Unit IV

Chapter 1: Virtualization and Cloud

What is Virtualization?

- Virtualization is one of the hardware reducing, cost saving and energy saving technology that is rapidly transforming the IT landscape and fundamentally changing the way that people compute.
- With VMware virtualization solutions you can reduce IT costs while increasing the efficiency, utilization and flexibility of their existing computer hardware.
- With Virtualization it is possible to run multiple operating systems and multiple applications on the same SERVER at the same time, increasing the utilization and flexibility of hardware.

History

- Virtualization's roots go back to the 1960s and IBM, where programmer Jim Rymarczyk was deeply involved in the first mainframe virtualization effort.
- In the late 1990s VMware step in and begin to apply its own virtualization model.
- These included low x86-platform server utilization, where perhaps 10-15% of server capacity was used, and rising costs associated with electrical power use, cooling and a fast-growing server and storage footprint.

- In 1999, VMware introduced virtualization to x86 systems
- By 2008, a significant percentage of companies had begun to virtualize a small portion of their not-business-critical applications, and they began carrying out Windows Server backup on their new virtual machines.

Requirement of Virtualization

- Build your virtual environment
- Configure your virtual environment
- Secure your virtual environment
- Populate your virtual environment
- Monitor your virtual environment
- Maintain your virtual environment
- Back up your virtual environment
- Troubleshoot your virtual environment
- Educate and document

Avoid virtualization implementation pitfalls while following your plan based on the steps above can prevent problems during virtualization implementation, there are specific pitfalls for you to avoid. Let's explore some of these dangers below:

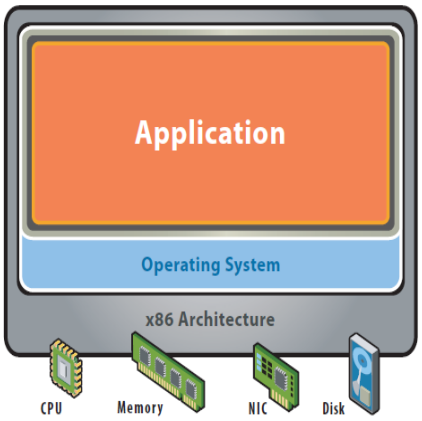
- Underestimating the amount of RAM needed in virtual hosts
- Underestimating the amount of storage needed in your shared storage
- Virtualizing faster than the rate of training and documentation
- Overprovisioning
- Lack of testing

Virtualization Station System Requirements

- Processor that supports Intel VT-X
- Minimum 2 GB Memory
- Minimum 550 MB Hard disk space

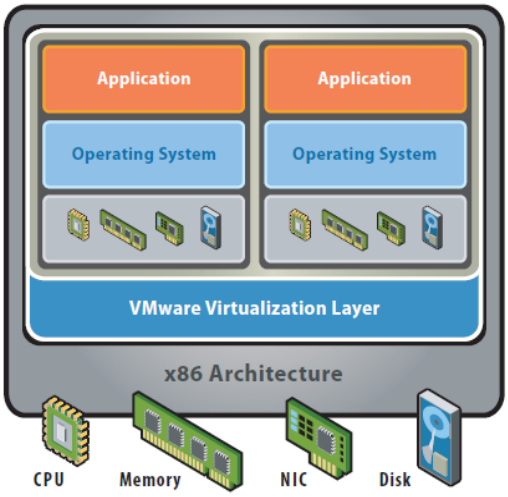
Before Virtualization

- Single OS image per machine
- Software and hardware tightly coupled
- Running multiple applications on same machine often creates conflict
- Inflexible and costly infrastructure



After Virtualization

- Hardware-independence of operating system and applications
- Virtual machines can be provisioned to any system
- Can manage OS and application as a single unit by encapsulating them into virtual Machines



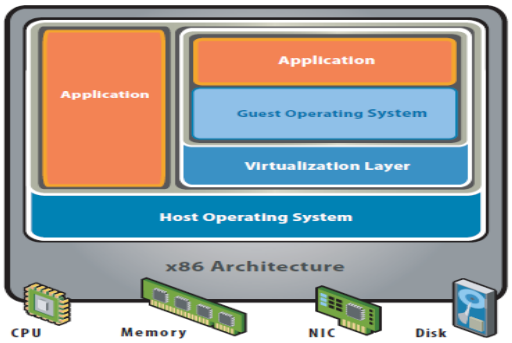
Disadvantages:

- Software Developing
- Application Monitoring
- Server Management
- Network Management
- Security Management
- Data Management
- Too many CO^2

Advantages:

- Software as a Service
- Platform as a Service
- **Infra** as a Service
- **Data** as a Service
- **IT as a Service**
- **Green IT**

Hosted Architecture

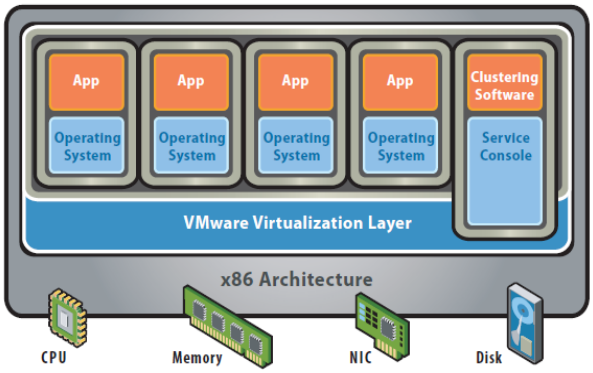


Bare Metal & Hypervisor

- A **bare metal** environment is a computer system or network in which a virtual machine is installed directly on hardware rather than within the host operating system (OS). The term "**bare metal**" refers to a hard disk, the usual medium on which a computer's OS is installed.

- A **hypervisor**, also called a virtual machine manager, is a program that allows multiple operating systems to share a single hardware host. Each operating system appears to have the host's processor, memory, and other resources all to itself.

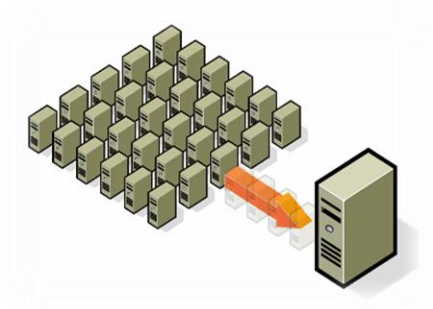
Bare-Metal (Hypervisor) Architecture



A virtual infrastructure offers the systematic ability to control a complex system consisting of several x86-based servers into several different execution environments.

Consolidation

- Operate different OS and applications on one single server
- Support existing applications on a new hardware
- Replace the old hardware in the data center
- Utilize your Existing Servers
- Realize instantly new projects with virtual infrastructure
- Postpone new physical hardware purchase



- Reduce Energy Costs and Go Green with VMware Virtualization
- Reduce the energy demands of your datacenter by dynamic management of computer capacity across a pool of servers.
- VMware infrastructure delivers the resources your infrastructure needs and enables you to:

1. -Reduce energy costs by 80%.
2. -Power down servers without affecting applications or users.
3. -Green your datacenter while decreasing costs and improving service levels.

