CHAPTER 1

Module I

Introduction

Syllabus Topics

Defining Cloud Computing, Cloud and other similar configurations, Components of Cloud Computing, Cloud types : NIST and Cloud Cube Models, Cloud Deployment Models and Service Models, Cloud computing architecture, Advantages and Disadvantages of Cloud Computing.

1.1 Introduction

- In Computer science, **Cloud computing** describes a type of outsourcing of computer services, similar to the way in which electricity supply is outsourced. Users can simply use it. They do not need to worry about from where the electricity comes from, how it is made, or transported. Every month, they pay for what they consumed. So the idea behind Cloud computing is similar.
- The users need not to worry about how the storage, computing power and development environments works internally.
- Cloud computing is usually Internet-based computing. The cloud is a metaphor for the Internet on how the internet is described in computer network diagrams, which means it is an abstraction of hiding the complex infrastructure of the internet.
- It is a style of computing in which IT-related activities are provided "as a service", which allows users to access technology-enabled services from the Internet ("in the cloud") without knowledge of the technologies behind these servers.
- According to a paper published by IEEE Internet Computing in 2008 "Cloud computing is a paradigm in which information is permanently stored in servers on the Internet and cached temporarily on clients that include computers, laptops, handhelds, sensors, etc."
- Cloud computing is a general concept that utilizes software as a service (SaaS), such as Web 2.0 and other technology trends, all of which depend on the Internet for satisfying users' needs.
- For example, Google Apps provides common business applications that are accessed from a web browser, while the software and data are stored on the Internet servers.
- Cloud computing is an information technology (IT) model used for enabling access to shared pools of configurable resources (such as computer networks, servers, storage, applications and services), which can be rapidly provisioned with minimal management effort, often over the Internet.

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- Cloud computing allows users and enterprises with various computing capabilities to store and process data either in a privately-owned cloud, or on a third-party server located in a data center, thus making data-accessing mechanisms more efficient and reliable.
- Cloud computing relies on sharing of resources to achieve consistency and economy of scale, similar to a utility.
- Cloud computing allows companies to avoid or minimize up-front IT infrastructure costs. As well, third-party clouds enable organizations to focus on their core businesses instead of expending resources on computer infrastructure and maintenance.
- Cloud computing allows enterprises to get their applications up and run faster, with improved manageability and leads to less maintenance, and it enables IT teams to more rapidly adjust resources to meet fluctuating and unpredictable business demands.
- Cloud providers typically use a "pay-as-you-go" model.
- In 2009 the availability of high-capacity networks, low-cost computers and storage devices as well as the widespread adoption of hardware virtualization, service-oriented architecture, and autonomic and utility computing led to a growth in Cloud computing.
- Companies can scale up as computing needs increase and then scale down again when demands decrease. In 2013 it was reported that Cloud computing had become a highly demanded service or utility due to the advantages of high computing power, cheap cost of services, high performance, scalability, and accessibility as well as availability.

Syllabus Topic : Defining Cloud Computing

1.2 Defining Cloud Computing

→ (MU - Dec. 15)

Q. 1.2.1 What is Cloud? (Ref. sec. 1.2) **Dec. 15, 1 Mark**

Definition

"Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

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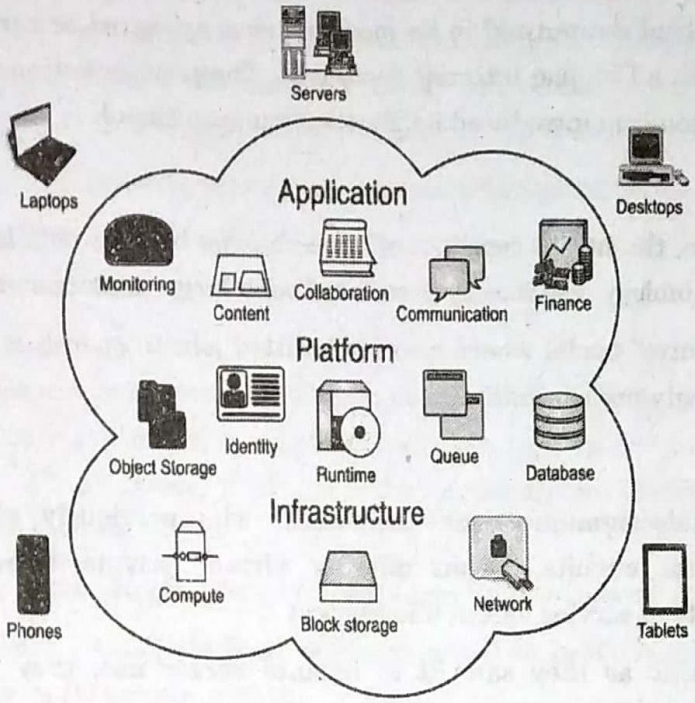

Fig. 1.2.1 : Cloud computing

Origin of Cloud Computing

- The origin of the term Cloud computing is unclear. The word cloud is commonly used in science to describe a large collection of objects that visually appear from a distance as a cloud and describes any set of things whose details are not further inspected in a given context.
- Another explanation is that the old programs that drew network schematics surrounded; the icons for servers with a circle, and a cluster of servers in a network diagram had several overlapping circles, which resembled a cloud.
- In analogy to the above usage, the word cloud was used as a metaphor for the Internet and a standardized cloud like shape was used to denote a network on telephony schematics. Later it was used to represent the Internet in computer network diagrams.
- With this simplification, the implication is that the specifics of how the end points of a network are connected are not relevant for the purposes of understanding the diagram. The cloud symbol was used to represent networks of computing equipment in the original ARPANET by as early as 1977, and the CSNET by 1981 both predecessors to the Internet itself.
- The term cloud has been used to refer platforms for distributed computing. In Wired's April 1994 feature "Bill and Andy's Excellent Adventure II" on the Apple spin-off General Magic, Andy Hertzfeld commented on General Magic's distributed programming language Telescript that :
- "The beauty of Telescript is that now, instead of just having a device to program, we now have the entire Cloud out there, where a single program can go and travel to many different sources of information and create sort of a virtual service. No one had conceived that before. The example Jim White uses is a date arranging service where a software agent goes to the flower store and orders flowers and then goes to the ticket shop and gets the tickets for the show, and everything is communicated to both parties."

