

CLOUD COMPUTING

UNIT 1: INTRODUCTION

What is Cloud?

C= (Common) Public to Every one

L= (Location) Independent area of use

O= (Online) through Online

U= (Utility) Multiple Services

On

D= (Demand) according to Need

- A Way of Computing, Via the Internet
- Share computer resources instead of using software or storage on local PC.
- No need to install documents, software, operating System.
- A physical storage center is no longer needed.
- Only need is High Speed Internet.

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.

Applications such as e-mail, web conferencing, customer relationship management (CRM) execute on cloud.

Key Technology: Virtualization

❑ Virtual workspaces:

- An abstraction of an execution environment that can be made dynamically available to authorized clients by using well-defined protocols,
- Resource quota (e.g. CPU, memory share),
- Software configuration (e.g. O/S, provided services).

❑ Implement on Virtual Machines (VMs):

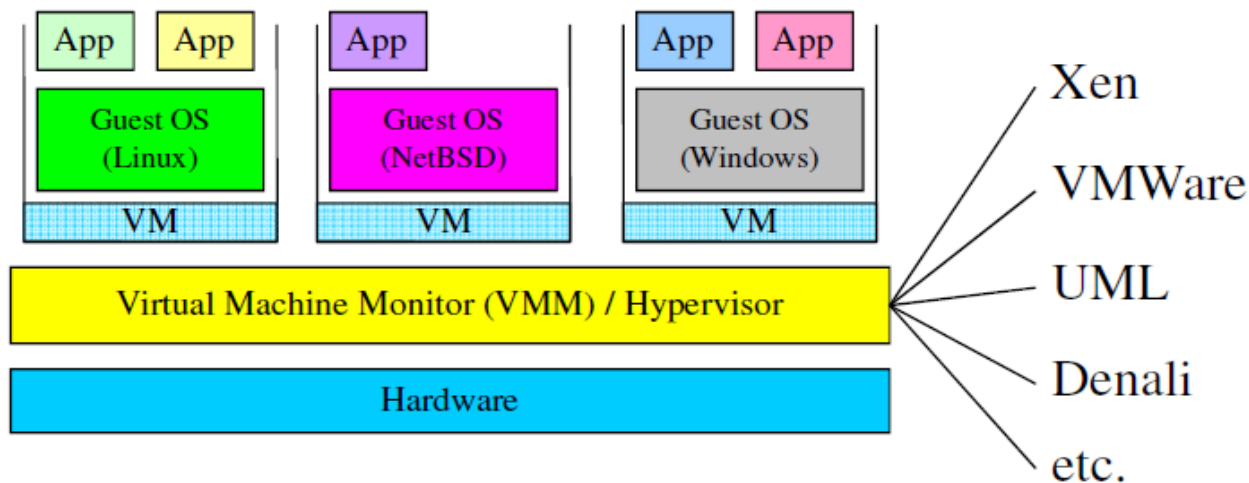
- Abstraction of a physical host machine,
- Hypervisor intercepts and emulates instructions from VMs, and allows management of VMs,
- VMWare, Xen, etc.

❑ Provide infrastructure API:

- Plug-ins to hardware/support structures

Virtual Machines

- ❑ VM technology allows multiple virtual machines to run on a single physical machine.



Definitions

- Cloud computing is using the internet to access someone else's software running on someone else's hardware in someone else's data center.

Lewis Cunningham^[2]

Definitions

- A large-scale **distributed computing paradigm** that is driven by economies of scale, in which **a pool of abstracted, virtualized, dynamically scalable, managed computing power, storage, platforms, and services** are delivered on demand to external customers over the Internet.

