication for mobile users. With data and services in the clouds, then are always(almost) available even when the users are moving.

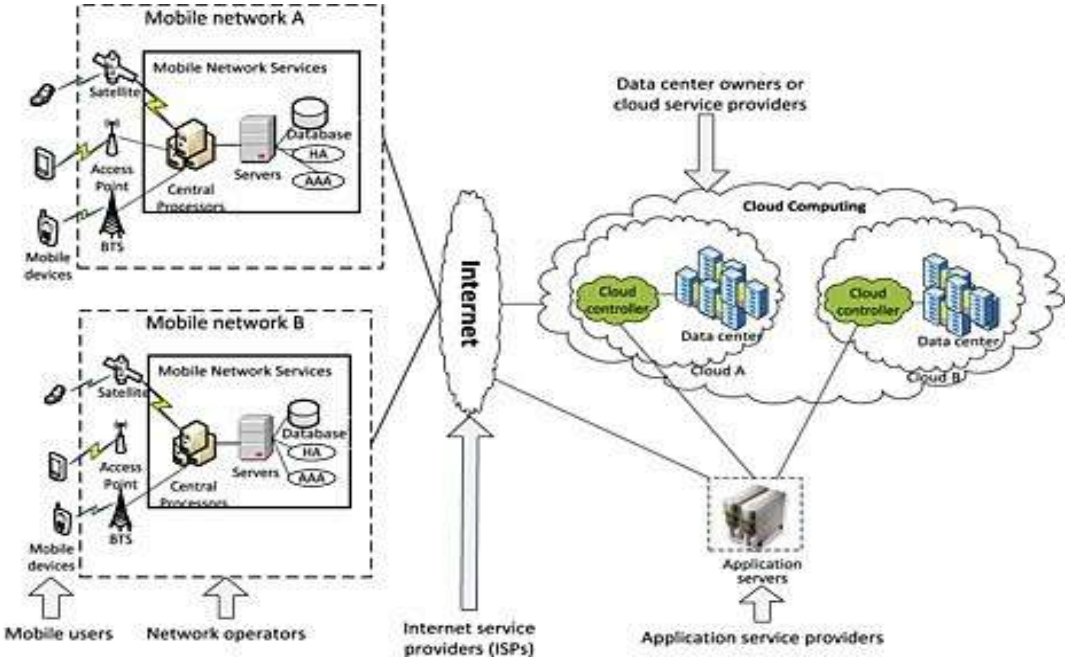


Fig:-Architecture of mobile cloud computing

The above figure shows the general architecture of mobile cloud computing. mobile devices are connected to the mobile network via base station (eg base transceiver station (BTS),Access point, or satellite) that establish and control the connection and functional interface between the network and mobile devices. Mobile user request and information eg. id and location and transmitted to the central processors that are connected to server providing mobile network services. here mobile network operator can provide services to mobile user for authentication authorization and accounting based on the home agent and subscriber data store in database. After that the subscriber request are delivered to a cloud through the internet. in the cloud controllers process the request to provide mobile user with corresponding cloud services these are developed with the concept of utility computing virtualization and services oriented.

MOBILE CLOUD COMPUTING BASIC APPLICATIONS:

1] Mobile Commerce:

Mobile commerce is a business model for commerce using mobile devices. Mobile commerce is a business model for commerce using mobile devices. the mcommerce application generally fulfil some task that require mobility ex mobile transaction payments, mobile messaging, mobile ticketing. Mcommerce applications can be classified in to a few classes including finance, advertising and shopping. it face various challenges (low network bandwidth, high complexity of mobile device configurations & security).Mcommerce are integrated in to cloud computing environment to address these issues.

2] Mobile Learning:

Traditional m-learning applications have limitations in terms of High cost of devices and network, Low network transmission rate, Limited educational resources. Cloud-based m-learning applications are introduced to solve these limitations. For example, utilizing a cloud with the large storage capacity and powerful processing ability, the applications provide learners with much richer services in terms of data (information) size, faster processing speed, and longer battery life.