Key features of the VMware server virtualization

Partitioning

- Different OS can run on one physical machine
- System resources can be divided between virtual machines

Isolation

- Fault and security isolation on a hardware level
- Extended resource control for constant performance

Encapsulation

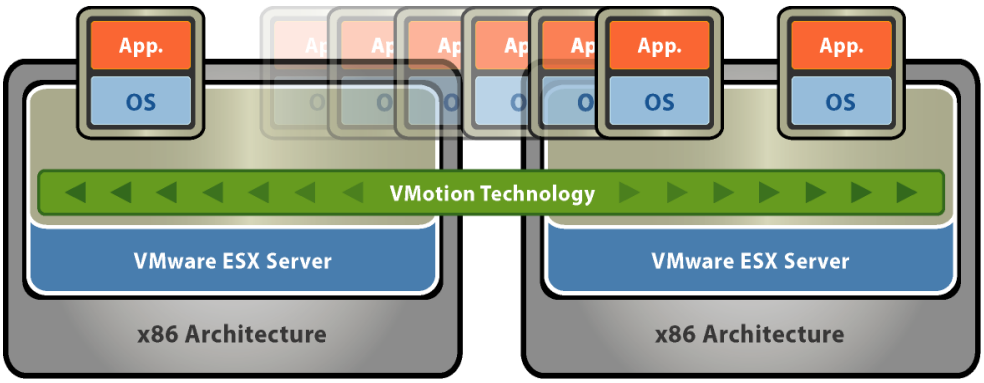
- Complete status of a virtual machine can be stored in a file
- Move and copy of a virtual machine is as easy as it is with files

Servers Consolidation

- 110 Servers without VMware software
- 12 Servers, 1 rack with VMware software

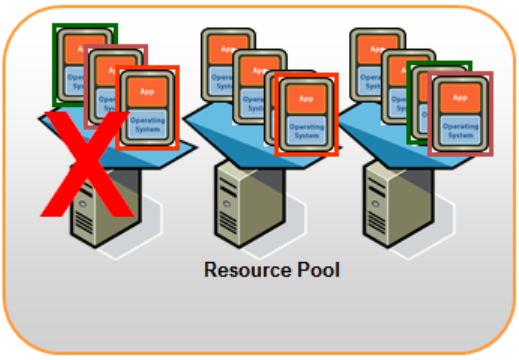
VMware VMotion

- The VMotion technology allows the live migration of virtual machines from one physical server to another and needs therefore no downtime for maintenance activities.
- Move running applications to other servers without disruption. Zero downtime for hardware maintenance.
- Automates moving virtual machines to other hosts and automates re-balancing after maintenance complete



- Unplanned Downtime: Server Failure - VMware HA
- Simple, Cost effective high availability for all servers

1. Automatic restart of virtual machines in case of server failure
2. No need for dedicated stand-by hardware
3. None of the cost and complexity of clustering



Benefits of VMware Virtualization

1. Easier Manageability
2. File, Server, OS, Data manage
3. Fault Isolation
4. Efficient use of Resources
5. Portability
6. Problem-Free Testing
7. Reduced Costs
8. The Ability to Separate Applications
9. Easier Manageability

What is Hypervisor?

- A Hypervisor also known as Virtual Machine Monitor (VMM) can be a piece of software, firmware or hardware that gives an impression to the guest machines(virtual machines) as if they were operating on a physical hardware. It allows multiple operating system to share a single host and its hardware. The hypervisor manages requests by virtual machines to access to the hardware resources (RAM, CPU, NIC etc) acting as an independent machine. Now the Hypervisor is mainly divided into two types namely

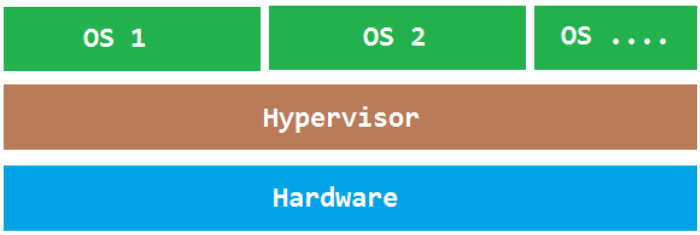
Type 1. Native/Bare Metal Hypervisor
Type 2. Hosted Hypervisor

Type 1 Hypervisor

1. This is also known as Bare Metal or Embedded or Native Hypervisor.
2. It works directly on the hardware of the host and can monitor operating systems that run above the hypervisor.
3. It is completely independent from the Operating System.
4. The hypervisor is small as its main task is sharing and managing hardware resources between different operating systems.
5. A major advantage is that any problems in one virtual machine or guest operating system do not affect the other guest operating systems running on the hypervisor.

Examples:

VMware ESXi Server
Microsoft Hyper-V
Citrix/Xen Server

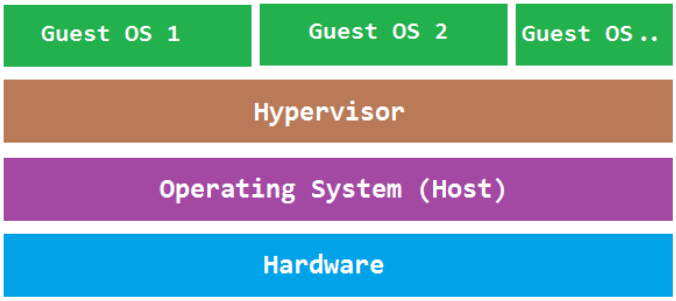


Type 2 Hypervisor

1. This is also known as Hosted Hypervisor.
2. In this case, the hypervisor is installed on an operating system and then supports other operating systems above it.
3. It is completely dependent on host Operating System for its operations
4. While having a base operating system allows better specification of policies, any problems in the base operating system affects the entire system as well even if the hypervisor running above the base OS is secure.

Examples:

VMware Workstation
Microsoft Virtual PC
Oracle Virtual Box

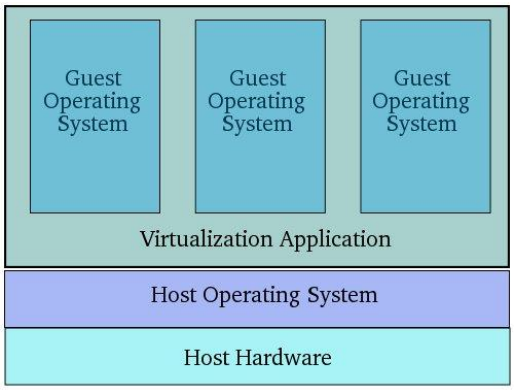


Techniques for efficient virtualization

1. Guest Operating System Virtualization

Guest OS virtualization is perhaps the easiest concept to understand. In this scenario the physical host computer system runs a standard unmodified operating system such as Windows, Linux, Unix or MacOS X. Running on this operating system is a virtualization application which executes in much the same way as any other application such as a word processor or spreadsheet would run on the system. It is within this virtualization application that one or more virtual machines are created to run the guest operating systems on the host computer. The virtualization application is responsible for starting, stopping and managing each virtual machine and essentially controlling access to physical hardware resources on behalf of the individual virtual machines. The virtualization application also engages in a process known as *binary rewriting* which involves scanning the instruction stream of the executing guest system and replacing any privileged instructions with safe emulations. This has the effect of making the guest system think it is running directly on the system hardware, rather than in a virtual machine within an application.

Some examples of guest OS virtualization technologies include VMware Server and VirtualBox.