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- The early code came from NASA's Nebula platform as well as from Rackspace's Cloud Files platform. As an open source offering and along with other open-source solutions such as CloudStack, Ganeti and OpenNebula, it has attracted attention by several key communities.
- Several studies aim at comparing these open sources offerings based on a set of criteria.
- On March 1, 2011, IBM announced the IBM SmartCloud framework to support Smarter Planet. Among the various components of the Smarter Computing foundation, Cloud computing is a critical part.
- On June 7, 2012, Oracle announced the Oracle Cloud. While aspects of the Oracle Cloud are still in development, this cloud offering is poised to be the first to provide users with access to an integrated set of IT solutions, including the Applications (SaaS), Platform (PaaS), and Infrastructure (IaaS) layers.
- Initially in April of 2008, Google released Google App Engine in beta.
- In May of 2012, Google Compute Engine was released in preview, before being rolled out into general availability in December of 2013.

1.2.1 Features of Cloud

➔ (MU - Dec. 15)

Q. 1.2.2 Explain the features of cloud in details (Ref. sec. 1.2.1) **Dec. 15, 3 Marks**

- Following are the Features of the Cloud Computing

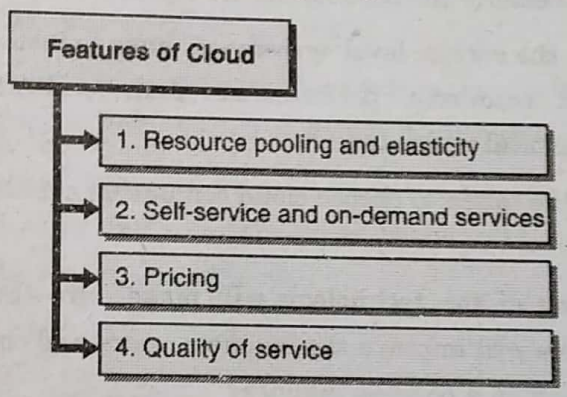

Fig. 1.2.2 : Features of Cloud

➔ **1. Resource pooling and elasticity**

- In cloud computing, resources are pooled to serve a large number of customers.
- Cloud technology uses multi-tenancy in which different resources are dynamically allocated and de-allocated according to demand. From the user's point of view, it is not possible to know where the resource actually resides.
- The resource allocation should be elastic that means it should change appropriately and quickly with on demand basis.
- If the requirement increases suddenly, then the system has to be elastic enough to meet the required result, and it should return to the normal level when the demand decreases.

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2. Self-service and on-demand services

- Cloud computing is established on self-service and on-demand service based models.
- It has to allow the user to interact with the cloud to perform the different jobs like building, deploying, managing, and scheduling.
- The user should be able to access computing capabilities when needed and without any interaction from the cloud-service provider.
- This would help users to be in control, bringing agility in their work, and to make better decisions on the current and future needs.

3. Pricing

- Cloud computing does not have any upfront cost. It is completely based on the custom usage. The user is payable based on the amount of resources he/she used.
- This will ultimately help the user to track their used resources and minimize the cost. Cloud computing must provide different ways to capture, monitor, and control the used information for accurate billing.
- The information which is collected should be transparent and readily available to the end users. This will help to make the customer realize the cost benefits that cloud computing brings.

4. Quality of service

- Cloud computing must ensure the best service for customers.
- Services mentioned in the service-level agreements have to include guarantees on round-the-clock availability, sufficient resources, performance, and bandwidth. Any compromise on these guarantees could prove fatal for customers.
- The decision that is to be taken to choose cloud computing should not be based on the advertise in the industry.
- The fine understanding of the technology will make sure the user to take proper decisions. Knowing all the features will improve the business users and they will understand and negotiate with the service providers in a positive manner.

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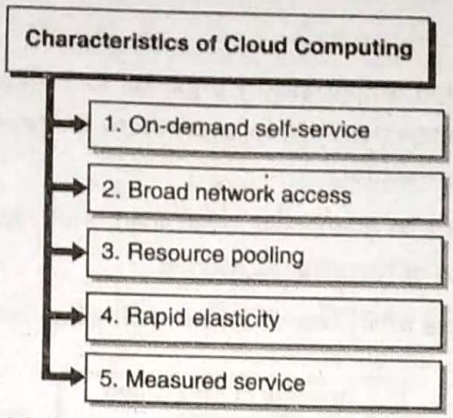

Fig. 1.5.1 : Characteristics of Cloud Computing

➜ 1. On-demand self-service

A cloud consumer can be unilaterally agrees computing capabilities, which can include server time and network storage. When needed it can be used without the human interface with each service provider.

➜ 2. Broad network access

- Broad network access will indicates the consumers regarding resources which are hosted in a private cloud (operated within a company's firewall) that are available for access from a variety of devices, such as tablets, PCs, Macs and smart phones. These resources will also be available from a wide range of locations that offer online access.
- Companies that are involved in the broad network access in a cloud networks need to deal with security issues that may occur.
- Many times, large companies prefer private cloud service because they deal with the probability for information leaks through the gaps left open outside networks in a public cloud.

➜ 3. Resource pooling

- The provider's computing resources are pooled to provide multiple end users using a multi-tenant model. This may involve many physical and virtual resources which are dynamically assigned and reassigned according to users demand.
- There is logic of location independence, in such a case the user generally has no access or knowledge about the exact location of the provided resources but he may be able to identify location at a higher level of abstraction (e.g., country, state, or datacenter).
- Examples of resources include storage, processing, memory, network bandwidth, and virtual machines.

➜ 4. Rapid elasticity

- Capabilities can be quickly and elastically provisioned, in some situations automatically, the reason is to quickly scale out.
- For the consumer, the capabilities accessible are often unlimited and can be purchased in any quantity at any time.

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→ **5. Measured service**

- The cloud environment will automatically organize and optimize resource use as per capability, hence at some level of abstraction it is appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts).
- Resource consumption can be monitored, controlled, and reported by providing transparency for both the provider and user of the utilized service.
- The NIST cloud computing architecture defines following five major elements :

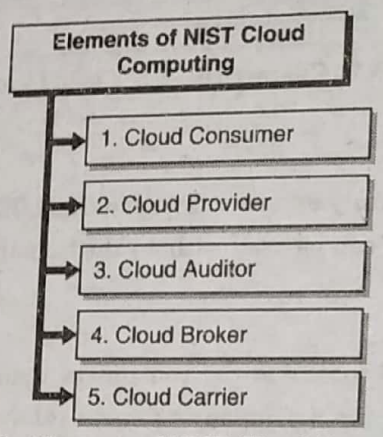

Fig. 1.5.2 : Elements of NIST Cloud Computing

- Here each element is an entity (a person or an organization) which takes part in any of the transaction or process and performs different tasks in cloud computing.

Table 1.5.1 : Actors in Cloud Computing

Actor	Definition
Cloud Consumer	A person or organization that maintains a business relationship with, and uses service from, cloud Providers.
Cloud Provider	A person, organization, or an entity responsible for making a service available to interested parties.
Cloud Auditor	A party that can conduct independent assessment of cloud services, information system operations, performance and security of the cloud implementation.

