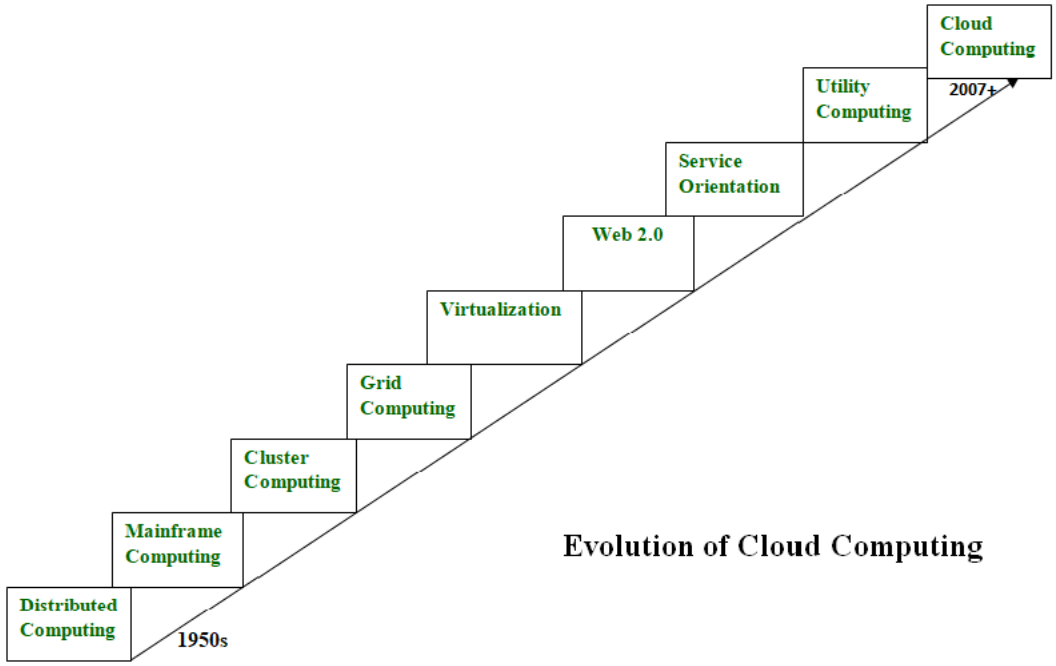
**Murang'a University of Technology**
**SIT 407 – Cloud Computing**
**Course Notes**

## Evolution of Cloud Computing

Cloud computing is all about renting computing services. This idea first came in the 1950s. In making cloud computing what it is today, five technologies played a vital role. These are distributed systems and its peripherals, virtualization, web 2.0, service orientation, and utility computing.



Evolution of Cloud Computing

### Distributed Systems:

It is a composition of multiple independent systems but all of them are depicted as a single entity to the users. The purpose of distributed systems is to share resources and also use them effectively and efficiently. Distributed systems possess characteristics such as scalability, concurrency, continuous availability, heterogeneity, and independence in failures. But the main problem with this system was that all the systems were required to be present at the same geographical location. Thus to solve this problem, distributed computing led to three more types of computing and they were-Mainframe computing, cluster computing, and grid computing.

### Mainframe computing:

Mainframes which first came into existence in 1951 are highly powerful and reliable computing machines. These are responsible for handling large data such as massive input-output operations. Even today these are used for bulk processing tasks such as online transactions etc. These systems have almost no downtime with high fault tolerance. After distributed computing, these increased the processing capabilities of the system. But these were very expensive. To reduce this cost, cluster computing came as an alternative to mainframe technology.

### Cluster computing:

In 1980s, cluster computing came as an alternative to mainframe computing. Each machine in the cluster was connected to each other by a network with high bandwidth. These were way cheaper than those mainframe systems. These were equally capable of high computations. Also, new nodes could easily be

added to the cluster if it was required. Thus, the problem of the cost was solved to some extent but the problem related to geographical restrictions still pertained. To solve this, the concept of grid computing was introduced.

**Grid computing:**

In 1990s, the concept of grid computing was introduced. It means that different systems were placed at entirely different geographical locations and these all were connected via the internet. These systems belonged to different organizations and thus the grid consisted of heterogeneous nodes. Although it solved some problems but new problems emerged as the distance between the nodes increased. The main problem which was encountered was the low availability of high bandwidth connectivity and with it other network associated issues. Thus. cloud computing is often referred to as "Successor of grid computing".

**Virtualization:**

It was introduced nearly 40 years back. It refers to the process of creating a virtual layer over the hardware which allows the user to run multiple instances simultaneously on the hardware. It is a key technology used in cloud computing. It is the base on which major cloud computing services such as Amazon EC2, VMware vCloud, etc work on. Hardware virtualization is still one of the most common types of virtualization.

**Web 2.0:**

It is the interface through which the cloud computing services interact with the clients. It is because of Web 2.0 that we have interactive and dynamic web pages. It also increases flexibility among web pages. Popular examples of web 2.0 include Google Maps, Facebook, Twitter, etc. Needless to say, social media is possible because of this technology only. In gained major popularity in 2004.