3] Mobile Healthcare:

Mobile healthcare provides mobile users with convenient helps to access resources (e.g. patient health records) easily and quickly. It offers hospital and healthcare organizations a variety of on demands services on cloud rather than owing standalone application on local servers. some schemes of mcc in healthcare Comprehensive health monitoring services, Intelligent emergency management system, Health-aware mobile devices Pervasive access to healthcare information, Pervasive lifestyle incentive management.

4] Mobile Gaming:

Mobile game (m-game) is a potential market generating revenues for service providers. M-game can completely offload game engine requiring large computing resource (e.g., graphic rendering) to the server in the cloud, and gamers only interact with the screen interface on their devices.

OPEN ISSUES IN MOBILE CLOUD COMPUTING:

1] Low Bandwidth:

The bandwidth limitation is a big issue because the number of mobile and clouds users is day by day increasing in very high speed so we considered that 4G network and Femtocell are a very promising technology that overcome the limitation and bring a revolution in improving bandwidth.

2] Network Access Management:

Network management improves the link performance and bandwidth usage for mobile users. Cognitive radio as a solution to achieve the wireless access management in mobile communication environment.

3] Quality of Services:

The mobile users faces many problems such as network disconnection, congestion due to limitation of wireless bandwidth and signal attenuation caused by mobile user, so quality of services is reduced significantly. To overcome this limitation in future directions two new research are clone cloud and cloudlets is expected to reduce the network delay.

4] Standard Interface:

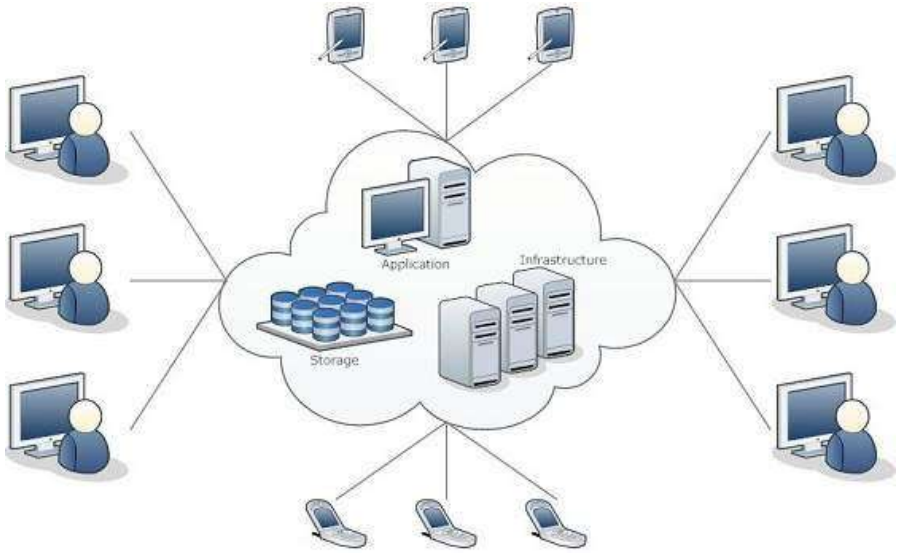
The interface between the mobile users and cloud are mostly based on the web interface. However first of all web interface is not specifically developed for mobile device and also not compatibility with the device so web interface could be an issue. To overcome this the promising technique is HTML5 is address this issue. HTML5 WebSockets offer an interface and it will work more efficiently.

Cloud Computing ? Enlist and Explain its Characterstics.

Cloud Computing provides us means of accessing the applications as utilities over the Internet. It allows us to create, configure, and customize the applications online.

The term **Cloud** refers to a **Network** or **Internet.** In other words, we can say that Cloud is something, which is present at remote location. Cloud can provide services over public and private networks, i.e., WAN, LAN or VPN.