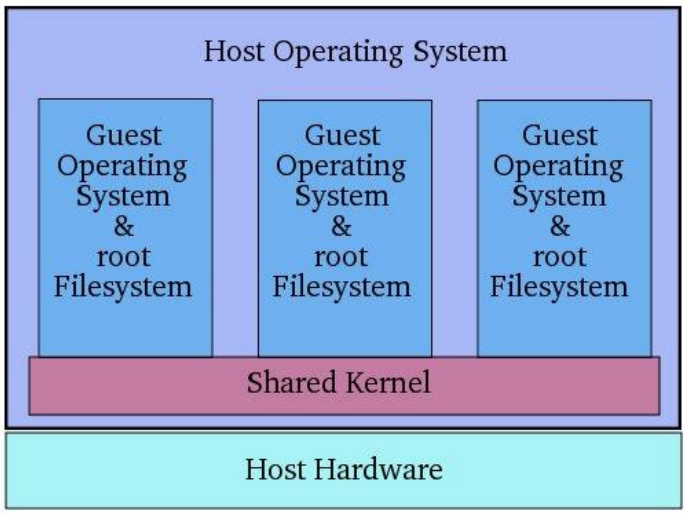


As outlined in the above diagram, the guest operating systems operate in virtual machines within the virtualization application which, in turn, runs on top of the host operating system in

the same way as any other application. Clearly, the multiple layers of abstraction between the guest operating systems and the underlying host hardware are not conducive to high levels of virtual machine performance. This technique does, however, have the advantage that no changes are necessary to either host or guest operating systems and no special CPU hardware virtualization support is required.

2. Shared Kernel Virtualization

Shared kernel virtualization (also known as system level or operating system virtualization) takes advantage of the architectural design of Linux and UNIX based operating systems. In order to understand how shared kernel virtualization works it helps to first understand the two main components of Linux or UNIX operating systems. At the core of the operating system is the *kernel*. The kernel, in simple terms, handles all the interactions between the operating system and the physical hardware. The second key component is the *root file system* which contains all the libraries, files and utilities necessary for the operating system to function. Under shared kernel virtualization the virtual guest systems each have their own *root file system* but share the kernel of the host operating system. This structure is illustrated in the following architectural diagram:



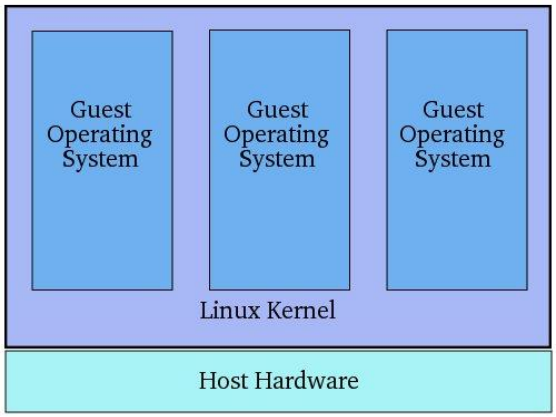
This type of virtualization is made possible by the ability of the kernel to dynamically change the current root file system (a concept known as *chroot*) to a different root file system without having to reboot the entire system. Essentially, shared kernel virtualization is an extension of this capability. Perhaps the biggest single drawback of this form of virtualization is the fact that the guest operating systems must be compatible with the version of the kernel which is being shared. It is not, for example, possible to run Microsoft Windows as a guest on a Linux system

using the shared kernel approach. Nor is it possible for a Linux guest system designed for the 2.6 version of the kernel to share a 2.4 version kernel. Linux VServer, Solaris Zones and Containers, FreeVPS and OpenVZ are all examples shared kernel virtualization solutions.

3. Kernel Level Virtualization

Under kernel level virtualization the host operating system runs on a specially modified kernel which contains extensions designed to manage and control multiple virtual machines each containing a guest operating system. Unlike shared kernel virtualization each guest runs its own kernel, although similar restrictions apply in that the guest operating systems must have been compiled for the same hardware as the kernel in which they are running. Examples of kernel level virtualization technologies include User Mode Linux (UML) and Kernel-based Virtual Machine (KVM).

The following diagram provides an overview of the kernel level virtualization architecture:



4. Hypervisor Virtualization

The x86 family of CPUs provide a range of *protection levels* also known as *rings* in which code can execute. Ring 0 has the highest level privilege and it is in this ring that the operating system kernel normally runs. Code executing in ring 0 is said to be running in *system space*, *kernel mode* or *supervisor mode*. All other code such as applications running on the operating system operates in less privileged rings, typically ring 3.

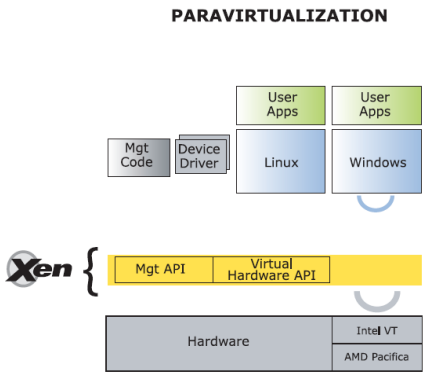
Under hypervisor virtualization a program known as a *hypervisor* (also known as a type 1 Virtual Machine Monitor or VMM) runs directly on the hardware of the host system in ring 0. The task of this hypervisor is to handle resource and memory allocation for the virtual machines in addition to providing interfaces for higher level administration and monitoring tools.

Clearly, with the hypervisor occupying ring 0 of the CPU, the kernels for any guest operating systems running on the system must run in less privileged CPU rings. Unfortunately, most

operating system kernels are written explicitly to run in ring 0 for the simple reason that they need to perform tasks that are only available in that ring, such as the ability to execute privileged CPU instructions and directly manipulate memory. A number of different solutions to this problem have been devised in recent years, each of which is described below:

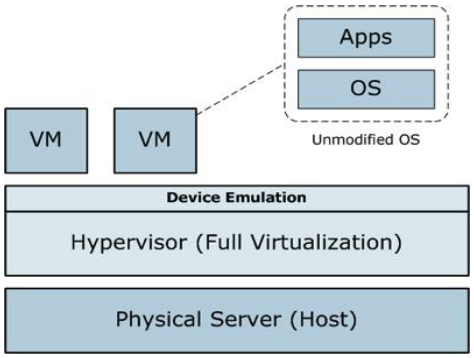
I. Paravirtualization

Under paravirtualization the kernel of the guest operating system is modified specifically to run on the hypervisor. This typically involves replacing any privileged operations that will only run in ring 0 of the CPU with calls to the hypervisor (known as *hypercalls*). The hypervisor in turn performs the task on behalf of the guest kernel. This typically limits support to open source operating systems such as Linux which may be freely altered and proprietary operating systems where the owners have agreed to make the necessary code modifications to target a specific hypervisor. These issues not withstanding, the ability of the guest kernel to communicate directly with the hypervisor results in greater performance levels than other virtualization approaches.