**Service orientation:**

It acts as a reference model for cloud computing. It supports low-cost, flexible, and evolvable applications. Two important concepts were introduced in this computing model. These were Quality of Service (QoS) which also includes the SLA (Service Level Agreement) and Software as a Service (SaaS).

**Utility computing:**

It is a computing model that defines service provisioning techniques for services such as compute services along with other major services such as storage, infrastructure, etc which are provisioned on a pay-per-use basis.

## CLOUD COMPUTING

In Simplest terms, cloud computing means storing and accessing the data and programs on remote servers that are hosted on internet instead of computer's hard drive or local server. Cloud computing is also referred as Internet based computing.

**Cloud Computing Architecture:**

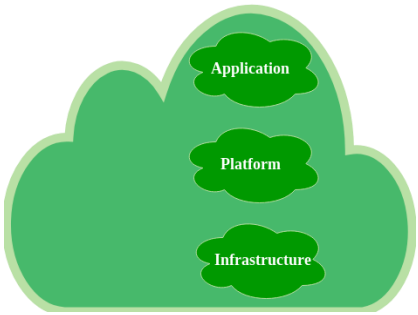
Cloud computing architecture refers to the components and sub components required for cloud computing. These component typically refer to:

1. Front end (fat client, thin client)
2. Back end platforms (servers, storage)
3. Cloud based delivery and a network (Internet, Intranet, Inter cloud).

**Hosting a cloud:**

There are three layers in cloud computing. Companies use these layers based on the service they provide.

- Infrastructure
- Platform
- Application




*Three layers of Cloud Computing*

At the bottom is the foundation, the Infrastructure where the people start and begin to build. This is the layer where the cloud hosting lives.

**Now, let's have a look at hosting:**
Let's say you have a company and a website and the website has a lot of communications that are exchanged between members. You start with a few members talking with each other and then gradually the numbers of members increases.
As the time passes, as the number of members increases, there would be more traffic on the network and your server will get slow down. This would cause a problem.

A few years ago, the websites are put in the server somewhere, in this way you have to run around or buy and set number of servers. It costs a lot of money and takes lot of time. You pay for these servers when you are using and as well as when you are not using. This is called hosting.

This problem is overcome by cloud hosting. With Cloud Computing, you have access to computing power when you needed. Now, your website is put in the cloud server as you put it on dedicated server. People start visiting your website and if you suddenly need more computing power, you would scale up according to the need.

**Benefits of Cloud Hosting:**
1. **Scalability:** With Cloud hosting, it is easy to grow and shrink the number and size of servers based on the need.

This is done by either increasing or decreasing the resources in the cloud. This ability to alter plans due to fluctuation in business size and needs is a superb benefit of cloud computing especially when experiencing a sudden growth in demand.

2. **Instant:** Whatever you want is instantly available in the cloud.
3. **Save Money:** An advantage of cloud computing is the reduction in hardware cost. Instead of purchasing in-house equipment, hardware needs are left to the vendor. For companies that are growing rapidly, new hardware can be a large, expensive, and inconvenience. Cloud computing alleviates these issues because resources can be acquired quickly and easily. Even better, the cost of repairing or replacing equipment is passed to the vendors.
   Along with purchase cost, off-site hardware cuts internal power costs and saves space. Large data centers can take up precious office space and

produce a large amount of heat. Moving to cloud applications or storage can help maximize space and significantly cut energy expenditures.

4. **Reliability:** Rather than being hosted on one single instances of a physical server, hosting is delivered on a virtual partition which draws its resource, such as disk space, from an extensive network of underlying physical servers. If one server goes offline it will have no effect on availability, as the virtual servers will continue to pull resource from the remaining network of servers.
5. **Physical Security:** The underlying physical servers are still housed within data centres and so benefit from the security measures that those facilities implement to prevent people accessing or disrupting them on-site

**CLOUD BASED SERVICES**

Cloud Computing can be defined as the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer. Companies offering such kinds of cloud computing services are called *cloud providers* and typically charge for cloud computing services based on usage. Grid and cluster are the foundations for cloud computing.

**Types of Cloud Computing**

Most cloud computing services fall into three broad categories:

1. Software as a service (Saas)
2. Platform as a service (PaaS)
3. Infrastructure as a service (IaaS)
4. Anything as a service (XaaS)

These are sometimes called the **cloud computing stack** because they are built on top of one another. Knowing what they are and how they are different, makes it easier to accomplish your goals. These abstraction layers can also be viewed as a **layered architecture** where services of a higher layer can be composed from services of the underlying layer i.e, Saas can provide Infrastructure.

**Software as a Service(SaaS)**

Software-as-a-Service (SaaS) is a way of delivering services and applications over the Internet. Instead of installing and maintaining software, we simply access it via the Internet, freeing ourselves from the complex software and hardware management. It removes the need to install and run applications on our own computers or in the data centers eliminating the expenses of hardware as well as software maintenance.