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This is parameterized or de-parameterized. This type of dimension will always measure that the operations are inside or outside the security boundary, firewall, etc.

(iv) Sourcing

In-sourcing or out-sourcing : It defines whether the customer or the service provider provides the service correctly or not.

Syllabus Topic : Cloud Deployment Models

1.7 Cloud Deployment Model

➔ **(MU - May 16, May 17, Dec. 17, May 18)**

Q. 1.7.1	What is Private ,Public and Hybrid cloud? (Ref. sec. 1.7)	Dec. 17, 10 Marks
Q. 1.7.2	What are the Cloud Deployment Models? (Ref. sec. 1.7)	May 16, May 17, May 18, 5 Marks

- These models are used to represent any customized specific type of cloud environment which is basically distinguished by the aspects like ownership, size, and access.
- There are four common cloud deployment models :

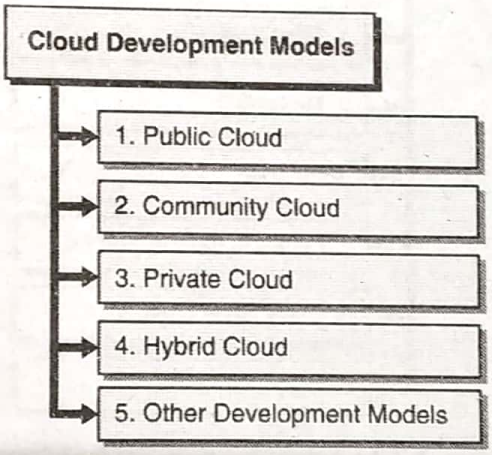

Fig. 1.7.1 : Cloud Deployment Models

.7.1 Public Clouds

Q. 1.7.3	Explain Public Clouds. (Ref. sec. 1.7.1)	(2 Marks)

- Public Cloud allows the various types of cloud based systems and services to be simply accessible to common public.
- The number of IT giants like Google, Zoho, Amazon, Salesforce, Microsoft, Yahoo etc. offer cloud services through the Internet.
- The Public Cloud Model is illustrated in the Fig. 1.7.2.

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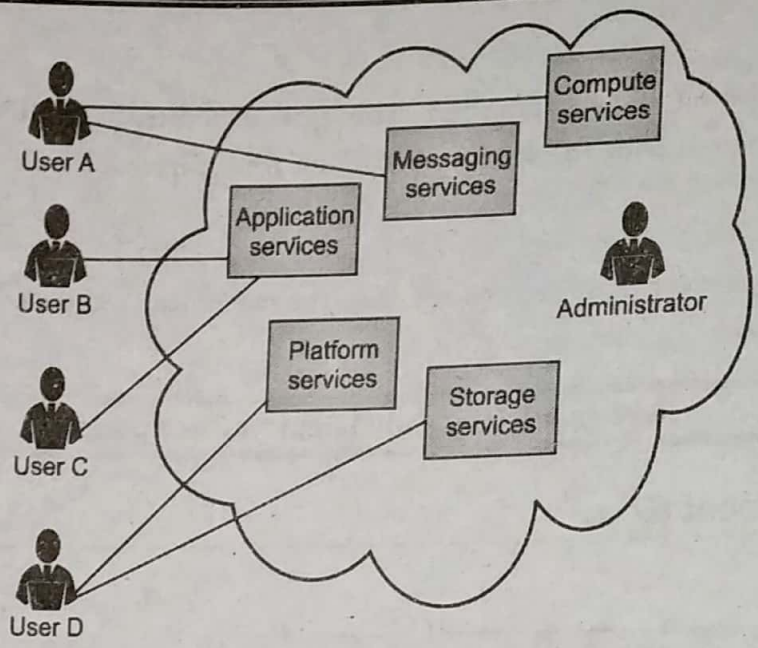

Fig. 1.7.2 : Public Cloud

Advantages of Public Cloud

Q. 1.7.4 Explain advantages of Public Clouds. (Ref. sec. 1.7.1) **(2 Marks)**

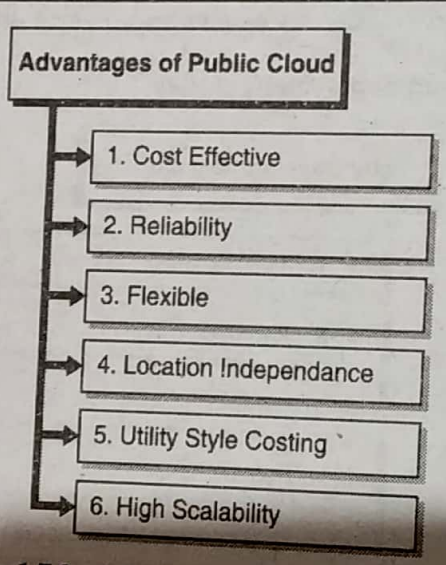

Fig. 1.7.3 : Advantages of Public Cloud

There are various advantages of deploying cloud in the form of public cloud model.

➜ **1. Cost Effective**

In public cloud the IT resources are shared by large number of customers, hence it is possible for provider to keep them cost effective.

➜ **2. Reliability**

A large number of resources are employed by the public cloud at various locations; hence if failure occurs in any of the resource, another resource is employed by the public cloud.

➜ **3. Flexibility**

Public cloud has ability to integrate with private cloud easily. This provides much better flexibility to customer.

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→ **4. Location Independence**

As services of public cloud are delivered through internet, it is completely location independent.

→ **5. Utility Style Costing**

Pay-per-use model is available in public cloud and resources made available to customer only when there is requirement.

→ **6. High Scalability**

As per demand, the cloud resources can be scaled up or down from the pool of resources.

☞ **Disadvantages of public cloud**

Q. 1.7.5 Explain disadvantages of Public Clouds. (Ref. sec. 1.7.1) **(2 Marks)**

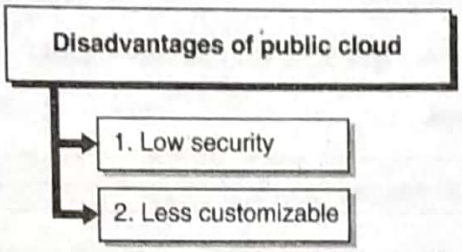

Fig. 1.7.4 : Disadvantages of public cloud

Here are few disadvantages of public cloud model :

→ **1. Low Security**

In this model the data hosting is done off site and public sharing of resources is done, which does not ensure strong security.

→ **2. Less Customizable**

As compared to private cloud, public cloud is less customizable.

1.7.2 Community Clouds

Q. 1.7.6 Explain the term Community Clouds. (Ref. sec. 1.7.2) **(2 Marks)**

Community Cloud allows the various types of cloud based systems and services to be simply accessible to group of organizations. An infrastructure is shared between various organizations which are of specific community. It is managed either by internally or by any contracted third party.