Ian Foster^[9]

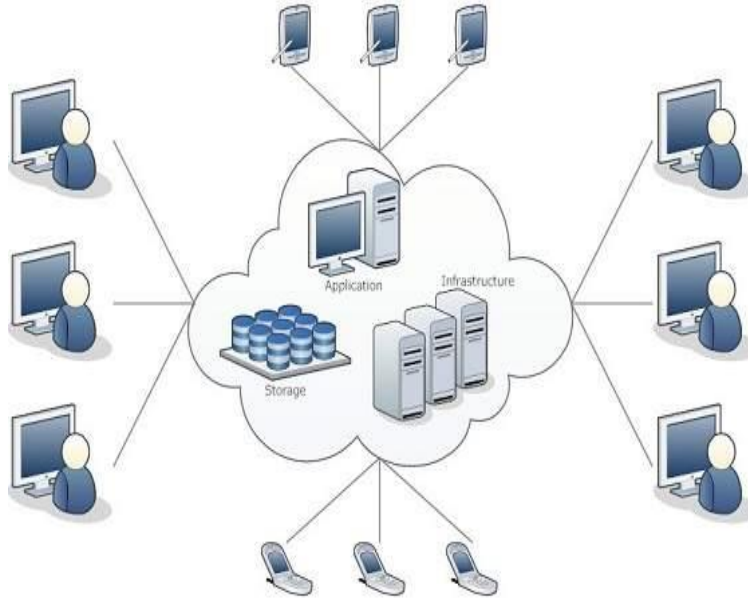
Definitions

- A Cloud is a type of parallel and distributed system consisting of **a collection of interconnected and virtualized computers** that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers.

Rajkumar Buyya^[10]

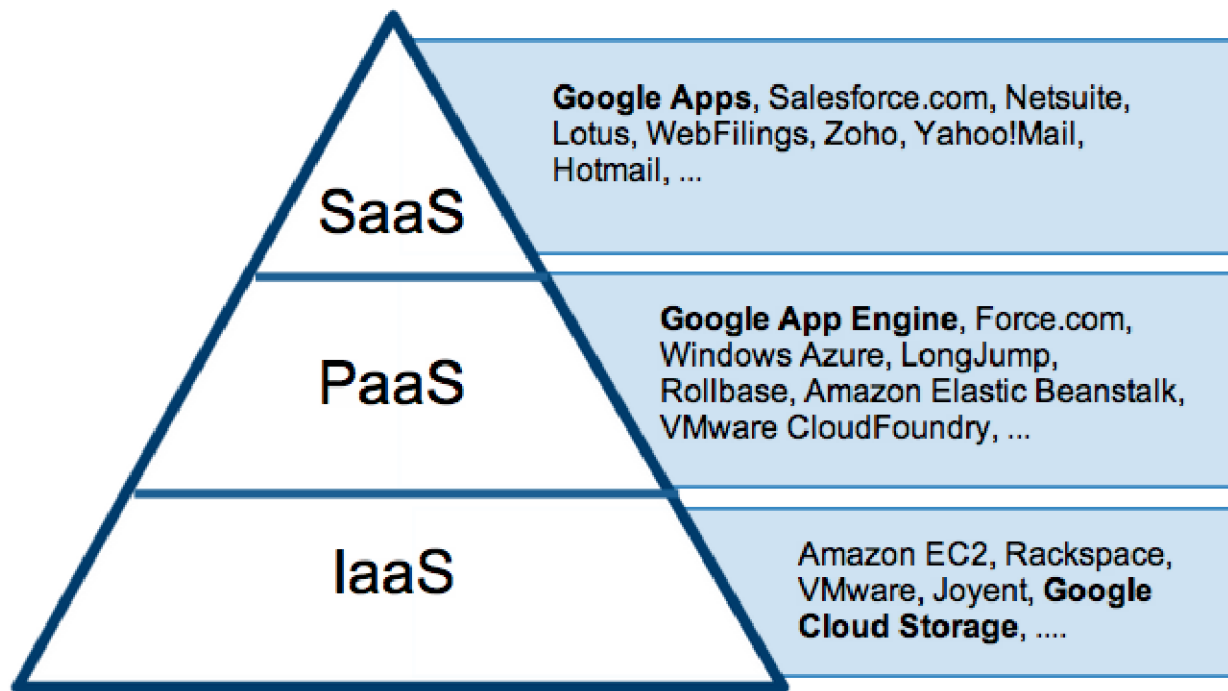
What is Cloud Computing?