SaaS provides a complete software solution that you purchase on a **pay-as-you-go** basis from a cloud service provider. Most SaaS applications can be run directly from a web browser without any downloads or installations required. The SaaS applications are sometimes called **Web-based software, on-demand software, or hosted software.**

**Advantages of SaaS**

1. **Cost-Effective:** Pay only for what you use.
2. **Reduced time:** Users can run most SaaS apps directly from their web browser without needing to download and install any software. This reduces the time spent in installation and configuration and can reduce the issues that can get in the way of the software deployment.
3. **Accessibility:** We can Access app data from anywhere.

4. **Automatic updates:** Rather than purchasing new software, customers rely on a SaaS provider to automatically perform the updates.
5. **Scalability:** It allows the users to access the services and features on-demand.

The various companies providing *Software as a service* are Cloud9 Analytics, Salesforce.com, Cloud Switch, Microsoft Office 365, Big Commerce, Eloqua, dropBox, and Cloud Tran.

**Platform as a Service**

PaaS is a category of cloud computing that provides a platform and environment to allow developers to build applications and services over the internet. PaaS services are hosted in the cloud and accessed by users simply via their web browser.

A PaaS provider hosts the hardware and software on its own infrastructure. As a result, PaaS frees users from having to install in-house hardware and software to develop or run a new application. Thus, the development and deployment of the application take place **independent of the hardware**.

The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment. To make it simple, take the example of an annual day function, you will have two options either to create a venue or to rent a venue but the function is same.

**Advantages of PaaS:**

1. **Simple and convenient for users:** It provides much of the infrastructure and other IT services, which users can access anywhere via a web browser.
2. **Cost-Effective:** It charges for the services provided on a per-use basis thus eliminating the expenses one may have for on-premises hardware and software.
3. **Efficiently managing the lifecycle:** It is designed to support the complete web application lifecycle: building, testing, deploying, managing, and updating.
4. **Efficiency:** It allows for higher-level programming with reduced complexity thus, the overall development of the application can be more effective.

The various companies providing *Platform as a service* are Amazon Web services Elastic Beanstalk, Salesforce, Windows Azure, Google App Engine, cloud Bess and IBM smart cloud.

**Infrastructure as a Service**

Infrastructure as a service (IaaS) is a service model that delivers computer infrastructure on an outsourced basis to support various operations. Typically IaaS is a service where infrastructure is provided as an outsource to enterprises such as networking equipment, devices, database, and web servers. It is also known as **Hardware as a Service (HaaS).** IaaS customers pay on a per-user basis, typically by the hour, week, or month. Some providers also charge customers based on the amount of virtual machine space they use. It simply provides the underlying operating systems, security, networking, and servers for developing such applications, services, and for deploying development tools, databases, etc.

**Advantages of IaaS:**

1. **Cost-Effective:** Eliminates capital expense and reduces ongoing cost and IaaS customers pay on a per-user basis, typically by the hour, week, or month.
2. **Website hosting:** Running websites using IaaS can be less expensive than traditional web hosting.
3. **Security:** The IaaS Cloud Provider may provide better security than your existing software.
4. **Maintenance:** There is no need to manage the underlying data center or the introduction of new releases of the development or underlying software. This is all handled by the IaaS Cloud Provider.

The various companies providing *Infrastructure as a service* are Amazon web services, Bluestack, IBM, Openstack, Rackspace, and Vmware.

**Anything as a Service**

Most of the cloud service providers nowadays offer anything as a service that is a compilation of all of the above services including some additional services.

**Advantages of XaaS:** As this is a combined service, so it has all the advantages of every type of cloud service.

**TYPES OF CLOUD**

Cloud computing is Internet-based computing in which a shared pool of resources is available over broad network access, these resources can be provisioned or released with minimum management efforts and service provider interaction.

**Types of Cloud**

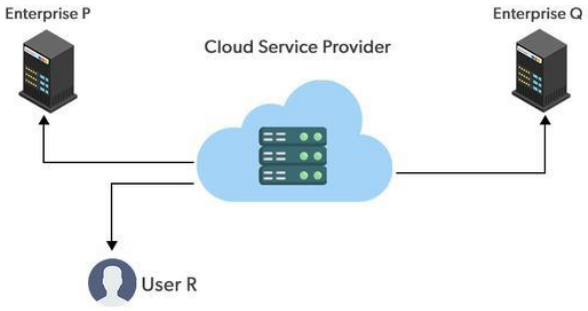
1. Public cloud
2. Private cloud
3. Hybrid cloud
4. Community cloud

**Public Cloud**

Public clouds are managed by third parties which provide cloud services over the internet to the public, these services are available as pay-as-you-go billing models.

They offer solutions for minimizing IT infrastructure costs and become a good option for handling peak loads on the local infrastructure. Public clouds are the go-to option for small enterprises, which are able to start their businesses without large upfront investments by completely relying on public infrastructure for their IT needs.