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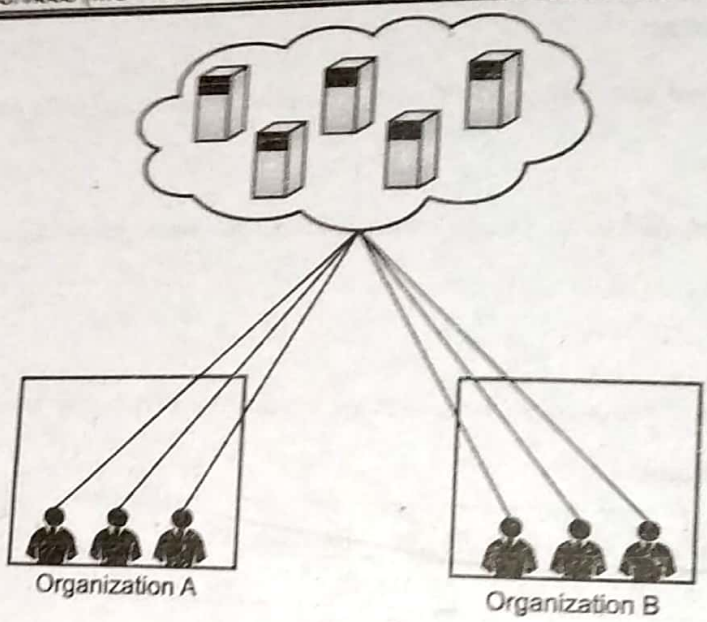

Fig. 1.7.5 : Community Cloud

Advantages of Community Clouds

Q. 1.7.7 Explain advantages of community Clouds. (Ref. sec. 1.7.2) (2 Marks)

There are number of advantages of deploying cloud as community cloud model.

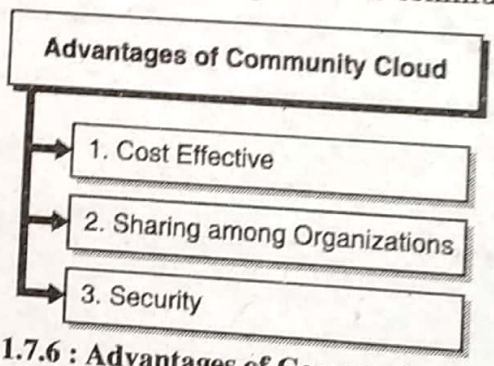

Fig. 1.7.6 : Advantages of Community Cloud

1. Cost Effective

In community cloud the IT resources are shared by number of organizations, hence it is possible for provider to keep them cost effective.

2. Sharing Among Organizations

Sharable infrastructure is provided by the Community cloud for sharing of cloud resources among the various organizations.

3. Security

The community cloud is secure as compared to the public cloud but it is less secured as compared to the private cloud.

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Disadvantages of Community Cloud

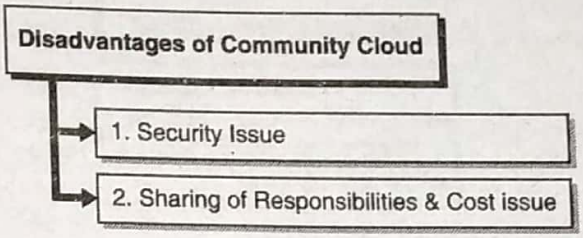

Fig. 1.7.7 : Disadvantages of Community Cloud

1. Security issue

The entire data is stored at one place, hence it may arise security concern as it might be accessible to others.

2. Sharing of Responsibilities and Cost issue

There may be confusion while assigning responsibilities of governance and security among organizations. Also the cost sharing is difficult.

1.7.3 Private Clouds

Q. 1.7.8 Explain the term Private Clouds. (Ref. sec. 1.7.3) **(2 Marks)**

- Private Cloud is implemented by an organization in its own private premises. The cloud based IT resources and services are accessible within the organization only. This cloud may be managed by the organization itself or by any other contracted third-party.
- The private cloud model is shown in the Fig. 1.7.8.

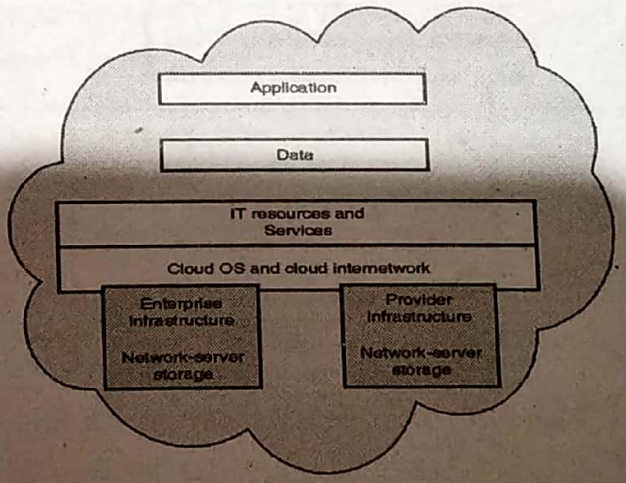

Fig. 1.7.8: Private Cloud

Advantages of Private Cloud

Q. 1.7.9 Write advantages of Private Clouds. (Ref. sec. 1.7.3) **(2 Marks)**

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There are number of advantages of deploying cloud as private cloud model.

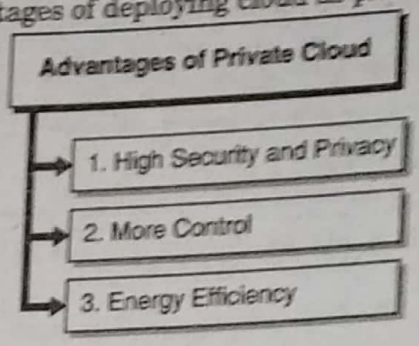

Fig. 1.7.9 : Advantages of Private Cloud

➜ **1. High Security and Privacy**

The operations performed in Private Cloud are not exposed to public and also the resou sharing is done from distinct pool of resources, hence a high security and privacy is ensured.

➜ **2. More Control**

As the accessibility is only within the boundary of an organization, the control of Private Cloud the resources and hardware is more than the Public Cloud.

➜ **3. Energy Efficiency**

The energy efficiency of Private Cloud is more than the Public Cloud.