Cloud Computing refers to **manipulating, configuring,** and **accessing** the hardware and software resources remotely. It offers online data storage, infrastructure, and application.



Cloud computing offers **platform independency,** as the software is not required to be installed locally on the PC. Hence, the Cloud Computing is making our business applications **mobile** and **collaborative.**

Characterstics of Cloud Computing -

On Demand Self Service:

Cloud Computing allows the users to use web services and resources on demand. One can logon to a website at any time and use them. A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.

Broad Network Access:

Since cloud computing is completely web based, it can be accessed from anywhere and at any time. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., **mobile** phones, tablets, laptops and workstations).

Resource Pooling

Cloud computing allows multiple tenants to share a pool of resources. One can share single physical instance of hardware, database and basic infrastructure.Examples of resources include storage, processing, memory and network bandwidth.

Rapid Elasticity

It is very easy to scale the resources vertically or horizontally at any time. Scaling of resources means the ability of resources to deal with increasing or decreasing demand.The resources being used by customers at any given point of time are automatically monitored.

Measured Service

In this service cloud provider controls and monitors all the aspects of cloud service. Resource optimization, billing, and capacity planning etc. depend on it. Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth and active user accounts).

History of cloud computing

1.In 1963, DARPA (the Defense Advanced Research Projects Agency), presented MIT with $2 million for Project MAC. The funding included a requirement MIT develop technology allowing for a "computer to be used by two or more people, simultaneously." In this case, one of those gigantic, archaic computers using reels of magnetic tape for memory and was the precursor to what has now become collectively known as Cloud Computing. It acted as a primitive Cloud with two or three people accessing it. The word "*Virtualization*" was used to describe this situation, though the word's meaning later expanded.

2. In its early stages, the Cloud was used to express the empty space between the end user and the provider. In 1997, Professor Ramnath Chellapa of Emory University defined Cloud Computing as the new "computing paradigm, where the boundaries of computing will be determined by economic rationale, rather than technical limits alone." This somewhat ponderous description rings true in describing the Cloud's evolution.

3.The Cloud gained popularity as companies gained a better understanding of its services and usefulness. In 1999, Salesforce became a popular example of using Cloud Computing successfully. They used it to pioneer the idea of using the Internet to deliver software programs to the end users. The program (or application) could be accessed and downloaded by anyone with Internet access. Businesses could purchase the software in an on-demand, cost-effective manner, without leaving the office.

4.In 2002, Amazon introduced its web-based retail services. It was the first major business to think of using only 10% of their capacity (which was commonplace at the time) as a problem to be solved. The Cloud Computing Infrastructure Model gave them the flexibility

to use their computer's capacity much more efficiently. Soon after, other large organizations followed their example.

5.In 2006, Amazon launched Amazon Web Services, which offers online services to other websites, or clients. One of Amazon Web Services' sites, called Amazon Mechanical Turk, provides a variety of Cloud-based services including storage, computation and "human intelligence." Another of Amazon Web Services' sites is the Elastic Compute Cloud (EC2), allowing individuals to rent virtual computers and use their own programs and applications.

6.In the same year, Google launched the Google Docs services. Google Docs was originally based on two separate products, Google Spreadsheets and Writely. Google purchased Writely, which offers renters the ability to save documents, edit documents, and transfer them into blogging systems. (These documents are compatible with Microsoft Word.) Google Spreadsheets (acquired from 2Web Technologies, in 2005) is an Internet-based program allowing users to develop, update, and edit spreadsheets, and to share the data online. An Ajax-based program is used, which is compatible with Microsoft Excel. The spreadsheets can be saved in an HTML format.