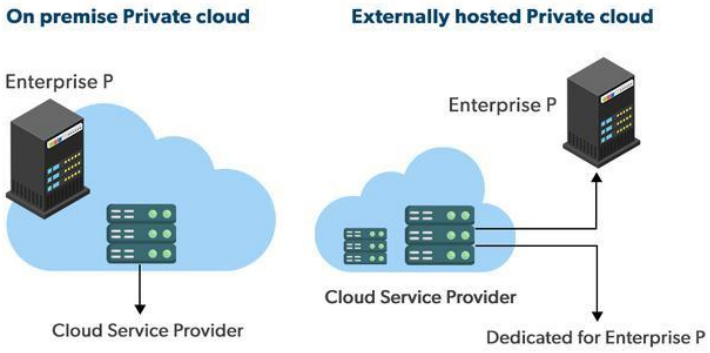
The fundamental characteristics of public clouds are **multitenancy**. A public cloud is meant to serve multiple users, not a single customer. A user requires a virtual computing environment that is separated, and most likely isolated, from other users.




*Public cloud*

**Private cloud**

Private clouds are distributed systems that work on private infrastructure and provide the users with dynamic provisioning of computing resources. Instead of a pay-as-you-go model in private clouds, there could be other schemes that manage the usage of the cloud and proportionally billing of the different departments or sections of an enterprise.




*Private Cloud*

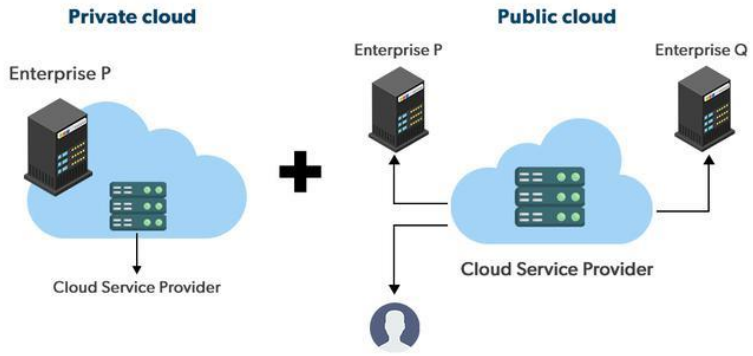
**Advantages of using a private cloud are:**

1. **Customer information protection:** In the private cloud security concerns are less since customer data and other sensitive information do not flow out of private infrastructure.
2. **Infrastructure ensuring SLAs:** Private cloud provides specific operations such as appropriate clustering, data replication, system monitoring, and maintenance, and disaster recovery, and other uptime services.
3. **Compliance with standard procedures and operations:** Specific procedures have to be put in place when deploying and executing applications according to third-party compliance standards. This is not possible in the case of the public cloud.

**Hybrid cloud:**

A hybrid cloud is a heterogeneous distributed system formed by combining facilities of public cloud and private cloud. For this reason, they are also called **heterogeneous clouds.**

A major drawback of private deployments is the inability to scale on-demand and efficiently address peak loads. Here public clouds are needed. Hence, a hybrid cloud takes advantage of both public and private clouds.

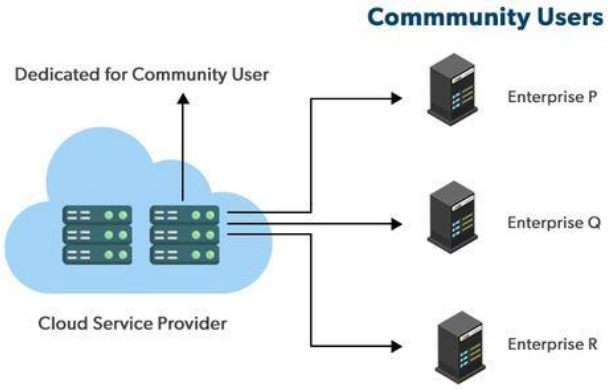



*Hybrid Cloud*

**Community cloud:**

Community clouds are distributed systems created by integrating the services of different clouds to address the specific needs of an industry, a community, or a business sector.

In the community cloud, the infrastructure is shared between organizations that have shared concerns or tasks. The cloud may be managed by an organization or a third party.




*Community Cloud*

**Sectors that use community clouds are:**

**1. Media industry:** Media companies are looking for quick, simple, low-cost ways for increasing the efficiency of content generation. Most media productions involve an extended ecosystem of partners. In particular, the creation of digital content is the outcome of a collaborative process that includes the movement of large data, massive compute-intensive rendering tasks, and complex workflow executions.

**2. Healthcare industry:** In the healthcare industry community clouds are used to share information and knowledge on the global level with sensitive data in the private infrastructure.

**3. Energy and core industry:** In these sectors, the community cloud is used to cluster a set of solution which collectively addresses management, deployment, and orchestration of services and operations.

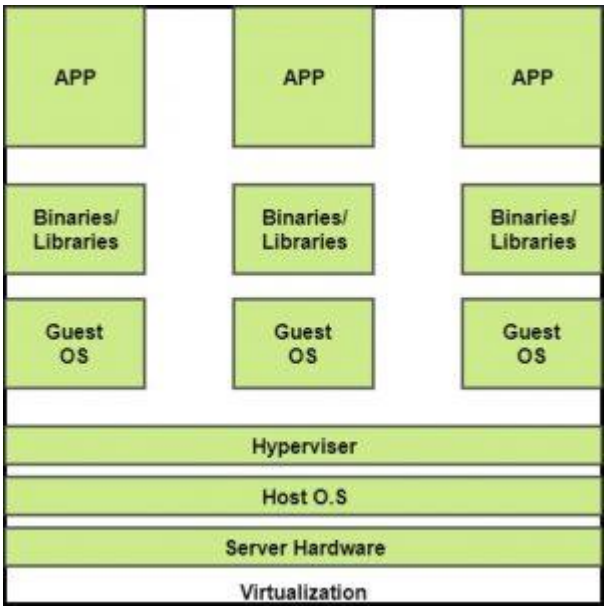
**4. Scientific research:** In this organization with common interests in science share a large distributed infrastructure for scientific computing.