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



Features of Cloud Computing

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

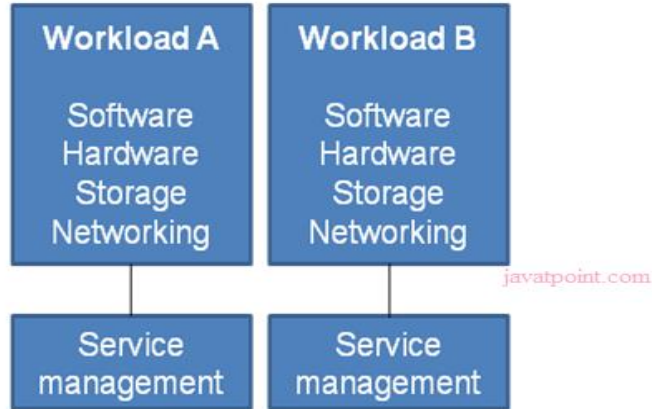


Why Cloud Computing?

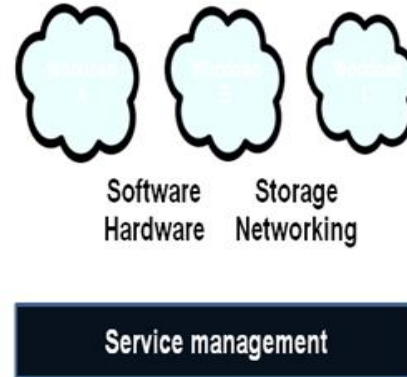
- Actually, Small as well as some large IT companies follows the traditional methods to provide the IT infrastructure. That means **for any IT company, we need a Server Room that is the basic need of IT companies.**
- In that server room, there should be a *database server, mail server, networking, firewalls, routers, modem, switches*, QPS(Query Per Second means how much queries or load will be handled by the server) , configurable system, *high net speed* and the *maintenance engineers*.
- To establish such IT infrastructure, we need to spend lots of money. To overcome all these problems and to reduce the IT infrastructure cost, Cloud Computing comes into existence.
- 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.

Why Cloud Computing?

Without cloud computing



With cloud computing



Understanding Cloud Computing

- Automated service management
- Standardized services
- Location independent
- Rapid scalability
- Self-service

History of Cloud Computing

- Before emergence of the cloud computing, there was **Client/Server computing** which is basically a centralized storage in which all the software applications, all the data and all the controls are resided on the server side.
- If a single user wants to access specific data or run a program, he/she need to connect to the server and then gain appropriate access, and then he/she can do his/her business.
- Then after, distributed computing came into picture, where all the computers are networked together and share their resources when needed.

