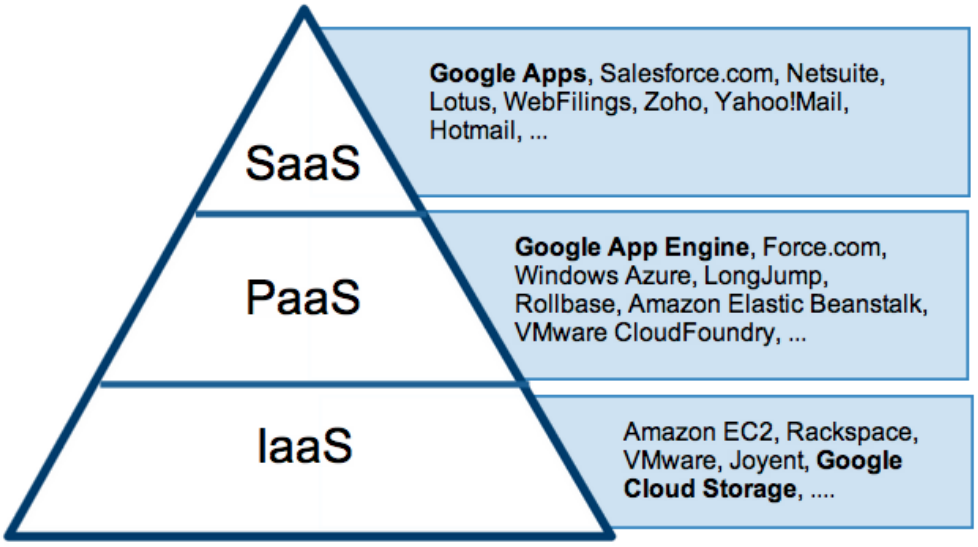
Cloud Computing

What is Cloud Computing?

Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet). The “cloud” in cloud computing can be defined as the set of hardware, networks, storage, services, and interfaces that combine to deliver aspects of computing as a service. Cloud services include the delivery of software, infrastructure, and storage over the Internet. Most of the cloud computing has following features:

- **It's virtual**
- **It can be secure**
- **It's flexible and scalable**
- **It can be affordable**
- **It can be secure and affordable**



Most IT departments are forced to spend a significant portion of their time on frustrating implementation, maintenance, and upgrade projects that too often don't add significant value to the company's bottom line. Increasingly, IT teams are turning to cloud computing technology to minimize the time spent on lower-value activities and allow IT to focus on strategic activities with greater impact on the business

In a cloud computing system, there's a significant workload shift. Local computers no longer have to do all the heavy lifting when it comes to running applications. The network of computers that make up the cloud handles them instead. Hardware and software demands on the user's side decrease. The only thing the user's computer needs to be able to run is the cloud computing system's interface software, which can be as simple as a Web browser, and the cloud's network takes care of the rest. Some of the advantages of cloud based services are:

- **Proven Web-services integration**. By their very nature, cloud computing technology is much easier and quicker to integrate with your other enterprise applications (both traditional software and cloud computing infrastructure-based), whether third-party or homegrown.

- **World-class service delivery**. Cloud computing infrastructures offer much greater scalability, complete disaster recovery, and impressive uptime numbers.

- **No hardware or software to install**: a 100% cloud computing infrastructure. The beauty of cloud computing technology is its simplicity… and in the fact that it requires significantly fewer capital expenditures to get up and running.