**VIRTUALIZATION IN CLOUD COMPUTING AND TYPES**

Virtualization is a technique of how to separate a service from the underlying physical delivery of that service. It is the process of creating a virtual version of something like computer hardware. It was initially developed during the

mainframe era. It involves using specialized software to create a virtual or software-created version of a computing resource rather than the actual version of the same resource. With the help of Virtualization, multiple operating systems and applications can run on same machine and its same hardware at the same time, increasing the utilization and flexibility of hardware.

In other words, one of the main cost effective, hardware reducing, and energy saving techniques used by cloud providers is virtualization. Virtualization allows to share a single physical instance of a resource or an application among multiple customers and organizations at one time. It does this by assigning a logical name to a physical storage and providing a pointer to that physical resource on demand. The term virtualization is often synonymous with hardware virtualization, which plays a fundamental role in efficiently delivering Infrastructure-as-a-Service (IaaS) solutions for cloud computing. Moreover, virtualization technologies provide a virtual environment for not only executing applications but also for storage, memory, and networking.




The machine on which the virtual machine is going to be built is known as Host Machine and that virtual machine is referred as a Guest Machine.

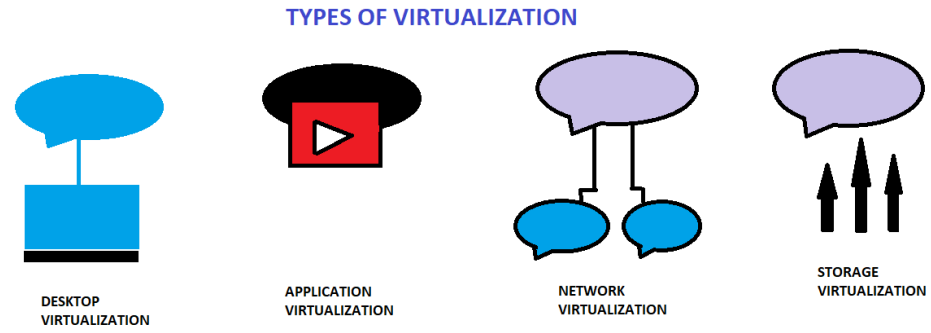
**BENEFITS OF VIRTUALIZATION**

1. More flexible and efficient allocation of resources.
2. Enhance development productivity.
3. It lowers the cost of IT infrastructure.
4. Remote access and rapid scalability.
5. High availability and disaster recovery.
6. Pay peruse of the IT infrastructure on demand.
7. Enables running multiple operating systems.

**Types of Virtualization:**

1.Application Virtualization.
2.Network Virtualization.
3.Desktop Virtualization.
4.Storage Virtualization.

5.Server Virtualization.
6.Data virtualization.




1. **Application Virtualization:**

Application virtualization helps a user to have remote access of an application from a server. The server stores all personal information and other characteristics of the application but can still run on a local workstation through the internet. Example of this would be a user who needs to run two different versions of the same software. Technologies that use application virtualization are hosted applications and packaged applications.

2. **Network Virtualization:**

The ability to run multiple virtual networks with each has a separate control and data plan. It co-exists together on top of one physical network. It can be managed by individual parties that potentially confidential to each other. Network virtualization provides a facility to create and provision virtual networks—logical switches, routers, firewalls, load balancer, Virtual Private Network (VPN), and workload security within days or even in weeks.

3. **Desktop Virtualization:**

Desktop virtualization allows the users' OS to be remotely stored on a server in the data centre. It allows the user to access their desktop virtually, from any location by a different machine. Users who want specific operating systems other than Windows Server will need to have a virtual desktop. Main benefits of desktop virtualization are user mobility, portability, easy management of software installation, updates, and patches.

4. **Storage Virtualization:**

Storage virtualization is an array of servers that are managed by a virtual storage system. The servers aren't aware of exactly where their data is stored, and instead function more like worker bees in a hive. It makes managing storage from multiple sources to be managed and utilized as a single repository. storage virtualization software maintains smooth operations, consistent performance and a continuous suite of advanced functions despite changes, break down and differences in the underlying equipment.

5. **Server Virtualization:**

This is a kind of virtualization in which masking of server resources takes place. Here, the central-server(physical server) is divided into multiple different virtual servers by changing the identity number, processors. So, each system can operate its own operating systems in isolate manner. Where each sub-server knows the identity of the central server. It causes an increase in the

performance and reduces the operating cost by the deployment of main server resources into a sub-server resource. It's beneficial in virtual migration, reduce energy consumption, reduce infrastructural cost, etc.