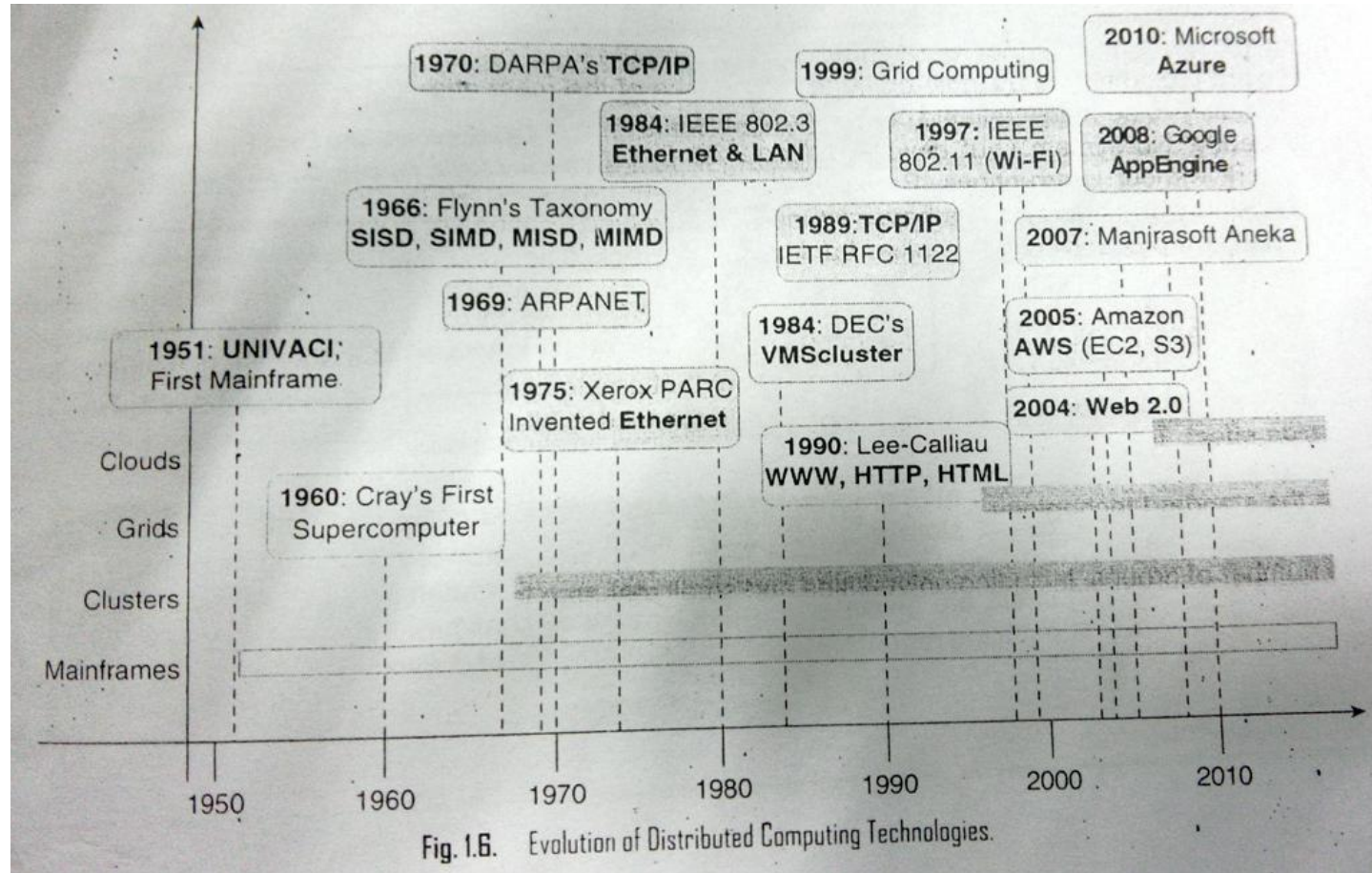
On the basis of above computing, there was emerged of cloud computing concepts that later implemented.

At around in 1961, John MacCharty suggested in a speech at MIT that computing can be sold like a utility, just like a water or electricity. It was a brilliant idea, but like all brilliant ideas, it was ahead if its time, as for the next few decades, despite interest in the model, the technology simply was not ready for it.

But of course time has passed and the technology caught that idea and after few years we mentioned that:

- *In 1999, **Salesforce.com** started delivering of applications to users using a simple website.* The applications were delivered to enterprises over the Internet, and this way the dream of computing sold as utility were true.
- *In 2002, **Amazon** started Amazon Web Services, providing services like storage, computation and even human intelligence. However, only starting with the launch of the Elastic Compute Cloud in 2006 a truly commercial service open to everybody existed.*
- *In 2009, **Google Apps** also started to provide cloud computing enterprise applications.*
- *In 2009, **Microsoft** launched Windows Azure, and companies like Oracle and HP have all joined the game.* This proves that today, cloud computing has become mainstream.