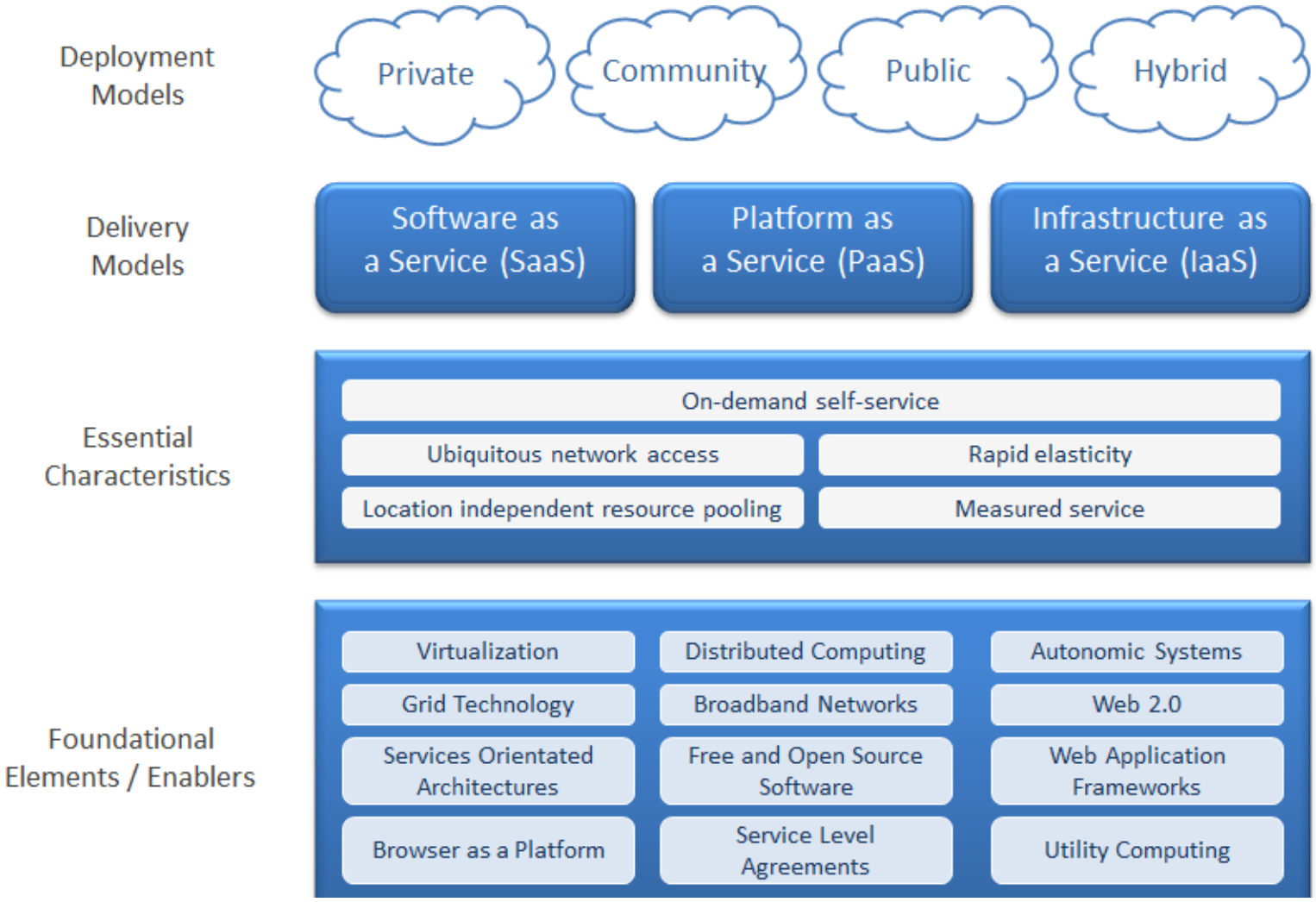
- **Faster and lower-risk deployment**. You can get up and running in a fraction of the time with a cloud computing infrastructure. No more waiting months or years and spending millions of dollars before anyone gets to log into your new solution. Your cloud computing technology applications are live in a matter of weeks or months, even with extensive customization or integration.

- **Support for deep customizations**. Some IT professionals mistakenly think that cloud computing technology is difficult or impossible to customize extensively, and therefore is not a good choice for complex enterprises. The cloud computing infrastructure not only allows deep customization and application configuration, it preserves all those customizations even during upgrades. And even better, cloud computing technology is ideal for application development to support your organization's evolving needs.