7.In 2007, IBM, Google, and several universities joined forces to develop a server farm for research projects needing both fast processors and huge data sets. The University of Washington was the first to sign up and use resources provided by IBM and Google. Carnegie Mellon University, MIT, Stanford University, the University of Maryland, and the University of California at Berkeley, quickly followed suit. The universities immediately realized computer experiments can be done faster and for less money, if IBM and Google were supporting their research. Since much of the research was focused on problems IBM and Google had interests in, they also benefitted from the arrangement. 2007 was also the year when Netflix launched it's streaming video service, using the Cloud, and provided support for the practice of "binge-watching."

8.In 2011, IBM introduced the IBM SmartCloud framework, in support of Smarter Planet (a cultural thinking project). Then, Apple launched the ICloud, which focuses on storing more personal information (photos, music, videos, etc.). Also, during this year, Microsoft began advertising the Cloud on television, making the general public aware of its ability to store photos, or video, with easy access.

9.Oracle introduced the Oracle Cloud in 2012, offering the three basics for business, IaaS (Infrastructure-as-a-Service), PaaS (Platform-as-a-Service), and SAAS (Software-as-a-Service).

Compare cloud,cluster and grid computing

Cluster Computing	Grid Computing	Cloud Computing
Characteristics of Cluster computing 1:Tightly coupled systems 2: Single system image 3: Centralized Job management & scheduling system	Characteristics of Grid Computing 1: Loosely coupled (Decentralization) 2: Diversity and Dynamism 3: Distributed Job Management & scheduling	Characteristic of cloud computing 1: Dynamic computing infrastructure 2: IT service-centric approach 3: Self-service based usage model 4: Minimally or self-managed platform 5: Consumption-based billing
In cluster computing, a bunch of similar (or identical) computers are hooked up locally (in the same physical location, directly connected with very high speed connections) to operate as a single computer	In grid computing, the computers do not have to be in the same physical location and can be operated independently. As far as other computers are concerned each computer on the grid is a distinct computer.	In cloud computing, the computers need not to be in the same physical location.
The cluster computers all have the same hardware and OS.	The computers that are part of a grid can run different operating systems and have different hardware	The memory, storage device and network communication are managed by the operating system of the basic physical cloud units. Open source software such as LINUX can support the basic physical unit management and virtualization computing.
The whole system (all nodes) behaves like a single system view and resources are managed by centralized resource manager.	Every node is autonomous i.e. it has its own resource manager and behaves like an independent entity	Every node acts as an independent entity
The computers in the cluster are normally contained in a single location or complex.	Grid are inherently distributed by its nature over a LAN, metropolitan or WAN	Clouds are mainly distributed over MAN
More than 2 computers are connected to solve a problem	A large project is divided among multiple computers to make use of their resources.	It does just the opposite. It allows multiple smaller applications to run at the same time.
Areas of cluster computing 1. Educational resources 2.Commercial sectors for industrial promotion 3.Medical research	Areas of Grid Computing 1.Predictive Modeling and Simulations 2.Engineering Design and Automation 3.Energy Resources Exploration 4.Medical, Military and Basic Research 5.Visualization	Areas of cloud Computing 1.Banking 2.Insurance 3.Weather Forecasting 4.Space Exploration 5.Software as a service 6.PaaS 7.Infrastructure- as -a-Service
Commodity computers	High-end computers (servers, clusters)	Commodity computers and high-end servers and network attached storage
Size or scalability is 100s	Size or scalability is 1000s	Size or scalability is 100s to 1000s
One of the standard OSs (Linux, Windows)	Any standard OS (dominated by Unix)	A hypervisor (VM) on which multiple OSs run
Single Ownership	Multiple Ownership	Single Ownership

Challenges in Cloud Computing

Following diagram shows the major challenges in cloud computing.