☞ **Disadvantages of Private Cloud**

Q. 1.7.10 Write disadvantages of Private Clouds. (Ref. sec. 1.7.3) (2 Marks)

There are some disadvantages of private cloud model :

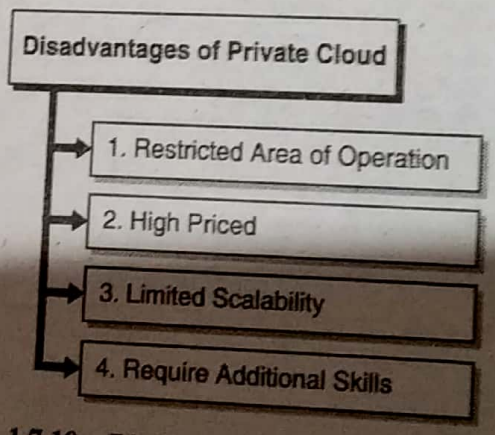

Fig. 1.7.10 : Disadvantages of Private Cloud

➜ **1. Restricted Area of Operation**

The accessibility of IT resources and service of Private cloud is only within the boundary of an organization.

➜ **2. High Priced**

Costing of hardware is the responsibility of the organization alone.

➜ **3. Limited Scalability**

The scaling is possible within the capacity of internal

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4. Require Additional Skills

High level skilled employees are required to manage the private cloud.

Comparison of Public, Private and Hybrid Clouds

Q. 1.7.11 Compare public and private cloud. (Ref. sec. 1.7.3) **(2 Marks)**

Parameter	Public Cloud	Private Cloud	Hybrid Cloud
Description	Multi-tenant environment with pay-as-you-grow scalability.	Scalability plus the enhanced security and control of a single-tenant environment.	Connect the public cloud to private cloud or dedicated servers ; even in personal data center.
Physical hardware	Shared	Dedicated	Shared + Dedicated
Best for	Non-sensitive, public-facing operations and unpredictable traffic.	Sensitive, business-critical operations.	Combine public, private and/or dedicated servers, for the best of each.

1.7.4 Hybrid Clouds

Q. 1.7.12 Write a note on Hybrid Clouds. (Ref. sec. 1.7.4) **(2 Marks)**

- A hybrid cloud is a mixture of two or more types of cloud deployment models.
- For example, a cloud consumer may want to deploy cloud services which process important data to private cloud and other cloud services which process less important data to a public cloud. Such combination is considered as Hybrid Cloud.

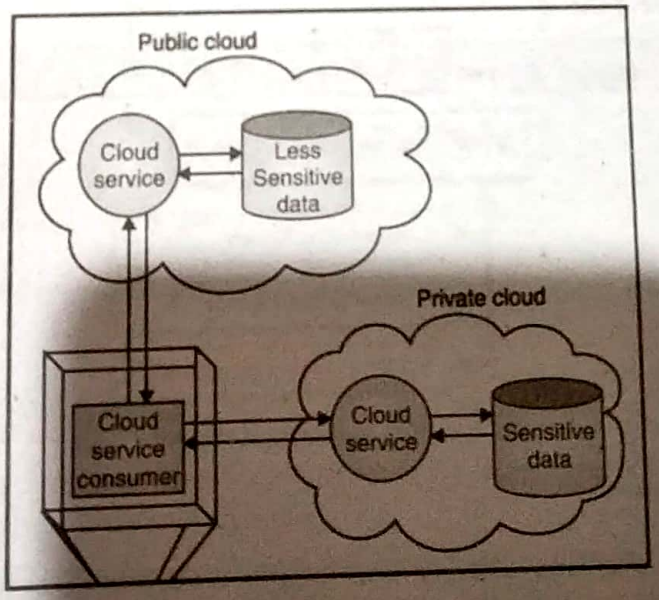

Fig. 1.7.11 : Hybrid Clouds

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Advantages of Hybrid Cloud

Q. 1.7.13 Write advantages of Hybrid Clouds. (Ref. sec. 1.7.4) **(2 Marks)**

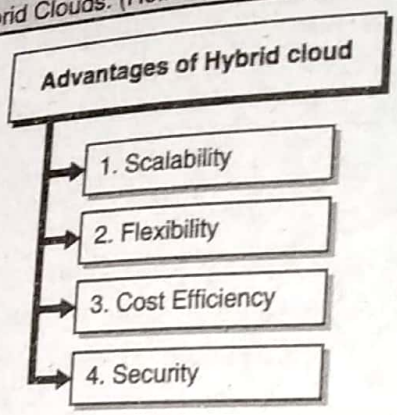

Fig. 1.7.12 : Advantages of Hybrid Cloud

There are number of advantages of deploying cloud as hybrid cloud model.

➜ **1. Scalability**

Both public and private scalability is provided by Hybrid Model.

➜ **2. Flexibility**

Both secure and scalable resources are available.

➜ **3. Cost Efficiency**

As compared to Private Cloud, it is cost effective.

➜ **4. Security**

The private part of hybrid cloud ensures strong security.

Disadvantages of Hybrid Cloud

Q. 1.7.14 Write disadvantages of Hybrid Clouds. (Ref. sec. 1.7.4) **(2 Marks)**

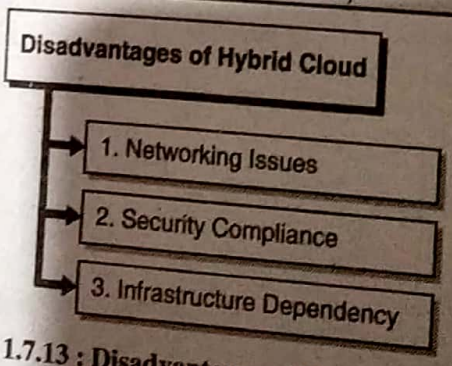

Fig. 1.7.13 : Disadvantages of Hybrid Cloud

➜ **1. Networking Issues**

Maintaining network between private and public cloud is complicated.

➜ **2. Security Compliance**

The involvement of public Cloud leads to security concerns.

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→ 3. **Infrastructure Dependency**

The dependency on internal IT infrastructure of Hybrid cloud is more.

1.7.5 Other Deployment Models

Q. 1.7.15 What are other deployment models like Virtual Private Cloud and Inter-cloud ? (Ref. sec. 1.7.5) **(2 Marks)**

Rather than these four clouds, there are some additional models available :

- **Virtual Private Cloud :** This model is also called as Dedicated Cloud or Hosted Cloud. In this cloud there is a self contained cloud environment which is basically hosted and managed by a public cloud provider.
- **Inter-Cloud :** In this model, architecture of two or more inter-connected clouds is implemented.

Syllabus Topic : Service Models

1.8 Service Models

→ **(MU - Dec. 17)**

Q. 1.8.1 Explain IaaS, PaaS,SaaS. (Ref. sec. 1.8) **Dec. 17, 10 Marks**

These models are the specific, pre-packaged grouping of IT resources provided by a cloud provider.