Historical Developments



Advantages of Cloud Computing

- **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.

Advantages of Cloud Computing

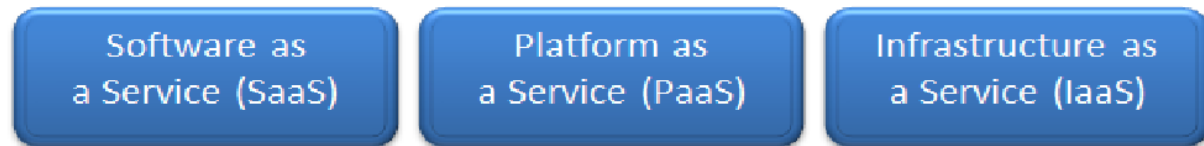
- **Empowered business users.** Cloud computing technology allows on-the-fly, point-and-click customization and report generation for business users, so IT doesn't spend half its time making minor changes and running reports.
- **Automatic upgrades that don't impact IT resources.** Cloud computing infrastructures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

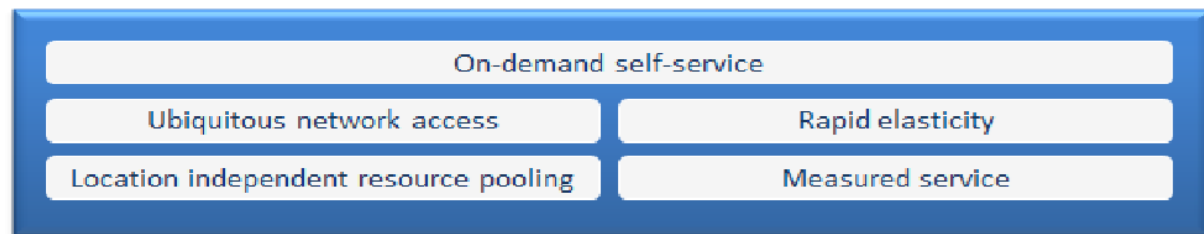
Deployment
Models



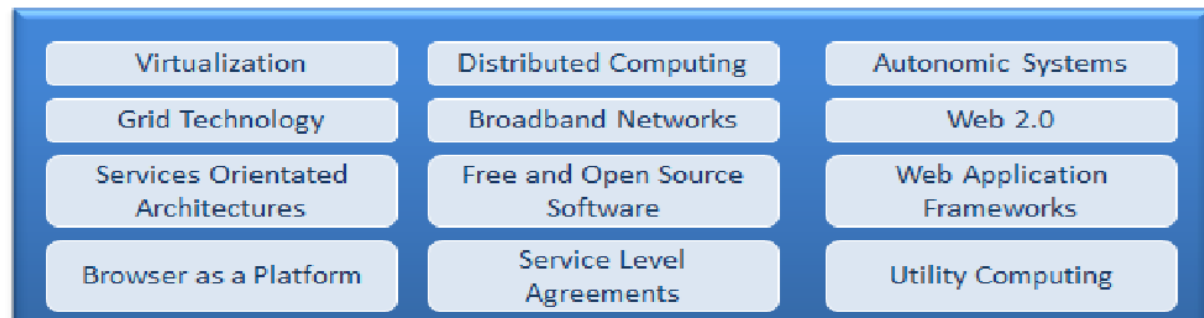
Delivery
Models



Essential
Characteristics



Foundational
Elements / Enablers



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.

Requirements of Grid Computing

- **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.