II. Full Virtualization

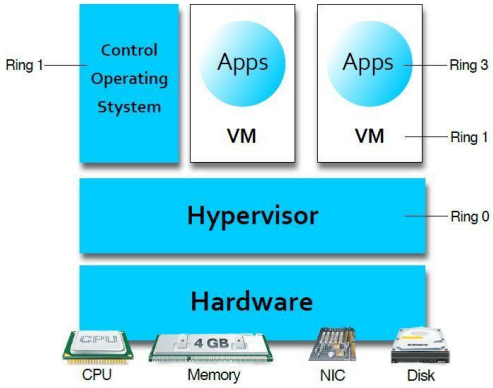
Full virtualization provides support for unmodified guest operating systems. The term *unmodified* refers to operating system kernels which have not been altered to run on a hypervisor and therefore still execute privileged operations as though running in ring 0 of the CPU. In this scenario, the hypervisor provides CPU emulation to handle and modify privileged and protected CPU operations made by unmodified guest operating system kernels. Unfortunately this emulation process requires both time and system resources to operate resulting in inferior performance levels when compared to those provided by paravirtualization.



III. Hardware Virtualization

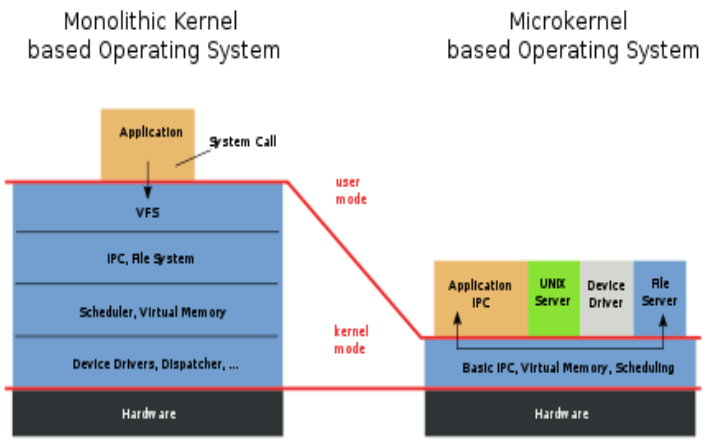
Hardware virtualization leverages virtualization features built into the latest generations of CPUs from both Intel and AMD. These technologies, known as Intel VT and AMD-V respectively, provide extensions necessary to run unmodified guest virtual machines without the overheads inherent in full virtualization CPU emulation. In very simplistic terms these new processors provide an additional privilege mode above ring 0 in which the hypervisor can operate essentially leaving ring 0 available for unmodified guest operating systems.

The following figure illustrates the hypervisor approach to virtualization:



Microkernels

- A microkernel is a piece of software or even code that contains the near-minimum amount of functions and features required to implement an operating system.
- It provides the minimal number of mechanisms, just enough to run the most basic functions of a system, in order to maximize the implementation flexibility so it allows for other parts of the OS to be implemented efficiently since it does not impose a lot of policies.



- Microkernels were first developed in the 1980s as a direct response to several challenges that were plaguing the adaption of mono-kernels into newer computer systems because of incompatibilities in the design and programming.
- This is because new protocol stacks, file systems, device drivers and other low-level systems were being developed quickly at that time. The above mentioned functionalities were often located in the monolithic kernel which results to a lot of work and careful code management when being modified to be used in newer systems.
- The microkernel idea was to implement all of these functions as user-space programs which allowed them to be turned on and off like normal programs; they are being run as daemons.
- This allowed for easier manipulation of these functions and for the separation of the kernel code for fine tuning without worrying about other side effects. But most especially, it allowed for other operating systems to be built on top of this common core or microkernel which greatly advanced the research on operating systems.

Memory Virtualization

- Memory Virtualization, like server and storage virtualization, offers the benefits of consolidation and compelling cost savings.
- Memory is required in every digital machine; switches, routers, appliances and servers. Each contains physical memory alongside the logic that manipulates the 1's and 0's. Memory is closely coupled with compute logic, and when performance gains are needed enterprises typically add more memory, which can be very expensive.
- For the first time, Memory Virtualization introduces a way to decouple memory from the processor, AND, from the server to provide a shared, distributed or networked

function. This is not more addressable memory but virtualized memory shared between multiple machines.

Memory Virtualization can be immediately applied across IT infrastructures.

- Extending memory beyond a physical server's capacity.
- Implementing shared memory for clustered or grid computing environments.
- Enabling Cloud Computing and Real-Time Infrastructure (RTI) in the enterprise data center.

I/O Virtualization:

- I/O virtualization addresses various problems related to performance bottlenecks. Virtual I/O machines that consists of Quality of service (QoS) controls can assign I/O bandwidth to a particular virtual device thereby allowing critical applications to deliver better performance. Some of the major advantages of I/O Virtualization are listed below:
- Flexibility: Since I/O virtualization involves abstracting the upper layer protocols from the underlying physical connections, it offers greater flexibility, utilization and faster provisioning in comparison with normal NIC and HBA cards.
- cost minimization: I/O virtualization methodology involves using fewer cables, cards and switch ports without compromising on network I/O performance.
- Increased density: I/O virtualization increases the practical density of I/O by allowing more connections to exist in a given space.
- Minimizing cables: The I/O virtualization helps to reduce the multiple cables needed to connect servers to storage and network.

Virtual Appliances

- A virtual appliance (VA) is a virtual machine (VM) image file consisting of a pre-configured operating system (OS) environment and a single application. The purpose of a virtual appliance is to simplify delivery and operation of an application. To this end, only necessary operating system components are included.

- A **virtual appliance** is a *pre-integrated, self contained* system that is made by combining a software application (e.g., server software) with just enough operating system for it to run optimally on industry standard hardware or a virtual machine (e.g., VMWare, VirtualBox, Xen HVM, KVM).
- **Simplified deployment**: A software appliance encapsulates an application's dependencies in a pre-integrated, self-contained unit. This can dramatically simplify software deployment by freeing users from having to worry about resolving potentially complex OS compatibility issues, library dependencies or undesirable interactions with other applications.
- **Improved isolation**: virtual appliances are typically used to run applications in isolation from one another. If the security of a virtual appliance is compromised, or if the virtual appliance crashes, other isolated virtual appliances will not be affected.

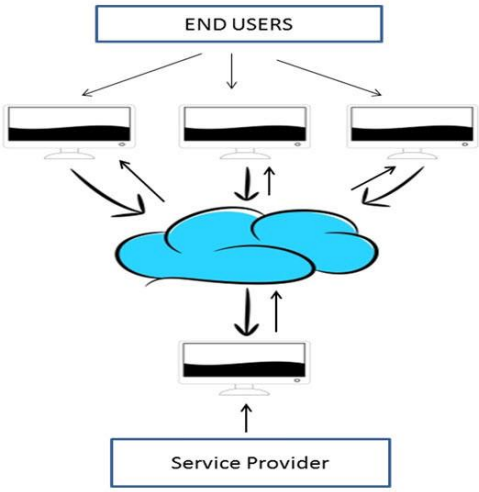
VIRTUAL MACHINES ON MULTICORE CPUS

- The combination of virtual machines and multicore CPUs creates a whole new world in which the number of CPUs available can be set by the software. If there are, say, four cores, and each can run, for example, up to eight virtual machines, a single (desktop) CPU can be configured as a 32-node multicomputer if need be, but it can also have fewer CPUs, depending on the software. Never before has it been possible for an application designer to first choose how many CPUs he wants and then write the software accordingly.
- Moreover, virtual machines can share memory. A typical example where this is useful is a single server hosting multiple instances of the same operating systems. All that has to be done is map physical pages into the address spaces of multiple virtual machines. Memory sharing is already available in deduplication solutions. **Deduplication** does exactly what you think it does: avoids storing the same data twice.
- If virtual machines can share memory, a single computer becomes a virtual multiprocessor. Since all the cores in a multicore chip share the same RAM, a single quad-core chip could easily be configured as a 32-node multiprocessor or a 32-node multicomputer, as needed.
- The combination of multicore, virtual machines, hypervisor, and microkernels is going to radically change the way people think about computer systems. Current software cannot deal with the idea of the programmer determining how many

- CPUs are needed, whether they should be a multicomputer or a multiprocessor, and how minimal kernels of one kind or another fit into the picture.