There are three types of cloud delivery models which are also known as **Cloud computing Services.**

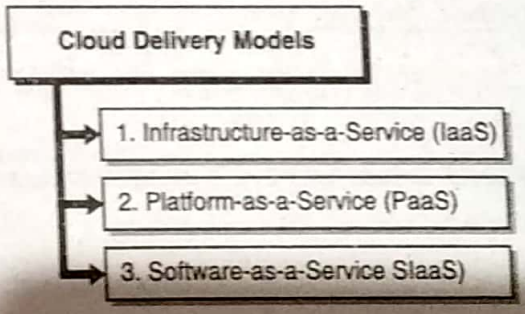

Fig. 1.8.1 : Cloud Delivery Models

1.8.1 Infrastructure-as-a-Service (IaaS)

→ **(MU - Dec. 17)**

Q. 1.8.2 Explain the IaaS model. (Ref. sec. 1.8.1) **Dec. 17, 5 Marks**

Infrastructure-as-a-Service is a model which provides access to primary resources like physical machines, virtual machines, virtual storage, etc.

In addition to these resources, the IaaS also provides following facilities :

(i) Virtual machine disk storage

(ii) Software bundles

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(iii) Virtual local area network (VLANs)

(iv) IP addresses

(v) Load balancers

The concept of server virtualization is used to make available these resources to the user. The extent of access rights gives feeling of owner of these resources to the end user.

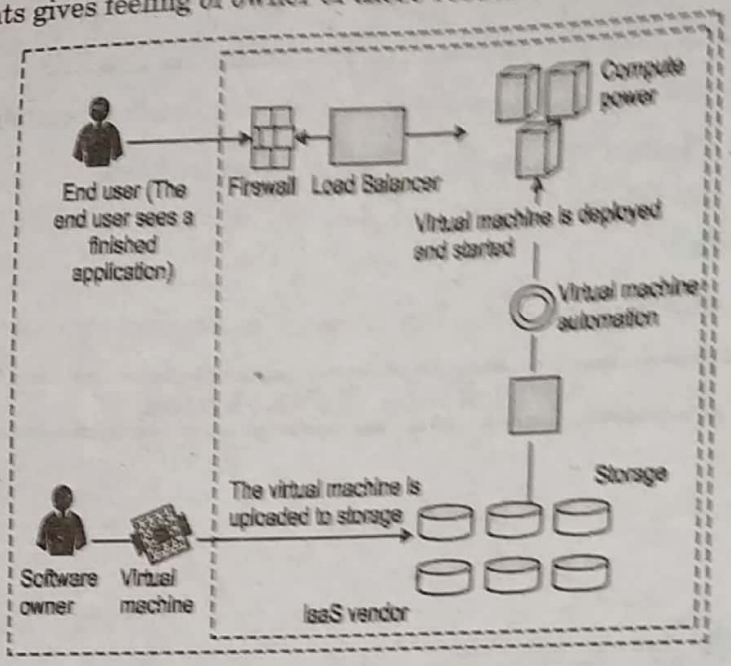

Fig. 1.8.2 : IaaS

Advantages of IaaS

Q. 1.8.3	Explain the benefits of IaaS.(Ref. sec. 1.8.1)	(3 Marks)
Q. 1.8.4	Explain advantages of IaaS. (Ref. sec. 1.8.1)	(3 Marks)

- IaaS helps the cloud provider to freely place the infrastructure over the Internet in a cost-effective manner.
- Through administrative level access to VMs, a complete control of the computing resources is provided.
- Using the administrative access, the customer can access computing resources in the following way :
  - If the end user wants to run the virtual machine or store data on cloud based server, then he issues an administrative command to cloud provider.
  - Administrative command is given by the customer to virtual machines to start the service or web server to install new applications.

(i) The renting of computer hardware is very flexible as well as efficient

Number of IT resources like virtual machines, IP addresses, storage devices, monitoring services, bandwidth, firewalls, etc. made available to the customers on lease. The payment of the service is depending upon the time for which the resources are retained by the customer. Also using the administrative access to virtual machines, number of software can be executed by the customer.

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(ii) Portability and interoperability is provided with legacy applications

A legacy can be maintained between applications and workloads within IaaS clouds. For example the network applications like web or email server which generally run on customer side server can be run on VMs in IaaS cloud.

Disadvantages of IaaS

Q. 1.8.5 Explain disadvantages of IaaS. (Ref. sec. 1.8.1) **(3 Marks)**

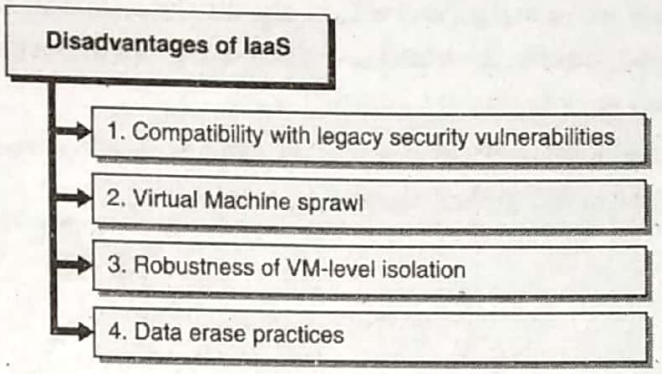

Fig. 1.8.3 : Disadvantages of IaaS

1. Compatibility with legacy security vulnerabilities

As the legacy software of customer is run in provider's infrastructure, the software gets exposed to all of the security vulnerabilities.

2. Virtual Machine sprawl

IaaS gives permission to customer to make use of virtual machines in running, suspended and off state modes; hence the Virtual Machine may be out-of-date with respect to security updates.

3. Robustness of VM-level isolation

IaaS provides an environment in isolated form to the customers through the software hypervisor.

The Hypervisor is an application layer which has hardware support for virtualization to divide a physical computer system into several virtual machines.

4. Data erase practices

The virtual machines use the common disk resources offered by the cloud provider. After releasing the resource by customer, the data may remain on the virtual machine.

1.8.2 Platform-as-a-Service (PaaS)

Q. 1.8.6 Explain the PaaS model. (Ref. sec. 1.8.2) **(4 Marks)**

- Platform-as-a-Service provides a readymade runtime environment for different types of applications.
- It also offers various tools regarding development and deployment which are necessary to develop applications.

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- PaaS provides a very important feature of point-and-click tool which is very useful for non-developers to create various types of web applications as per their requirements.
- Examples of PaaS offering vendors :
  - App Engine of Google
  - App Engine Force.com
- Developer can log on to these websites to take help of built-in API for the creation of web-based applications.
- The main disadvantage of using PaaS is that, the developer gets locked in with a specific vendor. For example if an application is created in Python using API of Google and App Engine of Google then it will now can work in that environment only.
- Fig. 1.8.4 illustrates that how PaaS provides an API and development tools to the developers and how it guide the user to access the business applications.