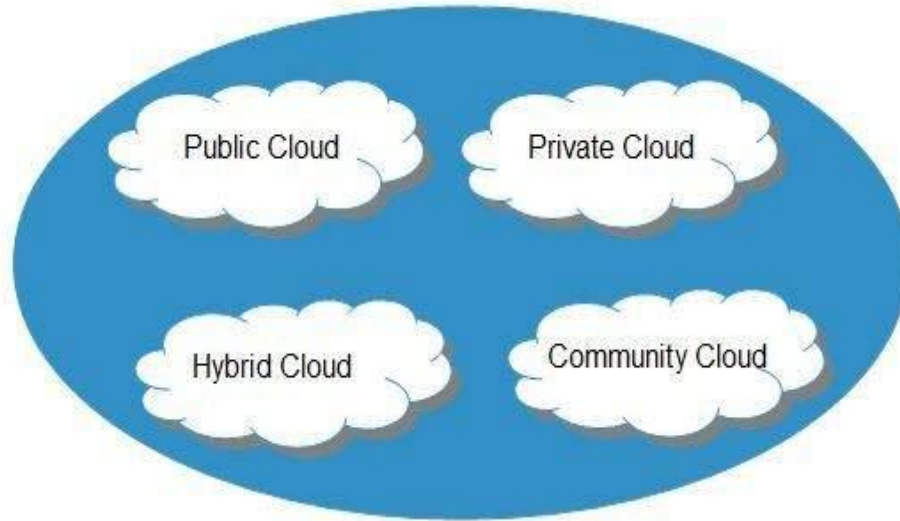
d. The Platform: The platform is where all the applications and services are based upon. The platform usually comes as the programming language such as Ajax (Asynchronous JavaScript and XML) or Ruby on Rails. In simple way, the platform is the cloud infrastructure where it provides application and service 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 Deployment Model

Deployment Models

Deployment models define the type of access to the cloud, i.e., how the cloud is located? Cloud can have any of the four types of access: Public, Private, Hybrid, and Community.



Public Cloud

- A **public cloud**, or **external cloud**, is the most common form of cloud computing, in which services are made available to the general public in a pay-as-you-go manner.
- Customers – individual users or enterprises – access these services over the internet from a third-party provider who may share computing resources with many customers.
- The **public cloud** model is widely accepted and adopted by many enterprises because the leading public cloud vendors as Amazon, Microsoft and Google, have equipped their infrastructure with a vast amount of data centers, enabling users to freely scale and shrink their rented resources with low cost and little management burden.

Advantages of Public Cloud Model

1) Low Cost

Public cloud is having low cost as compared to private or hybrid cloud, because it shares same resources with large number of consumer.

2) Reliable

Public cloud provides large number of resources from different locations, if any of the resource fail, public cloud can employ another one.

3) Flexible

It is very easy to integrate public cloud with private cloud and hence it gives flexible approach to consumers.

4) Location Independent

It ensures the independency of location, because public cloud services are delivered through Internet.

5) High Scalability

Cloud resources are available as per the demand from the pool of resources that means they can be scaled up or down according to the requirement.

Disadvantages of Public Cloud Model

1) Low security

In public cloud model, data is present off-site and resources are shared publicly. Hence it does not ensure the high level security.

2) Less customizable

It is less customizable than private cloud.

Continue...

- There are many public cloud service providers in place today, offering services ranging from infrastructure-as-a-service, to development-platform-as-a-service, to special purpose application-as-a-services.
- Amazon EC2, Force.com, and Google App Engine, are among some of the best known examples of public clouds,

Public Cloud (contd)...

- In simple terms, public cloud services are characterized as being available to clients from a third party service provider via the Internet.
- The term “public” **does not always mean free**, even though it can be free or fairly inexpensive to use.
- A public cloud **does not mean that a user’s data is publically visible**; public cloud vendors typically provide an access control mechanism for their users.
- Public clouds provide an elastic, cost effective means to deploy solutions.