- **Empowered business users**. Cloud computing technology allows on-the-fly, point-and-click customization and report generation for business users, so IT doesn't spend half its time making minor changes and running reports.

- **Automatic upgrades that don't impact IT resources**. Cloud computing infrastructures put an end to a huge IT dilemma: If we upgrade to the latest-and-greatest version of the application, we'll be forced to spend time and resources (that we don't have) to rebuild our customizations and integrations. Cloud computing technology doesn't force you to decide between upgrading and preserving all your hard work, because those customizations and integrations are automatically preserved during an upgrade.

CLOUD AT A GLANCE



Emergence/ History of Cloud Computing

One of the first milestones for cloud computing was the arrival of Salesforce.com in 1999, which pioneered the concept of delivering enterprise applications via a simple website. The services firm paved the way for both specialist and mainstream software firms to deliver applications over the internet.

The next development was Amazon Web Services in 2002, which provided a suite of cloud-based services including storage, computation and even human intelligence through the Amazon Mechanical Turk.

Then in 2006, Amazon launched its Elastic Compute cloud (EC2) as a commercial web service that allows small companies and individuals to rent computers on which to run their own computer applications.

Another big milestone came in 2009, as Web 2.0 hit its stride, and Google and others started to offer browser-based enterprise applications, though services such as Google Apps.

The most important contribution to cloud computing has been the emergence of "killer apps" from leading technology giants such as Microsoft and Google. When these companies deliver services in a way that is reliable and easy to consume, the knock-on effect to the industry as a whole is a wider general acceptance of online services.

Then came mature virtualization technologies in 2009-tilldate that changed landscape of cloud computing. Private, Public and hybrid cloud were dominant cloud types in Enterprise Level. Server and Storage Consolidation were major works in the cloud industry.

Cloud Based Services

- **Hosted Desktops:** The hosted virtual desktop is just like normal PC desktop, except that applications, data and user profile are stored in a secure data center. It is designed to replace traditional desktop PC environment, and provides the same level of functionality and performance as normal PC.

- **Hosted Websites/ Emails:** Websites and emails are hosted in cloud based servers. The main advantages of hosted websites and emails is the saving of cost used for procuring new servers, managing servers, power system, experts, maximum uptime, scalability and security.
- **Hosted Telephony:** Hosted telephony is the way of taking all the telephone infrastructure from on premises to some cloud based telephony system. The advantages of this technique are that it is easy for the service provider to upgrade the system, there's very little local infrastructure needed at your office location and it provides good

flexibility especially across multiple location. Hosted PBX companies handle call routing, or switching, at their own location and are responsible for managing all of the PBX equipment and software involved in the virtual PBX service. Hosted PBX services can function over the Public Switched Telephone Network (PSTN) over the Internet (hosted IP PBX via Internet telephony, or VoIP), or over a combination of the two. Because it is a hosted system, there's no high initial cost for buying the expensive hardware. There's also never an upgrade cost for changing hardware. Unlike traditional PBX services, hosted PBX makes advanced business technology available for even small businesses.

- **Cloud Storage:** Cloud storage is a service model in which data is maintained, managed and backed up remotely and made available to users over a network (typically the Internet). Availability and Scalability are the major advantages of using cloud based storage. By availability means, any user can access their data residing in cloud from any location via Internet. By Scalability means, user can increase their storage space as per need and load by paying they use the storage quantity.

Grid Computing:

Grid computing is a computer network in which each computer's resources are shared with every other computer in the system. Processing power, memory and data storage are all community resources that authorized users can tap into and leverage for specific tasks. A grid computing system can be as simple as a collection of similar computers running on the same operating system or as complex as inter-networked systems comprised of every computer platform you can think of. A grid computer is connected through a super-fast network and share the devices like disk drives, mass storage, printers and RAM.