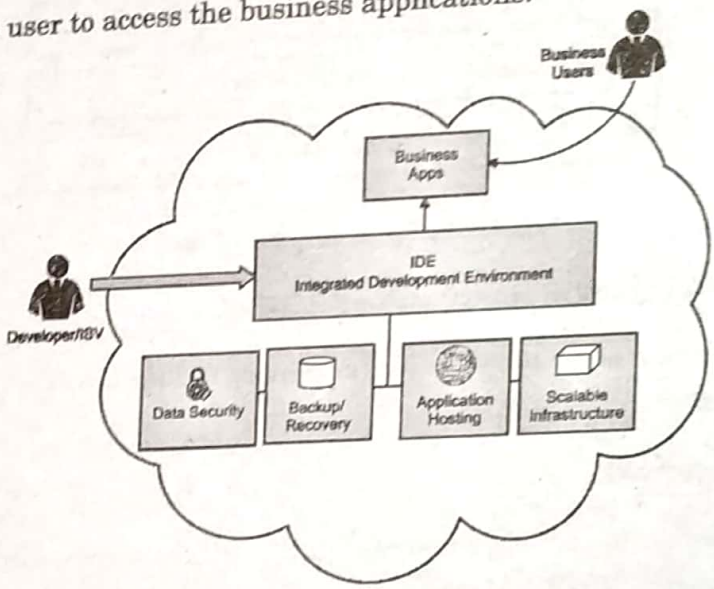

Fig. 1.8.4 : *PaaS*

Advantages of PaaS model

Q. 1.8.7 Explain advantages of PaaS model. (Ref. sec. 1.8.2) **(2 Marks)**

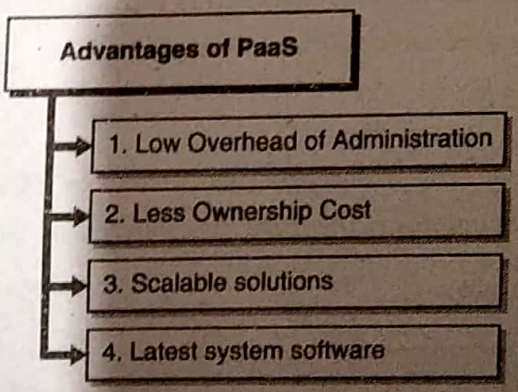

Fig. 1.8.5 : Advantages of PaaS

1. The overhead regarding administration are very low

As administration is the responsibility of cloud provider, it is not headache for customer.

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➜ **2. Overall total cost of ownership is very less**

For the customer, there is no need to purchase expensive hardware, servers, data storage and power.

➜ **3. Scalable solutions are available**

It is very simple and flexible to scale the available resources up or down automatically, depending on their requirement.

➜ **4. Latest system software**

It is the responsibility of the cloud provider to maintain and keep advanced and latest software versions.

☞ **Disadvantages of PaaS**

Q. 1.8.8 Explain the disadvantages of PaaS model. (Ref. sec. 1.8.2) **(2 Marks)**

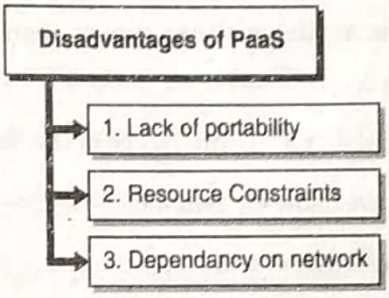

Fig. 1.8.6 : Disadvantages of PaaS

➜ **1. Lack of portability**

Lack of portability between PaaS clouds.

➜ **2. Resource Constraints**

Event based processor scheduling which constitutes resource constraints on the applications, i.e. time limitation to answer a request.

➜ **3. Dependency on network**

PaaS applications are completely reliant on network, hence they have to explicitly use cryptography and manage the upcoming security exposures.

1.8.3 Software-as-a-Service (SaaS)

Q. 1.8.9 Discuss SaaS maturity models. (Ref. sec. 1.8.3) **(5 Marks)**

- This model is basically used to provide software application as a service to the end users. It refers to any specific software which has been deployed on a host server and can be accessed through Internet. There are various types of SaaS applications available which are listed below :
  - Billing and invoicing system

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- Help desk applications
- Customer Relationship Management (CRM) applications
- Human Resource (HR) solutions

- It is not necessary that all the SaaS applications should be customizable, for example Microsoft Office Suite.
- For customized application development, SaaS provides Application Programming Interface (API) to the user.

Characteristics of SaaS

Q. 1.8.10 Write characteristics of SaaS model. (Ref. sec. 1.8.3) **(2 Marks)**

- SaaS makes available various types of software over the Internet.
- Vendor has the responsibility to maintain the software.
- The license of the software is available either subscription based or on usage based. And on the basis of recurring it is charged.
- User do not have any responsibility of maintenance of the software, hence it is cost effective.
- They are anytime anywhere available on demand.
- They can be scaled up or down on demand.
- Automatically up gradation and updation is available. .
- SaaS provides shared data model. Hence, several users can share single instance of infrastructure at a time. There is no need of hard coding for functionality for any specific user.

Advantages of SaaS

Q. 1.8.11 Explain advantages of SaaS model. (Ref. sec. 1.8.3) **(2 Marks)**

- Use of SaaS has proved to be beneficial in terms of scalability, efficiency and performance. Some of the benefits are listed below :

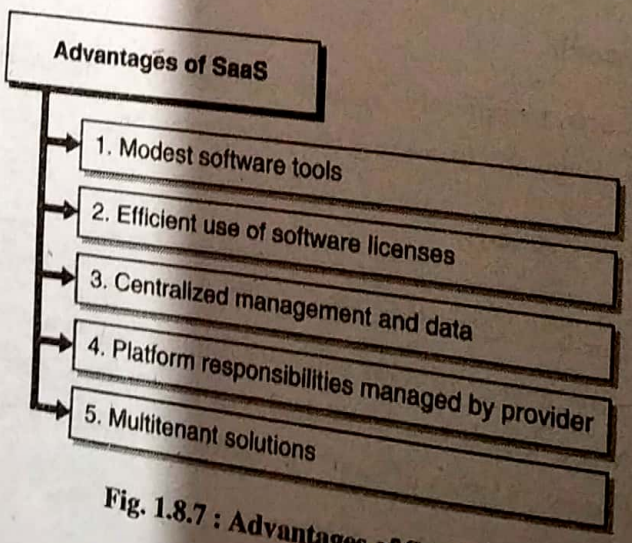

Fig. 1.8.7 : Advantages of SaaS

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→ **1. Modest software tools**

For the SaaS application deployment, there is no need of software installation on client side. This results in the following benefits :

- No need of any complex software packages to be installed at client side.
- Zero risk of configuration at client side.
- Low distribution cost.