Public Cloud



Private Cloud

- A Private Cloud, or internal cloud, is used when the cloud infrastructure, proprietary network or data center, is operated solely for a business or organization, and serves customers within the business fire-wall.
- Most of the private clouds are large company or government departments who prefer to keep their data in a more controlled and secure environment.

Reasons for Starting with a Private Cloud

Security and Privacy.

- Mitigates privacy and security concerns by maintaining data behind your own firewalls.

Strategic Opacity.

- Maintains strategic dullness, so your competitors cannot ascertain your intentions.

Focus on Internal Optimization First.

- Internally optimize internal utilization of infrastructure assets.

Continue...

Become an Internal Cloud Service Provider.

- Beginning your cloud strategy with a private cloud focus will accelerate your ability to become an internal cloud service provider to the enterprise.
- This is a key benefit of beginning your cloud initiative internally with a private Cloud Deployment Model.

Table 14.1 Public vs. private cloud

	Public cloud	Private cloud
Infrastructure Owner	Third party (Cloud provider)	Enterprise
Scalability	Unlimited and On-Demand	Limited to the installed Infrastructure
Control and Management	Only manipulate the virtual machines, resulting in less management burden	High level of control over the resources, and need more expertise to manage them.
Cost	Lower cost	High cost including: space, cooling, energy consumption and hardware cost
Performance	Unpredictable multi-tenant environment makes it hard to achieve guaranteed performance	Guaranteed performance
Security	Concerns regarding data privacy	Highly secure

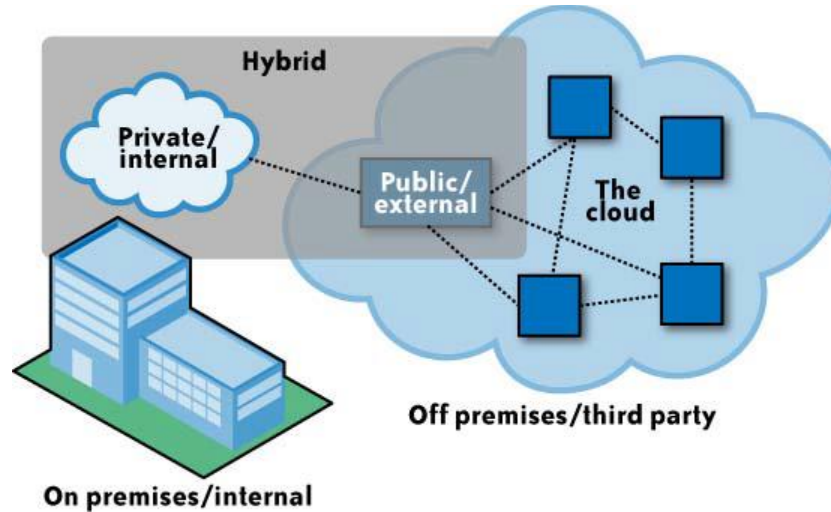
Hybrid Cloud

- A composition of the two types (private and public) is called a Hybrid Cloud, where a private cloud is able to maintain high services availability by scaling up their system with externally provisioned resources from a public cloud when there are rapid workload fluctuations or hardware failures.
- In the Hybrid cloud, an enterprise can keep their critical data and applications within their firewall, while hosting the less critical ones on a public cloud.

Hybrid Cloud

- While public and private clouds represent the two ends of the cloud computing spectrum in terms of ownership and efficiency of shared resources – and each is finding acceptance in accordance to the services offered and customer segments targeted – a third deployment model of cloud computing, the hybrid cloud model that blends the characteristics of public and private clouds, is emerging.
- A hybrid cloud is a deployment model for cloud services where an organization provides cloud services and manages some supporting resources in-house and has others provided externally.

Hybrid Cloud



Community Cloud

- The idea of a Community Cloud is derived from the Grid Computing and Volunteer Computing paradigms.
- In a community cloud, several enterprises with similar requirement can share their infrastructures, thus increasing their scale while sharing the cost.
- Another form of community cloud may be established by creating a virtual data center from virtual machines instances deployed on underutilized users machines

Community Cloud

- A community cloud is controlled and used by a group of organizations that have shared interests, such as specific security requirements or a common mission.
- The members of the community share access to the data and applications in the cloud.