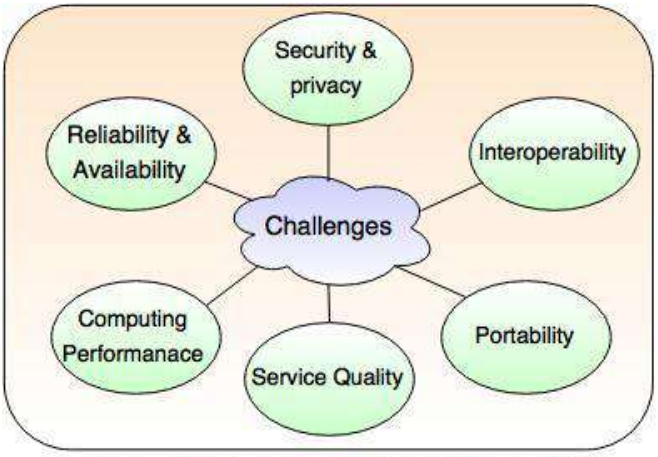


Fig. - Challenges in Cloud Computing

Security and Privacy

- Security and privacy are the main challenge in cloud computing.
- These challenges can reduced by using security applications, encrypted file systems, data loss software.

Interoperability

- The application on one platform should be able to incorporate services from the other platform. This is known as **Interoperability.**
- It is becoming possible through web services, but to develop such web services is complex.

Portability

- The applications running on one cloud platform can be moved to new cloud platform and it should operate correctly without making any changes in design, coding.
- The portability is not possible, because each of the cloud providers uses different standard languages for their platform.

Service Quality

The Service-Level Agreements (SLAs) of the providers are not enough to guarantee the availability and scalability. The businesses disinclined to switch to cloud without a strong service quality guarantee.

Computing Performance

- High network bandwidth is needed for data intensive applications on cloud, this results in high cost.
- In cloud computing, low bandwidth does not meet the desired computing performance.

Reliability and Availability

Most of the businesses are dependent on services provided by third-party, hence it is mandatory for the cloud systems to be reliable and robust.

Cloud providers still lack round-the-clock service; this results in frequent outages. It is important to monitor the service being provided using internal or third-party tools. It is vital to have plans to supervise usage, SLAs, performance, robustness, and business dependency of these services.

Advantages and disadvantages of Cloud Computing

Advantages:

- **Cost efficiency –** The biggest reason behind shifting to cloud computing is that it takes considerably lesser cost than an on-premise technology. Now the companies need not store the data in disks anymore as the Cloud offers enormous storage space, saving money and resources of the companies.
- **High Speed –** Cloud computing lets you deploy the service quickly in fewer clicks. This quick deployment lets you get the resources required for your system within fewer minutes.
- **Excellent accessibility –** Storing the information in cloud allows you to access it anywhere and anytime regardless of the machine making it highly accessible and flexible technology of present times.
- **Back-up and restore data –** Once the data is stored in Cloud, it is easier to get the back-up and recovery of that, which is quite a time taking process on-premise.
- **Manageability –** Cloud computing eliminates the need for IT infrastructure updates and maintenance since the service provider ensures timely, guaranteed and seamless delivery of your services and also takes care of all the maintenance and management of your IT services according to the service level agreement (SLA).
- **Sporadic Batch processing –** Cloud computing lets you add or subtract resources and services according to your needs. So, if the workload is not 24/7, you need not worry about the resources and services getting wasted and you won't end up stuck with unused services.
- **Strategic edge –** Cloud computing provides your company a competitive edge over the competitors when it comes to accessing the latest and mission critical applications whenever you need them without having to invest your time and money on installations. It lets you focus on keeping up with the business competition by offering access to most

trending and in demand applications and doing all the manual work of installing and maintaining the applications for you.