Why the Name Cloud?

The term "Cloud" came from a network design that was used by network engineers to represent the location of various network devices and there inter-connection. The shape of this network design was like a cloud.



Why Cloud Computing?

- With increase in computer and mobile user's, data storage has become a priority in all fields. Large and small scale businesses today thrive on their data & they spent a huge amount of money to maintain this data. It requires a strong IT support and a storage hub. Not all businesses can afford high cost of in-house IT infrastructure and back up support services. For them Cloud Computing is a cheaper solution. Perhaps its efficiency in storing data, computation and less maintenance cost has succeeded to attract even bigger businesses as well.

- Cloud computing decreases the hardware and software demand from the user's side. The only thing that user must be able to run is the cloud computing systems interface software, which can be as simple as Web browser, and the Cloud network takes care of the rest. We all have experienced cloud computing at some instant of time, some of the

popular cloud services we have used or we are still using are mail services like gmail, hotmail or yahoo etc.

- While accessing e-mail service our data is stored on cloud server and not on our computer. The technology and infrastructure behind the cloud is invisible. It is less important whether cloud services are based on HTTP, XML, Ruby, PHP or other specific technologies as far as it is user friendly and functional. An individual user can connect to cloud system from his/her own devices like desktop, laptop or mobile.

- Cloud computing harnesses small business effectively having limited resources, it gives small businesses access to the technologies that previously were out of their reach. Cloud computing helps small businesses to convert their maintenance cost into profit. Let's see how?

- In an in-house IT server, you have to pay a lot of attention and ensure that there are no flaws into the system so that it runs smoothly. And in case of any technical glitch you are completely responsible; it will seek a lot of attention, time and money for repair. Whereas, in cloud computing, the service provider takes the complete responsibility of the complication and the technical faults.

What is Cloud Computing

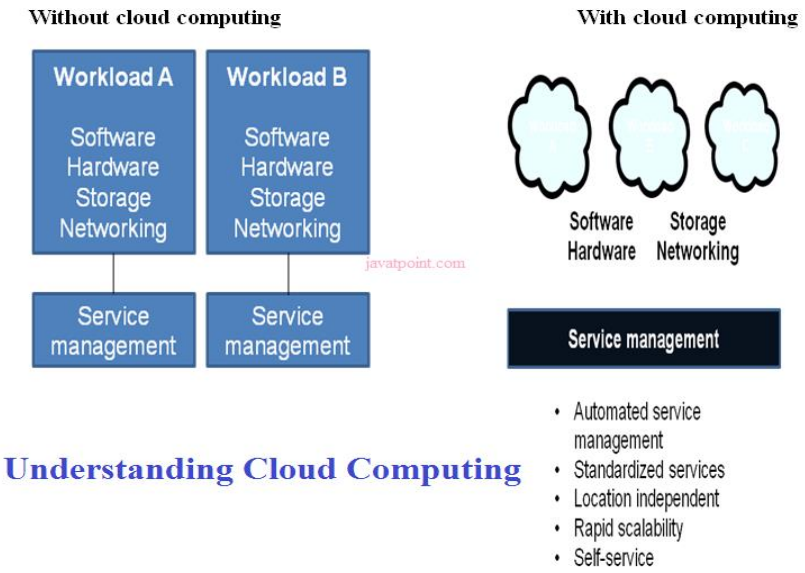
- **Cloud computing** means *on demand delivery of IT resources* via the internet with pay-as-you-go pricing. It provides a solution of IT infrastructure in low cost.

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.



Characteristics of Cloud Computing

1) Agility

- The cloud **works in the distributed computing environment**. It shares resources among users and works very fast.

2) High availability and reliability

- Availability of servers is high and more reliable, because **chances of infrastructure failure are minimal**.

3) High Scalability

- Means **"on-demand" provisioning of resources on a large scale**, without having engineers for peak loads.

4) Multi-Sharing

- With the help of cloud computing, **multiple users and applications can work more efficiently** with cost reductions by sharing common infrastructure.

5) Device and Location Independence

- Cloud computing enables the users to access systems using a web browser regardless of their location or what device they use e.g. PC, mobile phone etc. **As infrastructure is off-**

site (typically provided by a third-party) **and accessed via the Internet, users can connect from anywhere**.

6) Maintenance

- Maintenance of cloud computing applications is easier, since they **do not need to be installed on each user's computer and can be accessed from different places**. So, it reduces the cost also.

7) Low Cost

- By using cloud computing, the cost will be reduced because to take the services of cloud computing, **IT company need not to set its own infrastructure** and pay-as-per usage of resources.

8) Services in pay-per-use mode

- Application Programming Interfaces **(APIs) are provided to the users so that they can access services on the cloud** by using these APIs **and pay the charges as per the usage of services**.

Advantages of Cloud Computing

There are various advantages of cloud computing technology. The important advantages of cloud computing are given below.

1) Lower cost computer for users

In cloud, you don't require a high-powered (and accordingly high-priced) computer to run cloud computing's web based applications because applications run on cloud not on desktop PC or laptop.

2) Lower IT infrastructure cost

By using cloud computing, you need not to invest in larger numbers of more powerful servers, you also need not to require the IT staff for handling such powerful servers.

3) Fewer maintenance cost

The maintenance cost in cloud computing greatly reduces both hardware and software maintenance for organizations of all sizes.

4) Lower Software Cost

It reduces the software cost because you don't need to purchase separate software packages for each computer in the organization.

5) Instant software updates

Another software-related advantage in cloud computing is that users don't need to face with the choice between obsolete software and high upgrade costs. If the app is web-based, updates happen automatically and are available next time when the user logs in to the cloud.

6) Increased computing Power

The execution capacity of cloud servers are very high. It processes the application very fast.

7) Unlimited storage capacity

Cloud offers you a huge amount of storage capacity like 2000 GB or more than that if required.

<u>Disadvantages of Cloud Computing</u>

1) Require a constant Internet Connection

- Cloud computing is impossible without Internet connection. To access any applications and documents you need a constant Internet connection.

2) Require High Speed Internet connection

- Similarly, a low-speed Internet connection makes cloud computing painful at best and often impossible. Web based apps often require a lot of bandwidth to download, as need to download large documents.

3) Stored Data Might Not Be Secure

- With cloud computing, all your data is stored in the cloud. That's all well and good, but how secure is the cloud? Can't unauthorized users gain access to your confidential data?