Benefits of Using Cloud Model

- **Reduced Spending on Technology Infrastructure**
- **Globalizing Workspace/ Easy Accessibility**
- **Improve Flexibility and Scalability**
- **Better Resource Utilization**
- **Backup and Disaster Recovery**
- **Guaranteed Uptime and Strong Service Level Agreements (SLA)**

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.

Legal Issues in Cloud Computing:

- **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.

Legal Issues in Cloud Computing:

- **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.

Legal Issues in Cloud Computing:

- **Right to Audit**
- **Termination or Suspension Contract**

Characteristics of Cloud Computing

- **Service Oriented**
- **Broad Network Access**
- **On Demand**
- **Reliability, Elasticity and scalability**
- **Resource Pooling (Processor, Memory, and Storage)**
- **Measured Service (Pay per Use)**
- **Multi Tenancy**

Exhibit 1

Nine Challenges in Cloud Computing

1 Efficiency of Service Provisioning

- a. Usage of development tools and components
- b. Creation of scalable architectures
- c. Resource management and flexibility
- d. Availability of services

2 Effectiveness of Service Usage and Control

- a. Contracts including questions of liability
- b. Control of services by users
- c. Governance/escalation mechanisms

3 Transparency of Service Delivery and Billing

- a. Billing including license management
- b. Quality assurance and monitoring SLA
- c. Type and location of data processing

4 Information Security

- a. Identity and rights management
- b. Privacy and integrity
- c. Access control, logging, and attack prevention
- d. Verification and certification

5 Data Privacy

6 Interoperability

- a. Migration into/out of the cloud
- b. Ability to integrate into on-premise IT
- c. Cloud federation

7 Portability Between Providers

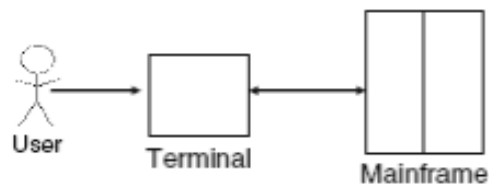
- a. Service portability
- b. Data portability

8 Ensuring Fair Competition in the Market

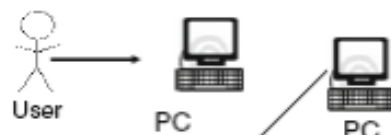
9 Compliance with Regulatory Requirements

Phases

1. Mainframe Computing



2. PC Computing



3. Network Computing



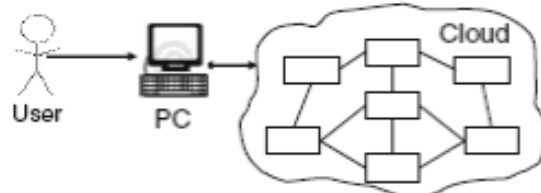
4. Internet Computing



5. Grid Computing



6. Cloud Computing



Assignment 1#

Due Date : 12/20/2024

1. Define the term cloud in cloud computing. Define cloud migration. What are the reasons for the companies to migrate from traditional computing environment to cloud computing environments?
2. Describe about cloud-based services. What are the benefits and challenges in cloud computing.
3. Describe the cloud service requirements.
4. How cloud computing is different than traditional on-premise computing? How properties like elasticity and scalability influence cloud computing?
5. Explain the cloud computing model and its benefits.
6. What is cloud computing? Explain the components of cloud computing.
7. Explain the cloud deployment models.
8. What are the differences between public clouds, hybrid cloud and private clouds model with suitable example?
9. What is the use of grid computing? How computing in grid architecture differs from cloud architecture? Explain.
10. Describe the evolution of cloud. Mention the advantages of using cloud computing.