In general, a grid computing system requires:

- **At least one computer, usually a server, which handles all the administrative duties for the system:** This type of computer are sometimes referred as a control node. All the administrative tasks required for computing are handled by this control node. The control node must prioritize and schedule tasks across the network. It's the control node's job to determine what resources each task will be able to access. The control node must also monitor the system to make sure that it doesn't become overloaded.
- **A network of computers running special grid computing network software:** These computers act both as a point of interface for the user and as the resources the system will look into for different applications.
- **A collection of computer software called middleware:** The purpose of middleware is to allow different computers to run a process or application across the entire network of machines. Middleware is the workhorse of the grid computing system. Without it, communication across the system would be impossible.

Grid Vs Cloud Computing

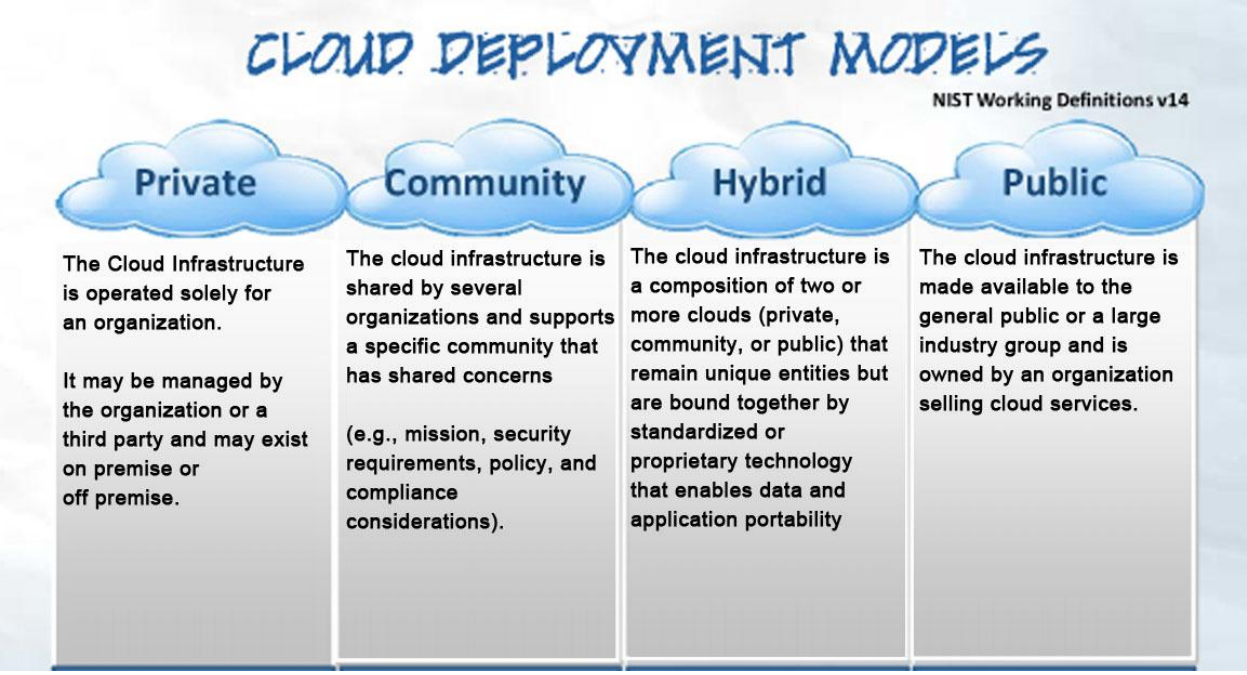
Parameter	Grid computing	Cloud computing
Goal	Collaborative sharing of resources	Use of everything as a service
Level of abstraction	Low (more details)	High (eliminate details)
Degree of scalability	Normal	High
Multitask	Yes	Yes
Transparency	Low	High
Time to	Not real-time	Real-time services
Requests type	Few but large allocation	Lots of small allocation
Virtualization	Not a necessity	Vital
Portal accessible	Via a DNS system	Only using IP (no DNS registered)
Transmission	Suffered from internet delays	Was significantly fast
Security	Low (grid certificate service)	High (Virtualization)
Infrastructure	Low level command	High level services (SaaS)
Operating System	Any standard OS	A hypervisor (VM) on which multiple OSs run
Ownership	Multiple	Single
Interconnection network	Mostly internet with latency and low bandwidth	Dedicated, high-end with low latency and high bandwidth
Service negotiation	SLA based	SLA based
User management	Decentralized and also Virtual Organization (VO)-based	Centralized or can be delegated to third party
Resource management	Distributed	Centralized/Distributed
Allocation/Scheduling	Decentralized	Both centralized/decentralized
Failure management	Limited (often failed tasks/applications are restarted)	Strong (VMs can be easily migrated from one node to other)
Pricing of services	Dominated by public good or privately assigned	Utility pricing, discounted for larger Customers
Type of service	CPU, network, memory, bandwidth, device, storage,…	IaaS, PaaS, SaaS, Everything as a service
Example of real world	SETI, BOINC, Folding@home, GIMPS	Amazon Web Service (AWS), Google apps
Response Time	Can’t be serviced at a time and need to be scheduled	Real-time