History of Cloud Computing

- Before emerging 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.*

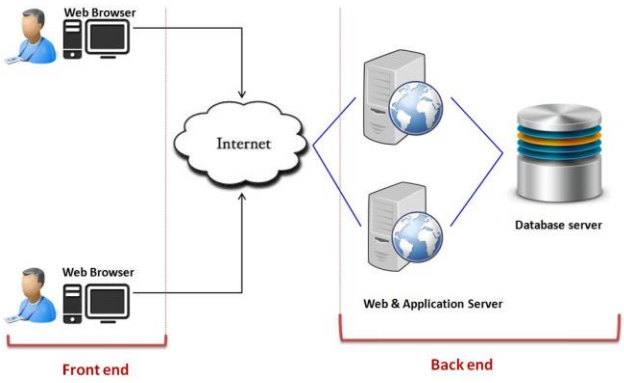
- Of course, all the big players are present in the cloud computing evolution, some were earlier, some were later. *In 2009,* **Microsoft** *launched Windows Azure*, and companies like Oracle and HP have all joined the game. This proves that today, cloud computing has become mainstream.

How does cloud computing work

- Assume that you are an executive at a very big corporation. Your particular responsibilities include to make sure that all of your employees have the right hardware and software they need to do their jobs. To buy computers for everyone is not enough. You also have to purchase software as well as software licenses and then provide these software's to your employees as they require. Whenever you hire a new employee, you need to buy more software or make sure your current software license allows another user. It is so stressful that you have to spend lots of money.
- But, there may be an alternative for executives like you. So, instead of installing a suite of software for each computer, you just need to load one application. That application will allow the employees to log-in into a Web-based service which hosts all the programs for the user that is required for his/her job. Remote servers owned by another company and that will run everything from e-mail to word processing to complex data analysis programs. It is called cloud computing, and it could change the entire computer industry.
- In a cloud computing system, there is a significant workload shift. Local computers have no longer to do all the heavy lifting when it comes to run applications. But cloud computing can handle that much heavy load easily and automatically. Hardware and software demands on the user's side decrease. The only thing the user's computer requires to be able to run is the cloud computing interface software of the system, which can be as simple as a Web browser and the cloud's network takes care of the rest.

Cloud Computing Architecture?

Let’s have a look into Cloud Computing and see what Cloud Computing is made of. Cloud computing comprises of two components front end and back end. Front end consist client part of cloud computing system. It comprise of interfaces and applications that are required to access the cloud computing platform.



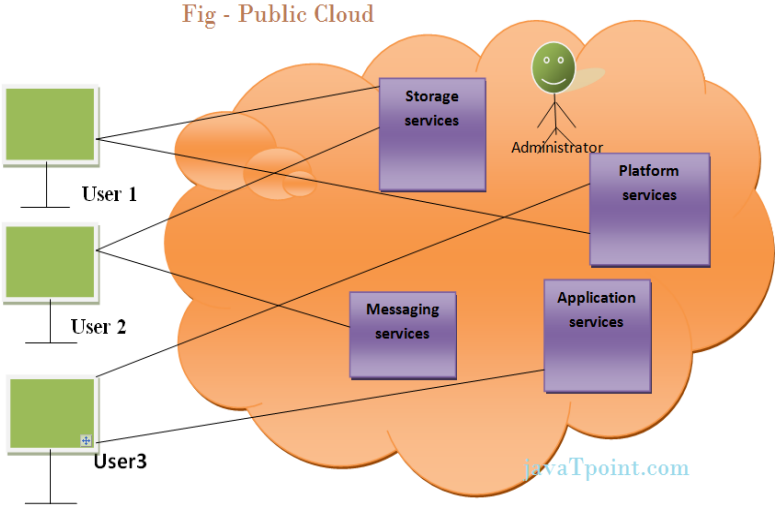
While back end refers to the cloud itself, it comprises of the resources that are required for cloud computing services. It consists of virtual machines, servers, data storage, security mechanism etc. It is under providers control.

Cloud computing distributes the file system that spreads over multiple hard disks and machines. Data is never stored in one place only and in case one unit fails the other will take over automatically. The user disk space is allocated on the distributed file system, while another important component is algorithm for resource allocation. Cloud computing is a strong distributed environment and it heavily depends upon strong algorithm.

<u>Types of Cloud:</u>

<u>Types: 1. Public Cloud</u>

Fig - Public Cloud



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.

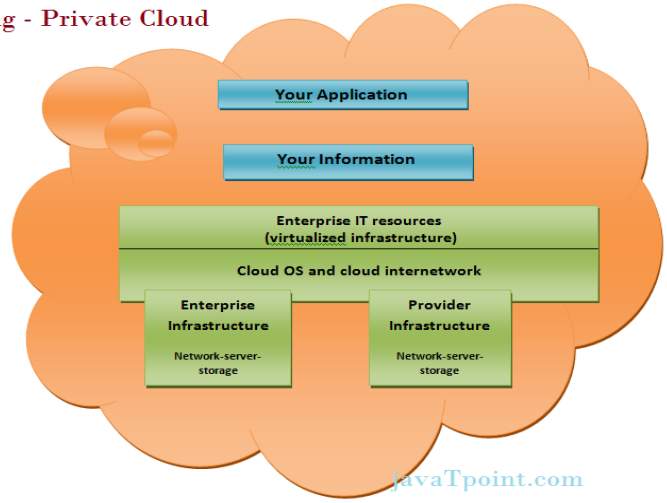
2) Less customizable

- It is less customizable than private cloud.

Type 2: Private Cloud

- The Private cloud allows the accessibility of systems and services within the organization. Private cloud is operated only within a particular organization. But it will be managed internally or by third party.

Fig - Private Cloud



Advantages of Private Cloud Model

1) High security and privacy

- Private cloud resources are shared from distinct pool of resources and hence highly secured.

2) More Control

- Private clouds have more control on its resources and hardware than public cloud because it is accessed only within the boundary of an organization.

Disadvantages of Private Cloud Model

1) Restriction

- Private cloud is only accessible locally and it is very difficult to deploy globally.

2) More Cost

- cloud is having more cost than public clouds.

3) Inflexible price

- In order to fulfill demands, purchasing new hardware is very costly.

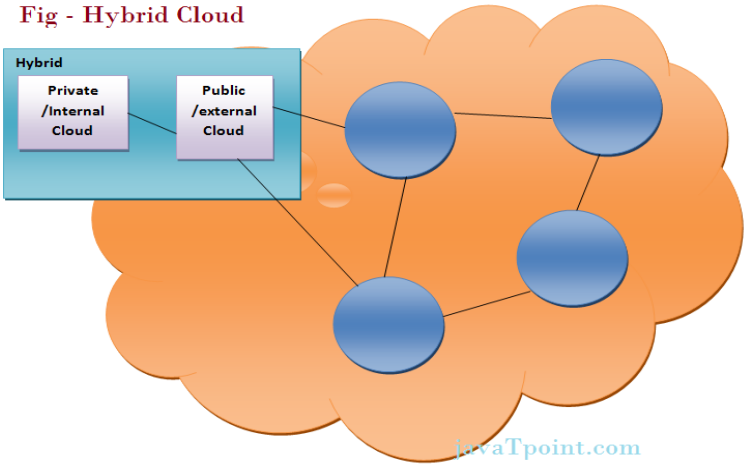
4) Less Scalability

- Private clouds are scaled only within capacity of internal hosted resources.

Hybrid Cloud

- The Hybrid cloud is the mixture of public and private cloud. Non-critical activities are performed by public cloud while critical activities are performed by private cloud.

Fig - Hybrid Cloud



Advantages of Hybrid Cloud Model

1) Scalable

- It provides both the features of public and private cloud scalability.

2) Flexible and secure

- It provides secure resources because of private cloud and scalable resources because of public cloud.