**6. Data virtualization:**

This is the kind of virtualization in which the data is collected from various sources and managed that at a single place without knowing more about the technical information like how data is collected, stored & formatted then arranged that data logically so that its virtual view can be accessed by its interested people and stakeholders, and users through the various cloud services remotely. Many big giant companies are providing their services like Oracle, IBM, At scale, Cdata, etc.

It can be used to performing various kind of tasks such as:

- **Data-integration**
- **Business-integration**
- **Service-oriented architecture data-services**
- **Searching organizational data**

**HYPERVISOR**

A hypervisor is a form of virtualization software used in Cloud hosting to divide and allocate the resources on various pieces of hardware. The program which provides partitioning, isolation or abstraction is called virtualization hypervisor. The hypervisor is a hardware virtualization technique that allows multiple guest operating systems (OS) to run on a single host system at the same time. A hypervisor is sometimes also called a virtual machine manager(VMM).

**Types of Hypervisor –**

**TYPE-1 Hypervisor:**

The hypervisor runs directly on the underlying host system. It is also known as "Native Hypervisor" or "Bare metal hypervisor". It does not require any base server operating system. It has direct access to hardware resources. Examples of Type 1 hypervisors include VMware ESXi, Citrix XenServer and Microsoft Hyper-V hypervisor.

**Pros & Cons of Type-1 Hypervisor:**

**Pros:** Such kind of hypervisors are very efficient because they have direct access to the physical hardware resources(like Cpu, Memory, Network, Physical storage). This causes the empowerment the security because there is nothing any kind of the third party resource so that attacker couldn't compromise with anything.

**Cons:** One problem with Type-1 hypervisor is that they usually need a dedicated separate machine to perform its operation and to instruct different VMs and control the host hardware resources.

**TYPE-2 Hypervisor:**

A Host operating system runs on the underlying host system. It is also known as 'Hosted Hypervisor". Such kind of hypervisors doesn't run directly over the underlying hardware rather they run as an application in a Host system (physical machine). Basically, software installed on an operating system. Hypervisor asks the operating system to make hardware calls. Example of Type 2 hypervisor includes VMware Player or Parallels Desktop. Hosted hypervisors are often found on endpoints like PCs. The type-2 hypervisor is are very useful

for engineers, security analyst (for checking malware, or malicious source code and newly developed applications).

**Pros & Cons of Type-2 Hypervisor:**

**Pros:** Such kind of hypervisors allows quick and easy access to a guest Operating System alongside the host machine running. These hypervisors usually come with additional useful features for guest machine. Such tools enhance the coordination between the host machine and guest machine.

**Cons:** Here there is no direct access to the physical hardware resources so the efficiency of these hypervisors lags in performance as compared to the type-1 hypervisors, and potential security risks are also there an attacker can compromise the security weakness if there is access to the host operating system so he can also access the guest operating system.

**Choosing the right hypervisor**:

**Type 1 hypervisors offer much better performance than Type 2** ones because there's no middle layer, making them the logical choice for mission-critical applications and workloads. But that's not to say that hosted hypervisors don't have their place – they're much simpler to set up, so they're a good bet if, say, you need to deploy a test environment quickly. One of the best ways to determine which hypervisor meets your needs is to compare their performance metrics. These include CPU overhead, amount of maximum host and guest memory, and support for virtual processors. The following factors should be examined before choosing a suitable hypervisor:

**1. Understand your needs:** The company and its applications are the reason for the data centre (and your job). Besides your company's needs, you (and your co-workers in IT) also have your own needs. Needs for a virtualization hypervisor are:

a. Flexibility
b. Scalability
c. Usability
d. Availability
e. Reliability
f. Efficiency
g. Reliable support

**2. The cost of a hypervisor:** For many buyers, the toughest part of choosing a hypervisor is striking the right balance between cost and functionality. While a number of entry-level solutions are free, or practically free, the prices at the opposite end of the market can be staggering. Licensing frameworks also vary, so it's important to be aware of exactly what you're getting for your money.

**3. Virtual machine performance:** Virtual systems should meet or exceed the performance of their physical counterparts, at least in relation to the applications within each server. Everything beyond meeting this benchmark is profit.

**4. Ecosystem:** It's tempting to overlook the role of a hypervisor's ecosystem – that is, the availability of documentation, support, training, third-party developers and consultancies, and so on – in determining whether or not a solution is cost-effective in the long term.

**5. Test for yourself:** You can gain basic experience from your existing desktop or laptop. You can run both VMware vSphere and Microsoft Hyper-V in either VMware Workstation or VMware Fusion to create a nice virtual learning and testing environment.

**HYPERVISOR REFERENCE MODEL**:
There are 3 main modules coordinates in order to emulate the underlying hardware:

1. **DISPATCHER:**
   The dispatcher behaves like the entry point of the monitor and reroutes the instructions of the virtual machine instance to one of the other two modules.
2. **ALLOCATOR:**
   The allocator is responsible for deciding the system resources to be provided to the virtual machine instance. It means whenever virtual machine tries to execute an instruction that results in changing the machine resources associated with the virtual machine, the allocator is invoked by the dispatcher.

3. **INTERPRETER:**
   The interpreter module consists of interpreter routines. These are executed, whenever virtual machine executes a priviliged instruction.