Critical object	Computer resource	Service
Number of users	Few	More
Resource	Limited (because hardware are limited)	Unlimited
Configuration	Difficult as users haven't administrator privilege	Very easy to configure
Future	Cloud computing	Next generation of internet

Components of Cloud Computing

a. **The Client- The End User:** Everything ends with the client. The hardware components, the application and everything else developed for cloud computing will be used in the client. Client systems has some application installed which enables them to connect to cloud software or some infrastructure.
b. **The Service (Functions in Cloud Computing):** Cloud computing always has a purpose. One of the main reasons cloud computing become popular is due to the adoption of businesses as the easier way to implement business processes. It has some standard service or procedure of interfacing/ connecting client computers with cloud infrastructure. Cloud computing is all about processes and the services launched through cloud computing always has to deal with processes with an expected output.
c. **The Application:** Application is the core of what users are going to use. It is the mainstay of what users are wanting for their daily operations. Application are normally a program that users use to connect cloud infrastructure either with web interface or any application interface. In simple way, we can define application as a software that end user uses to do their operations in which their main data resides in cloud.
d. **The Platform:** The platform is where all the applications and services are based upon. The platform usually comes as the programming language such as Ajax (Asynchronous JavaScript and XML) or Ruby on Rails. In simple way, the platform is the cloud infrastructure where it provides application and service the base to operate. It is the environment provided by cloud vendors which enables all the application to operate and services to operate.
e. **The Storage:** The last and most critical components in cloud computing is the storage. Everything that the application knows and the functions that could be provided by service are possible through storage. Modern day cloud storage is based on highly virtualized infrastructure and has the same characteristics as cloud computing in terms of agility, scalability, elasticity and multi-tenancy. Some cloud storage systems are small operations, while others are so large that the physical equipment can fill up an entire warehouse.

Cloud Computing Deployment Model



Public Cloud: This is the deployment model that most commonly described as cloud computing. In this model, all of the physical resources are owned and operated by a third party cloud computing provider. The provider services multiple clients that may consist of individuals or corporations utilizing these resources through the public Internet. Services can be dynamically provisioned and are billed based on usage alone. This model provides the highest degree of cost savings while requiring the least amount of overhead.

This model is best suited for business requirements wherein it is required to manage load spikes, host SaaS applications, utilize interim infrastructure for developing and testing applications, and manage applications which are consumed by many users that would otherwise require large investment in infrastructure from businesses.