3) Cost effective

- It is having less cost as compared to private cloud.

Disadvantages of Hybrid Cloud Model

1) Networking issues

- Networking becomes complex because of private and public cloud.

2) Security Compliance

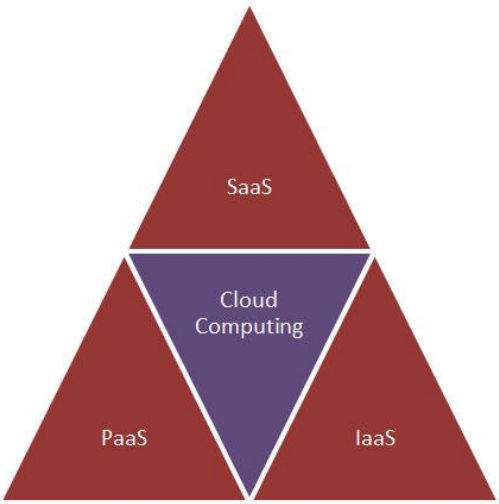
- It is necessary to ensure that cloud services are compliant with the security policies of an organization.

Cloud Computing Services

The three major Cloud Computing Offerings are

- **Software as a Service (SaaS)**
- **Platform as a Service (PaaS)**
- **Infrastructure as a Service (IaaS)**

Different business use some or all of these components according to their requirement.



SaaS (Software as a Service)

- SaaS is a software distribution model in which applications are hosted by a cloud service provider and made available to customers over internet. SaaS is also known as **"On-Demand Software"**. In SaaS, software and associated data are centrally hosted on the cloud server. SaaS is accessed by users using a thin client via a web browser.

Advantages of SaaS cloud computing layer

1) SaaS is easy to buy

- SaaS pricing is based on a monthly fee or annual fee, SaaS allows organizations to access business functionality at a low cost which is less than licensed applications.

- Unlike traditional software which is sold as a licensed based with an up-front cost (and often an optional ongoing support fee), SaaS providers generally pricing the applications using a subscription fee, most commonly a monthly or annually fee.

2) Less hardware required for SaaS

- The software is hosted remotely, so organizations don't need to invest in additional hardware.

3) Low Maintenance required for SaaS

- Software as a service removes the necessity of installation, set-up, and often daily unkeep and maintenance for organizations. Initial set-up cost for SaaS is typically less than the enterprise software. SaaS vendors actually pricing their applications based on some usage parameters, such as number of users using the application. So SaaS does easy to monitor and automatic updates.

4) No special software or hardware versions required

- All users will have the same version of software and typically access it through the web browser. SaaS reduces IT support costs by outsourcing hardware and software maintenance and support to the IaaS provider.

<u>Disadvantages of SaaS cloud computing layer</u>

1) Security

- Actually data is stored in cloud, so security may be an issue for some users. However, cloud computing is not more secure than in-house deployment. Learn more cloud security.

2) Latency issue

- Because the data and application are stored in cloud at a variable distance from the end user, so there is a possibility that there may be more latency while interacting with the application than a local deployment. So, SaaS model is not suitable for applications whose demand response times are in milliseconds.

3) Total Dependency on Internet

- Without internet connection, most SaaS applications are not usable.

4) Switching between SaaS vendors is difficult

- Switching SaaS vendors involves the difficult and slow task of transferring the very large data files over the Internet and then converting and importing them into another SaaS also.

IaaS (Infrastructure as a Service)

- IaaS is one of the layers of cloud computing platform wherein the customer organization outsources its IT infrastructure such as servers, networking, processing, storage, virtual machines and other resources. Customers access these resources over internet i.e. cloud computing platform, on a pay-per-use model.
- Iaas, **earlier called Hardware as a Service** (HaaS), is a cloud computing platform based model.
- In traditional hosting services, IT infrastructure was rented out for a specific periods of time, with pre-determined hardware configuration. The client paid for the configuration and time, regardless of the actual use. With the help of IaaS cloud computing platform layer, clients can dynamically scale the configuration to meet changing requires, and are billed only for the services actually used.
- IaaS cloud computing platform layer eliminates the need for every organization to maintain the IT infrastructure.
- IaaS is offered in three models: public, private, and hybrid cloud. Private cloud implies that the infrastructure resides at the customer-premise. In case of public cloud, it is located at the cloud computing platform vendor's data center; and hybrid cloud is a combination of two with customer choosing the best of both worlds.

Advantages of IaaS cloud computing layer

1) You can dynamically choose a CPU, memory and storage configuration as per your needs.

2) You easily access the vast computing power available on IaaS cloud platform.

3) You can eliminate the need of investment in rarely used IT hardware.

4) IT infra will be handled by the IaaS cloud computing platform vendors.

Disadvantages of IaaS cloud computing layer

1) There is a risk of IaaS cloud computing platform vendor by gaining the access to the organizations data. But it can be avoided by opting for private cloud.

2) IaaS cloud computing platform model is dependent on internet availability.

3) It is also dependent on the availability of virtualization services.

4) IaaS cloud computing platform can limit the user privacy and customization options.

Some pinpoint about IaaS cloud computing layer

- IaaS cloud computing platform cannot replace traditional hosting method but it provides more than that and each resources which are used are predictable as per the usage.
- IaaS cloud computing platform may not eliminate the need for an in-house IT department. It will be needed to monitor or control the IaaS setup. IT salary expenditure might not reduce significantly, but other IT expenses can be reduced.
- Breakdowns at the IaaS cloud computing platform vendor's end can bring your business to at the halt stage. Assess the IaaS cloud computing platform vendor's stability and finances. Make sure that SLAs (i.e. Service Level Agreement) provide backups for data, hardware, network and application failures. Image portability and third-party support is a plus point.
- The IaaS cloud computing platform vendor can get access to your sensitive data. So, engage with the credible companies or organizations. Study their security policies and precautions.

Top vendors who are providing IaaS cloud computing platform

IaaS Vendor	Iaas Solution	Details
Amazon Web Services	Elastic, Elastic Compute Cloud (EC2) MapReduce, Route 53, Virtual Private Cloud, etc.	The cloud computing platform pioneer, Amazon offers auto scaling, cloud monitoring, and load balancing features as part of its portfolio.

Netmagic Solutions	Netmagic IaaS Cloud	Netmagic runs from data centers in Mumbai, Chennai, and Bangalore, and a virtual data center in the United States. Plans are underway to extend services to West Asia.
Rackspace	Cloud servers, cloud files, cloud sites, etc.	The cloud computing platform vendor focuses primarily on enterprise-level hosting services.
Reliance Communications	Reliance Internet Data Center	RIDC supports both traditional hosting and cloud services, with data centers in Mumbai, Bangalore, Hyderabad, and Chennai. The cloud services offered by RIDC include IaaS and SaaS.
Sify Technologies	Sify IaaS	Sify's cloud computing platform is powered by HP's converged infrastructure. The vendor offers all three types of cloud services: IaaS, PaaS, and SaaS.
Tata Communications	InstaCompute	InstaCompute is Tata Communications' IaaS offering. InstaCompute data centers are located in Hyderabad and Singapore, with operations in both countries.