Disadvantages

- **Vulnerability to attacks –** Storing data in cloud may pose serious challenge of information theft since in cloud every data of your company is online. Security breach is something that even the best organizations have suffered from and it's a potential risk in cloud as well. Though advanced security measures are deployed on cloud, still storing a confidential data in cloud can be a risky affair.
- **Network connectivity dependency –** Cloud computing is entirely dependent on the internet. This direct tie up with internet means that you need a reliable and consistent internet service as well as a good connection speed and bandwidth for your business to reap the benefits of cloud computing.
- **Downtime –** Downtime is considered as one of the biggest potential downside of using Cloud computing. Your cloud providers may sometimes face technical outages which can happen due to various reasons such as loss of power, low internet connectivity, data centres going out of service for maintenance etc. This can lead to a temporary downtime in your cloud services.
- **Vendor lock in –** When in need to migrate from one cloud platform to another, your company might face some serious challenges because of the differences between vendor platforms. Hosting and running the applications of your current cloud platform on some other platform may cause support issues, configuration complexities and additional expenses. Your data might also be left vulnerable to security attacks due to compromises that might have been made during migrations.
- **Limited control –** Cloud customers may face limited control over their deployments. The cloud services run on remote servers which are completely owned and managed by the service providers, which makes it hard for the companies to have the level of control that they would want over their back-end infrastructure.

Cluster and Grid Computing with advantages and disadvantages

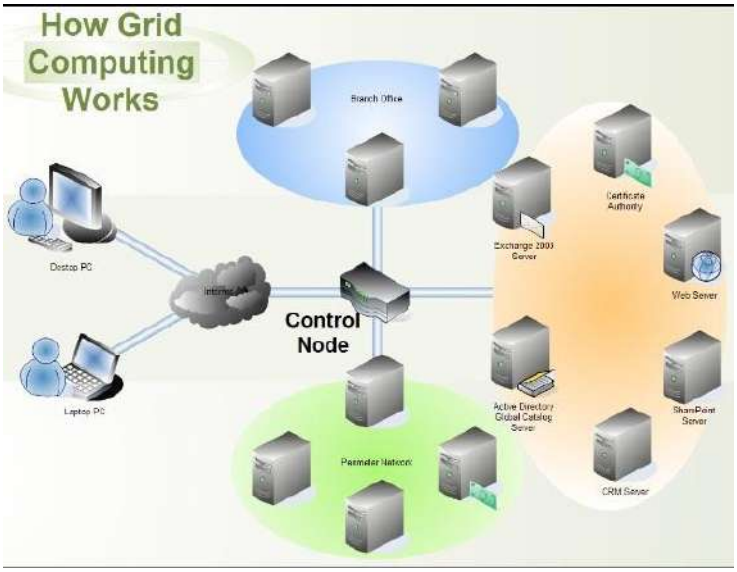
Grid Computing

1.Grid computing is a group of computers physically connected (over a network or with Internet) to perform a dedicated tasks together, such as analysing e-commerce data and solve a complex problem. Grids are a form of "super virtual computer" that solve a particular application.The grid size may vary from small to large enterprises network.

2.A *computing grid* is constructed with the help of grid middleware software that allows them to communicate. middleware is used to translates one node information passed stored or processed information to another into a recognizable format. It is the form of "distributed computing" or "peer-to-peer computing".

3.'Grid computing' is distinguished from the cluster computing, because in Grid computing each node has heterogeneous and geographically dispersed (such as a WAN) and its own

resource manager and perform a different task and are loosely connected by the Internet or low-speed networks, but in cluster computing resources are managed in a single location (Like a LAN).



4.The **grid computing model** is a special kind of cost-effective distributed computing.In distributed computing, resources are shared by same network computers.In grid computing architecture, every computer in network turning into a powerful supercomputer that access to enormous processing power,memory and data storage capacity.

Advantages/ Disadvantage of Grid Computing

Advantages

- Can solve larger, more complex problems in a shorter time
- Easier to collaborate with other organizations
- Make better use of existing hardware

Disadvantages

- Grid software and standards are still evolving
- Learning curve to get started
- Non-interactive job submission

Cluster Computing

1.Cluster computing or *High-Performance computing* frameworks is a form of computing in which bunch of computers (often called nodes) that are connected through a LAN (local area network) so that, they behave like a single machine. A computer cluster help to solve complex operations more efficiently with much faster processing speed, better data integrity than a single computer and they only used for mission-critical applications.