**CHARACTERISTICS OF CLOUD COMPUTING**
There are basically 5 essential characteristics of Cloud Computing.

1. **On-demand self-services:**
   The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.
2. **Broad network access:**
   The Computing services are generally provided over standard networks and heterogeneous devices.
3. **Rapid elasticity:**
   The Computing services should have IT resources that are able to scale out and in quickly and on as needed basis. Whenever the user require services it is provided to him and it is scale out as soon as its requirement gets over.
4. **Resource pooling:**
   The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.
5. **Measured service:**
   The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource.

**ISSUES IN CLOUD COMPUTING**
Cloud Computing is a new name for an old concept. The delivery of computing services from a remote location. Cloud Computing is Internet-based computing, where shared resources, software, and information are provided to computers and other devices on demand.
These are major issues in Cloud Computing:
**1. Privacy:** The user data can be accessed by the host company with or without permission. The service provider may access the data that is on the cloud at any

point in time. They could accidentally or deliberately alter or even delete information.

**2. Compliance:** There are many regulations in places related to data and hosting. To comply with regulations (Federal Information Security Management Act, Health Insurance Portability and Accountability Act, etc.) the user may have to adopt deployment modes that are expensive.

**3. Security:** Cloud-based services involve third-party for storage and security. Can one assume that a cloud-based company will protect and secure one's data if one is using their services at a very low or for free? They may share users' information with others. Security presents a real threat to the cloud.

**4. Sustainability:** This issue refers to minimizing the effect of cloud computing on the environment. Citing the server's effects on the environmental effects of cloud computing, in areas where climate favors natural cooling and renewable electricity is readily available, the countries with favorable conditions, such as Finland, Sweden, and Switzerland are trying to attract cloud computing data centers. But other than nature's favors, would these countries have enough technical infrastructure to sustain the high-end clouds?

**5. Abuse:** While providing cloud services, it should be ascertained that the client is not purchasing the services of cloud computing for a nefarious purpose. In 2009, a banking Trojan illegally used the popular Amazon service as a command and control channel that issued software updates and malicious instructions to PCs that were infected by the malware So the hosting companies and the servers should have proper measures to address these issues.

**6, Higher Cost:** If you want to use cloud services uninterruptedly then you need to have a powerful network with higher bandwidth than ordinary internet networks, and also if your organization is broad and large so ordinary cloud service subscription won't suit your organization. Otherwise, you might face hassle in utilizing an ordinary cloud service while working on complex projects and applications. This is a major problem before small organizations, that restricts them from diving into cloud technology for their business.

**7. Recovery of lost data in contingency:** Before subscribing any cloud service provider goes through all norms and documentations and check whether their services match your requirements and sufficient well-maintained resource infrastructure with proper up keeping. Once you subscribed to the service you almost hand over your data into the hands of a third party. If you are able to choose proper cloud service then in the future you don't need to worry about the recovery of lost data in any contingency.

**8. Up keeping(management) of Cloud:** Maintaining a cloud is a herculin task because a cloud architecture contains a large resources infrastructure and other challenges and risks as well, user satisfaction, etc. As users usually pay for how much they have consumed the resources. So, sometimes it becomes hard to decide how much should be charged in case the user wants scalability and extend the services.

**9. Lack of resources/skilled expertise:** One of the major issues that companies and enterprises are going through today is the lack of resources and skilled employees. Every second organization is seeming interested or has already been moved to cloud services. That's why the workload in the cloud is increasing so the cloud service hosting companies need continuous rapid advancement. Due to these factors, organizations are having a tough time keeping up to date with the tools. As new tools and technologies are emerging

every day so more skilled/trained employees need to grow. These challenges can only be minimized through additional training of IT and development staff.

**10. Pay-per-use service charges:** Cloud computing services are on-demand services a user can extend or compress the volume of the resource as per needs. so you paid for how much you have consumed the resources. It is difficult to define a certain pre-defined cost for a particular quantity of services. Such types of ups and downs and price variations make the implementation of cloud computing very difficult and intricate. It is not easy for a firm's owner to study consistent demand and fluctuations with the seasons and various events. So it is hard to build a budget for a service that could consume several months of the budget in a few days of heavy use.

## ANATOMY OF CLOUD COMPUTING

**Provisioning and Configuration Module:**

It is the lowest level of cloud and typically resides on bare hardware (as a firmware) or on the top of the hypervisor layer. Its function is to abstract the underlying hardware and provide a standard mechanism to spawn instance of virtual machine on demand. It also handles the post-configuration of the operating systems and applications residing on the VM

**Monitoring and Optimization:**

This layer handles the monitoring of all services, storage, networking and applications components in cloud. Based on the statistics, it could perform routine functions that optimize the behavior of the infrastructure components and provide relevant data to the cloud administrator to further optimize the configuration for maximum utilization and performance,

**Metering and Chargeback:**

This layer provides functions to measure the usage of resources in cloud. The metering module collects all the utilization data per domain per use. This module gives the cloud administrator enough data to measure ongoing utilization of resources and to create invoices based on the usage on a periodic basis.