Private Cloud: Private cloud computing systems emulate public cloud service offerings within an organization's boundaries to make services accessible for one designated organization. Private cloud computing systems make use of virtualization solutions and focus on consolidating distributed IT services often within data centers belonging to the company. The chief advantage of these systems is that the enterprise retains full control

over corporate data, security guidelines, and system performance. This model doesn't bring much in terms of cost efficiency: it is comparable to buying, building and managing your own infrastructure. Still, it brings in tremendous value from a security point of view. In addition to security reasons, this model is adopted by organizations in cases where data or applications are required to conform to various regulatory standards, which may require data to be managed for privacy and audits that govern the corporation.

Hybrid Cloud: This can be a combination of private and public clouds that support the requirement to retain some data in an organization, and also the need to offer services in the cloud. A company may use internal resources in a private cloud maintain total control over its proprietary data. It can then use a public cloud storage provider for backing up less sensitive information. At the same time, it might share computing resources with other organizations that have similar needs. By combining the advantages of the other models, the hybrid model offers organizations the most flexibility.
This model is also used for handling cloud bursting, which refers to a scenario where the existing private cloud infrastructure is not able to handle load spikes and requires a fallback option to support the load. Hence, the cloud migrates workloads between public and private hosting without any inconvenience to the users.

Community Cloud: In the community deployment model, the cloud infrastructure is shared by several organizations with the same policy and compliance considerations. This helps to further reduce costs as compared to a private cloud, as it is shared by larger group.

A community cloud contains features of the public and private cloud models. Like a public cloud, the community cloud may contain software, data storage, and computing resources that are utilized by multiple organizations. Where this model differs from the public model is that the infrastructure is only utilized by a group of organizations that are known to each other. Similarly to a private cloud, these organizations are responsible for the operation of their own infrastructure. The community cloud model can provide greater cost savings than the private cloud while offering some of its security features. This model is best suited for organizations that share common requirements such as security or legal compliance policies. It can be managed by the member organizations or by a third party provider.

Benefits of Using Cloud Model/ Why Switch from Traditional IT to cloud/ Goal of Cloud Computing

- **Reduced Spending on Technology Infrastructure:** Moving to cloud computing may reduce the cost of managing and maintaining your IT systems. Rather than purchasing expensive systems and equipment for your business, you can reduce your costs by using the resources of your cloud computing service provider. You may be able to reduce your operating costs because
    - the cost of system upgrades, new hardware and software may be included in your contract
    - you no longer need to pay wages for expert staff
    - your energy consumption costs may be reduced
    - There are fewer time delays.

- **Globalizing Workspace/ Easy Accessibility:** Globalizing your workspace or system may add additional agility and effectiveness to your system. For example, you have the ability to access data from home, on holiday, or via the commute to and from work (providing you have an internet connection). If you need access to your data while you are off-site, you can connect to your virtual office, quickly and easily.

- **Improve Flexibility and Scalability**: Your business can scale up or scale down your operation and storage needs quickly to suit your situation, allowing flexibility as your needs change. Rather than purchasing and installing expensive upgrades yourself, your cloud computer service provider can handle this for you. Using the cloud frees up your time so you can get on with running your business.

- **Better Resource Utilization:** Using technologies such as virtualization and distributed computing, computing resources can be used fully up to their potentials. In cloud model, you can pay whatever you use for your operational purpose.

- **Backup and Disaster Recovery:** Since all your data is stored in the cloud, backing it up and restoring the same is relatively much easier than storing the same on a physical device. Furthermore, most cloud service providers are usually competent enough to handle recovery of information. Hence, this makes the entire process of backup and recovery much simpler than other traditional methods of data storage.

Also adding to backup management, cloud infrastructure can be used as a very strong disaster recovery site as they do have enough infrastructure and technology to be a potent DR Site.

- **Guaranteed Uptime and Strong Service Level Agreements (SLA):** Cloud infrastructure by nature is built for robustness and high availability. Uptime is a major attribute for rapid popularity of cloud computing as all the services provided by cloud vendors should be guaranteed to be working all the time. Hence, the service level agreements between the cloud provider and customer are supposed to be very strong in case of availability and security. By achieving strong SLA's, customer can operate very effectively with zero downtime.