2.A computer cluster defined as the addition of processes for delivering large-scale processing to reduce downtime and larger storage capacity as compared to other desktop workstation or computer.

3.Some of the critical Applications of Cluster Computers are Google Search Engine, Petroleum Reservoir Simulation, Earthquake Simulation, Weather Forecasting.

4.Cluster Can be classified into two category Open and Close Cluster.

Open Cluster: All nodes in Open Cluster are needed IPs, and that are accessible through internet/web,that cause more security concern.
Close Cluster: On the other hand Close Cluster are hide behind the gateway node and provide better security.

Advantages

1. **Cost efficiency**: In a Cluster computing Cost efficiency is the ratio of cost to output, that is the connecting group of the computer as computer cluster much cheaper as compared to mainframe computers.
2. **Processing speed**: The Processing speed of computer cluster is the same as a mainframe computer.
3. **Expandability**: The best benefit of Cluster Computing is that it can be expanded easily by adding the additional desktop workstation to the system.
4. **High availability of resources**: If any node fails in a computer cluster, another node within the cluster continue to provide uninterrupted processing. When a mainframe system fails, the entire system fails.

Disadvantages:

1.Difficult to manage and organize a large number of computers

2.Poor performance in the case of non-parallelizable applications

3.Physical space needed is considerably greater than that of a single server

4.Increased power consumption compared to a single server

Cloud Computing in a Nutshell

Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet). The name comes from the common use of a cloud-shaped symbol as an abstraction for the complex infrastructure it contains in system diagrams. Cloud computing entrusts remote services with a user's data, software and computation.

Essential Characteristics

- On Demand Self-Service: Allows for provisioning of computing resources automatically as needed.

- Broad Network Access: Access to cloud resources is over the network using standard mechanisms provided through multi-channels.
- Resource Pooling: The vendors' resources are capable of being pooled to serve multiple clients using a multi-tenant model, with different physical and virtual resources in a dynamic way.Example of resources include; computation capabilities, storage and memory.
- Rapid Elasticity: Allows for rapid capability provisioning, for quick scaling out and scaling in of capabilities. The capability available for provisioning to the client seems to be unlimited and that it can be purchased as demanded.
- Measured Service: Allows monitoring, control and reporting of usage. It also allows for transparent between the provider and the client.

Service Models of Cloud Computing:

Software as a Service (SaaS) – In which applications run on a cloud but the user doesn't provision or modify the cloud service, or even application capabilities, apart from limited user-specific configuration settings.

Platform as a service (PaaS) – In which users can utilise cloud-provided programming tools to deploy applications without controlling most of the underlying infrastructure, with the possible exception of the application hosting environment configuration.

Infrastructure as a service (IaaS) – Consumer has control over the operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls) of the cloud environment available to the user via the network.

Deployment Models:

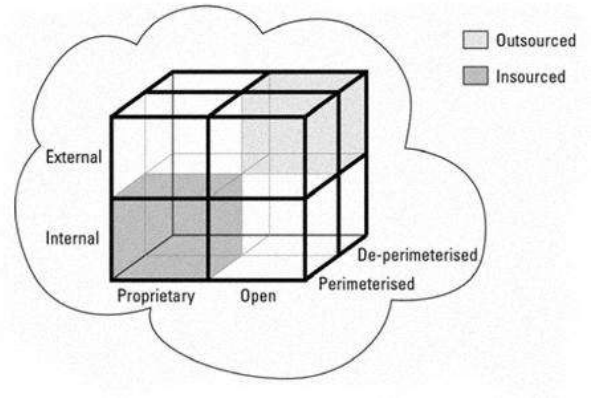
Private cloud. The cloud infrastructure is provisioned for exclusive use by a single organisation comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organisation, a third party, or some combination of them, and it may exist on or off premises. More on Private Clouds.