**Orchestration:**

Orchestration is a central to cloud operations. Orchestration converts requests from the service management layer and the monitoring, chargeback modules to appropriate action item which are then submitted to provisioning and configuration module for final closure. Orchestration updates the CMDB in the process.

**Configuration Management Database (CMDB):**

It is a central configuration repository wherein all the meta data and configuration of different modules, resources are kept and updated in the real-time basis. The repository can then be accessed using standards protocols like SOAP by third-party software and integration components. All updates in CMDB happen in real time as requests get processed in cloud.

**Cloud Life cycle Management Layer (CLM):**

This layer handles the coordination of all other layers in cloud. All requests internal and external are addressed to the CLM layer first. CLM may internally route requests and actions to other layers for further processing.

**Service Catalog:**

It is central to the definition of cloud, SC defines what kind of services the cloud is capable of providing and at what cost to the end user. SC is the first

thing that is drafted before a cloud is architecture. The service management layer consults SC before it processes any request for a new resource.

**ECONOMICS OF CLOUD COMPUTING**

Economics of Cloud Computing is based on the PAY AS YOU GO method. Users/Customers must have to pay only for their way of usage of the cloud services. It definitely beneficial for the users. So that Cloud is economically very convenient for all. Another side is to eliminate some indirect cost which is generated by assets such as license of software and their support. In cloud, users can use software application on subscription basis without any cost because the property of the software providing service remains to the cloud provider.

**Economical background of cloud** is more useful for developers in the following ways:

- Pay as you go model offered by cloud providers.
- Scalable and Simple.

**Cloud Computing Allows:**

- Reduces the capital costs of infrastructure.
- Removes the maintenance cost.
- Removes the administrative cost.

**What is Capital Cost ?**

It is cost occurred in the purchasing infrastructure or the assets that is important in the production of goods. It takes long time to generate profit.

In the case of start-ups, there is no extra budget for the infrastructure and its maintenance. So cloud can minimizes expenses of any small organization in terms of economy. It leads to the developers can only focus on the development logic and not on the maintenance of the infrastructure.

There are three different **Pricing Strategies** which are introduced by the Cloud Computing: Tiered Pricing, Per-unit Pricing, and Subscription based Pricing. These are explained as following below.

1. **Tired Pricing:**

Cloud Services are offered in the various tiers. Each tier offers fix service agreements at specific cost. Amazon EC2 uses this kind of pricing.

2. **Per-unit Pricing:**

The model is based upon the unit specific service concept. Data transfer and memory allocation includes in this model for specific units. GoGrid uses this kind of pricing in terms of RAM/hour.

3. **Subscription based Pricing:**

In this model users are paying periodic subscription fee for the usage of software.

**Business Benefits of Cloud Computing**

There are some clear business benefits to building applications in the cloud:

**Almost Zero Upfront Infrastructure Investment.**

If we have to build a large scale system, it may cost to invest in real estate, physical security, hardware (racks, servers, routers, backup power supplies), hardware management (power management, cooling), and operations personnel. Because of the high upfront costs, the project would typically require several rounds of management approvals before the project could even get star t ed. Now, with utility- style cloud

computing, there is no fixed cost or startup cost.

**Just- in- Time Infrastructure:**

By deploying applications in- the- cloud with just- in- time self- provisioning, we do not have to worry about pre-procuring capacity for large-scale systems. This increase s agility, lower s risk, and lower s operational cost because you scale only as you grow and only pay for what you use.

**More Efficient Resource Utilization:**

System administrators usually worry about procuring hardware (when they run out of capacity) and higher infrastructure utilization (when they have excess and idle capacity). With the cloud, they can manage resources more effectively and efficiently by having the applications request and relinquish resources on- demand

**Usage-Based Costing:**

With utility-style pricing, you are billed only for the infrastructure that has been used

**Reduced Time to Market:**

Parallelization is one of the great ways to speed up processing. Having available an elastic infrastructure provides the application with the ability to exploit parallelization in a cost-effective manner reducing time to market

**Technical Benefits of Cloud Computing**

Some of the technic al benefits of cloud computing includes:

**Automation**

"Scriptable Infrastructure": create repeatable build and deployment systems by leveraging programmable (API-driven) infrastructure.

**Auto-scaling:**

scale applications up and down to match unexpected demand without any human intervention. Auto-scaling encourages automation and drives more efficiency.

**Proactive Scaling:**

Scale application up and down to meet anticipated demand with proper planning under s t a n ding of traffic patterns so that costs are kept low while scaling.

**More Efficient Development Life Cycle:**

Product ion systems may be easily cloned for use as development and test environments. Staging environment s may be easily promoted to production.

**Improved Testability:**

We can inject and automate testing at every stage during the development process. without running out of hardware. "instant test lab" can be spawned with preconfigured environments only for the duration of testing phase

**Disaster Recovery and Business Continuity:**

The cloud provides a lower cost option for maintaining a fleet of server s and data storage. With the cloud, advantage of geo-distribution can be used to replicate the environment in other location within minutes

**"Overflow" the Traffic to the Cloud:**

With a few clicks and effective load balancing tactics, a complete overflow-proof application can be created by routing excess traffic to the cloud.