- **Helps smaller business compete:** Cloud infrastructure is a global platform where smaller and large scale business both can use the resources. Hence, smaller business industries can be equally competent in regard to IT Infrastructure and can focus more on their business side. By decreasing their capital expenses (CAPex) they can move forward by using financials to business development.

Legal Issues in Cloud Computing:

- **Confidentiality:** Data in enterprise world is as important as anything. Placing your data in cloud infrastructure is supposed to be vulnerable and insecure. Hence, before and after moving to cloud infrastructure, organizations should carefully judge whether their data is managed confidentially or not.
- **Liability and responsibility**: Liability and responsibility is another legal issues that has to be addressed by cloud vendor as well as customers. It should be regularly monitored to investigate that whether cloud vendors has performed their duties in accordance to Service Level Agreements (SLA) or not. As is cloud definition, customer has to ensure that cloud vendors has sufficient infrastructure, proper backup policy, business continuity plan and all the prerequisite to host valuable data.
- **Compliance**: Before customers will entrust their IT needs to managed or cloud services, they need two things: first, assurance that cloud infrastructure is secure and compliant, and second, visibility into their own security and compliance stance in cloud or managed infrastructure. Cloud vendors should ensure the security and compliance of their customer with powerful incident management capabilities, immediate alerts about suspicious activities, and access to detailed

forensic data. It should give its customer all the components required to deliver the compliance and security reports and dashboards they demand.

- **Data protection, safety and recovery:** Data in cloud as said should be safe enough to be trusted and protected from various attacks. Safety and protection is not only enough for operating in cloud but it should have some standard recovery mechanism to recover data in case of failure of system.
- **Copyright and Ownership:** Even though data may be residing in cloud infrastructure in any part of the world, data should be owned by customer and it should have legal obligation of being owned by customer themselves. Data once migrated to the cloud data centers should be completely owned and should be protected by some copyright. Customers should be aware of intentional duplication of data, data being copied or any leakage of data.
- **Data portability:** What if customers want to shift data/ app to other cloud vendors? Data portability is a major hurdle for any customer to migrate from on cloud vendor to another. Is there any legal obligation of cloud vendor regarding the move or not? What if existing cloud vendor do not allow customer to migrate data to other provider? These questions should be clear enough for both customer and vendor and there should be defining answer for these questions.
- **Right to Audit**: IT audit in cloud infrastructure is a necessity for maintaining compliance of cloud vendor as well as customer. Before moving to the cloud, and ideally during the procurement process, you should know your risk appetite and how it feeds the control environment — and then determine the potential cloud provider's risk appetite. Security, Risk, Compliance are some of the factors that customers need to check periodically for the risk free operations. And while moving to cloud data centers, customers should be legally enforced to have the right to audit their hardware, software, systems and applications.
- **Termination or Suspension Contract:** Cloud computing agreement can be terminated on the account of various reasons. The contract may expire at the end of its stipulated term or it may be terminated for default or material breach of terms of contract. User may also want to terminate the contract to migrate to a better or more cost effective cloud computing service. The user's data is most vulnerable after the termination of contract and in most cases service provider has no legal duty or liability to handle the user's data properly unless stipulated otherwise in the cloud computing contract. Hence a careful steps should be taken whenever for various reason a customer terminates the services from cloud service provider.

Characteristics of Cloud Computing

- **Service Oriented**: The defining characteristics of cloud computing is the service oriented feature. All the IT related services are hosted in cloud infrastructure. Companies should not have to buy expensive servers, network equipment's and invest on expensive manpower. All they need is to subscribe to any cloud service provider and get what they want. In this way, we can decrease our capital expenditure and move to operate via Operating expenditure.

- **Broad Network Access:** Cloud Capabilities are available over the network and accessed
  through standard mechanisms that promote use by heterogeneous thin or thick client
  platforms such as mobile phones, laptops and PDAs.