Platform as a Service | PaaS

- **PaaS cloud computing platform** is a developer programming platform which *is created for the programmer to develop, test, run and manage the applications*. A developer is able to write the application as well as deploy it directly into this layer easily. PaaS extend and abstract the IaaS layer by removing the hassle of managing the individual virtual machine. In PaaS cloud computing platform, back end scalability is handled by the cloud service provider and the end user does not have to worry about to manage the infrastructure. All the infrastructure to run the applications will be over the internet.

<u>Advantages of PaaS cloud computing layer</u>

1) Simplified Development

- Developers can focus on development and innovation without worrying about the infrastructure.

2) Lower risk

- No requirements of up-front investment in hardware and software. Developers only need a PC and an internet connection to start building applications.

3) Prebuilt business functionality

- Some PaaS vendors also provide already defined business functionality so that users can avoid building everything from very scratch and hence can directly start the projects only.

4) Instant community

- PaaS vendors frequently provides online communities where developer can get the ideas, share experiences and seek advice from others.

5) Scalability

- Applications deployed can scale from one to thousands of users without any changes to the applications.

Disadvantages of PaaS cloud computing layer

1) Vendor lock-in

- One have to write the applications according to the platform provided by PaaS vendor so migration of an application to another PaaS vendor would be a problem.

2) Data Privacy

- Corporate data, whether it can be critical or not, will be private so if it is not located within the walls of the company there can be a risk in terms of privacy of data.

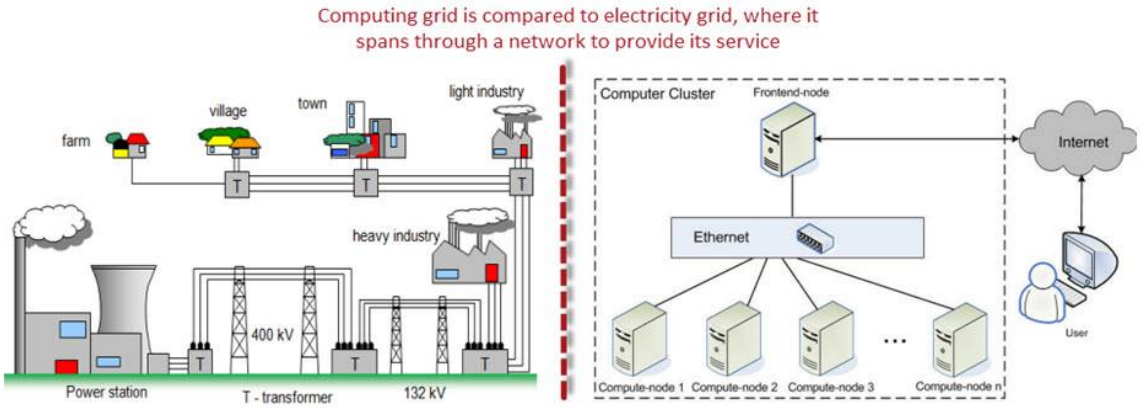
3) Integration with the rest of the systems applications

- It may happen that some applications are local and some are in cloud. So there will be chances of increased complexity when we want to use data which in the cloud with the local data.

- Top vendors who are providing PaaS cloud computing platform
- Google Apps Engine (GAE)
- SalesFroce.com
- Windows Azure
- AppFog
- Openshift
- Cloud Foundary from VMware

Grid Computing Vs Cloud Computing

When we switch on the fan or any electric device, we are less concern about the power supply from where it comes and how it is generated. The power supply or electricity that we receives at our home travels through a chain of network, which includes power stations, transformers, power lines and transmission stations. These components together make a 'Power Grid'. Likewise, 'Grid Computing' is an infrastructure that links computing resources such as PCs, servers, workstations and storage elements and provides the mechanism required to access them.



Grid Computing is a middle ware to co-ordinate disparate IT resources across a network, allowing them to function as whole. It is more often used in scientific research and in universities for educational purpose. For example, a group of architect students working on a different project requires a specific designing tool and a software for designing purpose but only couple of them got access to this designing tool, the problem is how they can make this tool available to rest of the students. To make available for other students they will put this designing tool on campus network, now the grid will connect all these computers in campus network and allow student to use designing tool required for their project from anywhere.

Cloud computing and Grid computing is often confused, though there functions are almost similar there approach for their functionality is different. Let see how they operate-

Cloud Computing	**Grid Computing**
• Cloud computing works more as a service provider for utilizing computer resource	• Grid computing uses the available resource and interconnected computer systems to accomplish a common goal
• Cloud computing is a centralized model	• Grid computing is a decentralized model, where the computation could occur over many administrative model
• Cloud is a collection of computers usually owned by a single party.	• A grid is a collection of computers which is owned by a multiple parties in multiple locations and connected together so that users can share the combined power of resources
• Cloud offers more services all most all the services like web hosting, DB (Data Base)	• Grid provides limited services

support and much more	
• Cloud computing is typically provided within a single organization (eg : Amazon)	• Grid computing federates the resources located within different organization.

Utility Computing Vs Cloud Computing

- In our previous conversation in "Grid Computing" we have seen how electricity is supplied to our house, also we do know that to keep electricity supply we have to pay the bill. Utility Computing is just like that, we use electricity at home as per our requirement and pay the bill accordingly likewise you will use the services for the computing and pay as per the use this is known as 'Utility computing'. Utility computing is a good source for small scale usage, it can be done in any server environment and requires Cloud Computing.

- Utility computing is the process of providing service through an on-demand, pay per use billing method. The customer or client has access to a virtually unlimited supply of computing solutions over a virtual private network or over the internet, which can be sourced and used whenever it's required. Based on the concept of utility computing , grid computing, cloud computing and managed IT services are based.

- Through utility computing small businesses with limited budget can easily use software like CRM (Customer Relationship Management) without investing heavily on infrastructure to maintain their clientele base.

Utility Computing	Cloud Computing
• Utility computing refers to the ability to charge the offered services, and charge customers for exact usage	• Cloud Computing also works like utility computing, you pay only for what you use but Cloud Computing might be cheaper, as such, Cloud based app can be up and running in days or weeks.
• Utility computing users want to be in control of the geographical location of the infrastructure	• In cloud computing, provider is in complete control of cloud computing services and infrastructure
• Utility computing is more favorable when performance and selection infrastructure is critical	• Cloud computing is great and easy to use when the selection infrastructure and performance is not critical
• Utility computing is a good choice for less resource demanding	• Cloud computing is a good choice for high resource demanding
• Utility computing refers to a business model	• Cloud computing refers to the underlying IT architecture

<u>Security concerns for Cloud Computing</u>

While using cloud computing, the major issue that concerns the users is about its security. One concern is that cloud providers themselves may have access to customer's unencrypted data- whether it's on disk, in memory or transmitted over the network.

As computing has expanded to different devices like hard disk drives and mobile phones, TCG has extended the security measures to include these devices. It provides ability to create a unified data protection policy across all clouds.

Some of the trusted cloud services are Amazon, Box.net, Gmail and many others.

Privacy Concern & Cloud Computing

Privacy present a strong barrier for users to adapt into Cloud Computing systems

There are certain measures which can improve privacy in cloud computing.

1. The administrative staff of the cloud computing service could theoretically monitor the data moving in memory before it is stored in disk.To keep the confidentiality of a data, administrative and legal controls should prevent this from happening.
2. The other way for increasing the privacy is to keep the data decrypted at the cloud storage site, preventing unauthorized access through the internet; even cloud vendor can't access the data either.