Community cloud. The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organisations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organisations in the community, a third party, or some combination of them, and it may exist on or off premises. More on Community Clouds.

Public cloud. The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organisation, or some combination of them. It exists on the premises of the cloud provider. More on Public Clouds.

Hybrid cloud. The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardised or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds). More on Hybrid Clouds.

Four dimension of Cloud Cube model



Cloud Cube Model, designed and developed by **Jericho forum**. Which helps to categorize the cloud network based on the four-dimensional factor: Internal/External, Proprietary/Open, De-Perimeterized/Perimeterized, and Insourced/Outsourced.

Cloud Cube model, helps to categorize the cloud network based on the four-dimensional factor. Their main focus is to protect and secure the cloud network. This cloud cube model helps to select cloud formation for secure collaboration. This model helps IT managers, organizations, and business leaders by providing the secure and protected network.

The Cloud Cube Model effectively summarizes these four dimensions:

1. Internal/External
2. Proprietary/Open
3. Perimeterised/De-perimeterized Architectures
4. Insourced/Outsourced

Dimension 1: Internal/External

This dimension defines the physical location of the data; where does the cloud form exist – inside or outside organization boundaries? If the cloud form is within the organization's physical boundaries, then it is internal. If it is outside the organization's physical boundaries, then it is external. It's important to note that the assumption that internal is necessarily

more secure than external is false. The most secure usage model is the effective use of both internal and external cloud forms.

Dimension 2: Proprietary/Open

This dimension defines the state of ownership of the cloud technology, services, interfaces, etc. It indicates the degree of interoperability, as well as enabling data/application transportability between an organization's own systems and other cloud forms and the ability to withdraw your data from a cloud form, or to move it to another without constraint. This dimension indicates any constraints on being able to share apps.

"Proprietary" suggests that the organization providing the service is keeping the means of provision under its ownership. By contrast, "open" clouds use technology that is not proprietary, which means that there are likely to be more suppliers, and the organization is not as constrained in terms of ability to share data and collaborate with selected parties. Experts suggest that open clouds most effectively enhance collaboration between multiple organizations.

Dimension 3: Perimeterised/De-perimeterised Architectures

This dimension represents the architectural mindset of the organization. It asks if the organization is operating within its traditional IT perimeter or outside it. De-perimeterisation relates to the gradual failure, removal, shrinking or collapse of the traditional silo-based IT perimeter.

"Perimeterised" suggest a system that continues to operate within the traditional IT perimeter, often characterized by "network firewalls." This approach is known to inhibit collaboration. Operating within such areas means extending an organization's perimeter into the external cloud computing domain via a VPN and operating the virtual server in its own IP domain. The organization uses its own directory services to control access. Once the computing task is complete, the perimeter is withdrawn to its original, traditional position.

"De-perimeterised" suggests that the system perimeter is designed following the principles outlined in the Jericho Forum's Commandments and Collaboration Oriented Architectures Framework. De-perimeterised areas in the Cloud Cube Model use both internal and external domains, but the collaboration or sharing of data should not be seen as internal or external. Rather, it is controlled by and limited to the parties that the using organizations select.

Dimension 4: Insourced/Outsourced

This dimension has two states in each of the eight cloud forms. It responds to the question: who do you want running your clouds? "Outsourced" means that the service is provided by a third party. Insourced means that the service is provided by your own staff under your control. These states describe the party managing the delivery of the cloud service(s) used by the organization.

It's important to note that few organizations that are traditionally bandwidth, software or hardware providers will be able to smoothly transition to becoming cloud service providers. Organizations looking to procure cloud services must develop the ability to rapidly set up legally binding collaboration agreements, and to close them just as quickly once they become unnecessary. When terminating an agreement with a provider, an organization should ensure that the data is appropriately deleted from the service provider's infrastructure (including backups), to avoid risk of a data breach or leak.