- **On Demand:** A consumer can provision computing capabilities, such as server processing and network storage, as needed automatically without requiring human interaction with each service's provider. computer services such as email, applications, network or
  server service can be provided without requiring human interaction with each service
  provider. Cloud service providers providing on demand self-services include Amazon Web Services (AWS), Microsoft, Google, IBM and Salesforce.com.
- **Reliability, Elasticity and scalability**: The cloud is reliable in the sense that the infrastructure setup for cloud is robust and backed up for high availability. It is some resilient replication and backup strategy that is targeted for huge customer base. The cloud is **elastic**, meaning that resource allocation can get bigger or smaller depending on demand. Elasticity enables **scalability**, which means that the cloud can scale upward for peak demand and downward for lighter demand. Scalability also means that an application can scale when adding users and when application requirements change.

- **Resource Pooling (Processor, Memory, and Storage):** Cloud infrastructure should have features of resource pooling i.e. resources (CPU, Memory, Disk) should be categorized in a hierarchy as per the need of computing. Resource pooling is mainly used for utilizing servers up to its potential. Since most of the times server

resources are unused, we can use the concept of virtualization to pool its resources.

- **Measured Service (Pay per Use):** Cloud computing resource usage can be measured, controlled, and reported providing transparency for both the provider and consumer of the utilized service. Cloud computing services use a metering capability which enables to control and optimize resource use. This implies that just like air time, electricity or municipality water IT services are charged per usage metrics – pay per use. The more you utilize the higher the bill. Just as utility companies sell power to subscribers, and telephone companies sell voice and data services, IT services such as network security management, data center hosting or even departmental billing can now be easily delivered as a contractual service.

- **Multi Tenancy:** Multi tenancy refers to a principle in IT infrastructure where a single instance of the software runs on a server, serving multiple client organizations (tenants). With a multitenant architecture, a software application is designed to virtually partition its data and configuration, and each client organization works with a customized virtual application instance. Each customer does its own work without interfering other customer even though they are hosted at the same platform.

Challenges in Cloud Computing/ Security Issues

- Privacy
- Data Security
- Ownership
- RASP (Reliability, Availability, Scalability and Performance)
- Data Recovery and Backup
- Cross Country Data Migration and Portability
- Multiplatform Support
- Intellectual Property
- Misuse
- Real Time Processing
- Compliance

Distributed Computing in Grid and Cloud Computing

A distributed computing consists of multiple software components that are on multiple computers, but run as a single system. The computers that are in a distributed system can be physically close together and connected by a local network, or they can be geographically distant and connected by a wide area network. A distributed system can consist of any number of possible configurations, such as mainframes, personal computers, workstations, minicomputers, and so on. The goal of distributed computing is to make such a network work as a single computer.

Distributed computing, as one can imagine, is where the computing elements of a network are spread over a large geographical area. Both cloud and grid computing are prime examples of distributed computing architectures.

Another type of distributed computing is known as **grid computing**. Grid computing consists of many computers operating together remotely and often simply using the idle processor power of normal computers. Grid provides the sharing of:

- Computational resources
- Storage elements
- Specific applications
- Equipment
- Other

While there are many similarities between grid and cloud computing, it is the differences that matter most. Grid computing is better suited for organizations with large amounts of data being

requested by a small number of users (or few but large allocation requests), whereas cloud computing is better suited to environments where there are a large number of users requesting small amounts of data (or many but small allocation requests).

Cloud computing is basically a sales and distribution model for various types of resources over the internet, while distributed computing can be identified as a type of computing, which uses a group of machines to work as a single unit to solve a large scale problem. Distributed computing achieves this by breaking the problem up to simpler tasks, and assigning these tasks to individual nodes.

Compared to other distributed systems such as grids or clusters, cloud computing solutions give enterprises significantly more flexibility. They can dispense with IT infrastructures of their own and only have to pay for the resources and services they actually use (“pay-per-use”/ “pay as you go”). These can be dynamically adapted to changed business requirements and processes with the help of virtualization technologies and service oriented, distributed software systems.