→ **2. Efficient use of software licenses**

Single license copy can be used on multiple computers which may be at different locations. This lowers the licensing cost. As well, there is no need of license servers since the software runs in the infrastructure of service provider.

→ **3. Centralized management and data**

The data is saved centrally by the cloud provider. This helps to manage the data effectively. But sometimes to maintain the redundancy and reliability, the data may be in decentralized manner.

→ **4. Platform responsibilities managed by providers**

All platform responsibilities are performed by the cloud provider. These responsibilities include backups of data, maintenance of the system, security, hardware updates, power management, etc. No need for the customer to bother about them.

→ **5. Multitenant solutions**

Multitenant solutions enable several users to share single instance of multiple resources in virtual isolation. It is possible for the customer to customize the application without disturbing the core functionality.

☞ **Disadvantages of SaaS**

Q. 1.8.12 List disadvantages of SaaS model. (Ref. sec. 1.8.3) **(2 Marks)**

1. Browser based risks.
2. Network dependence.
3. Lack of portability between SaaS clouds.

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1.8.4 Comparison between SaaS, PaaS and IaaS

Parameter	SaaS	PaaS	IaaS
Level of control for consumer	As per usage and corresponding configuration.	limited level of administrative.	full level of administrative.
Functionality for consumer	access to front-end user interface.	moderate level of administrative control on available IT resources.	full access to the IT resources.
Common Cloud Consumer Activities	uses and configures the cloud service.	development, deployment, testing , and management of cloud services.	sets up and configures bare infrastructure and do the installation, management, and monitoring of any needed software.
Common Cloud Provider Activities	Does the implementation, management, and maintenance of cloud service monitors usage by the cloud consumers.	pre-configures the platform and make provisions of underlying infrastructure, middleware, and other necessary IT resources, monitors usage by cloud consumers.	Do the provisions and management of the networking, storage, and hosting, monitors usage by the cloud consumers.

Syllabus Topic : Cloud Computing Architecture

1.9 Cloud Computing Architecture

Q. 1.9.1 Write a note on : The fundamental requirements for cloud computing architecture. (Ref. sec. 1.9) ➔ **(Dec. 15, May 16)**

Dec. 15, May 16, 10 Marks

- Cloud Computing architecture comprises of many cloud components, which are loosely coupled.
- It can broadly divided into two fundamental parts :
  1. Front End
  2. Back End
- Each end is connected through a network, usually Internet. The Fig. 1.9.1 shows the graphical view of cloud computing architecture :

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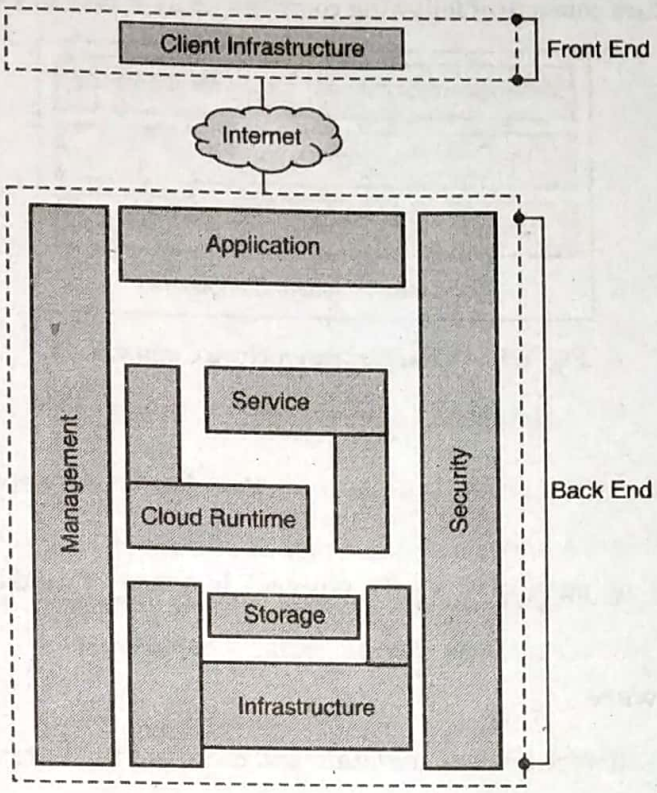

Fig. 1.9.1: Cloud Architecture

1. **Front End**

- The front end refers to the client part of cloud computing system.
- It includes interfaces and applications which are required to access the cloud computing platforms. Example - Web Browser.

2. **Back End**

- The Back End refers to the cloud itself.
- The cloud computing platform consists of large number of resources which are required to provide cloud computing services.
- The cloud infrastructure consists of large data storage, virtual technology, security method, services, deployment models, servers, etc.
- It is the accountability of the back end to provide built-in security mechanism, traffic control and protocols.
- The server offers certain protocols known as middleware so that the connected devices can communicate with each other.

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- Cloud infrastructure consists of following components as shown in Fig. 1.9.2 :

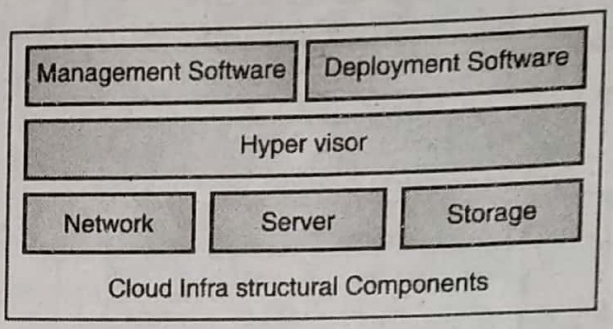

Fig. 1.9.2 : Cloud Infrastructure Components

1. **Hypervisor**

- Hypervisor is a firmware or we can say that it is low-level program which acts as a Virtual Machine Manager.
- It allows sharing of particular single physical instance of cloud resources between several machines.

2. **Management Software**

The management software helps to maintain and configure the infrastructure of the cloud.

3. **Deployment Software**

Deployment software helps to deploy and integrate the different applications on the cloud.

4. **Network**

- It is the main constituent of cloud infrastructure.
- It also connects the cloud services over the Internet.

5. **Server**

- The server helps to figure out the resource sharing and other services such as resource allocation and de-allocation to monitor the resources providing security.

6. **Storage**

- Cloud structure always keeps several replicas of storage.
- Suppose that one of the storage resources fails, then it can be fetched from another one, which makes cloud computing more reliable.

1.9.1 Infrastructural Constraints

- The Fundamental constraints of the cloud infrastructure are shown in the Fig. 1.9.3.

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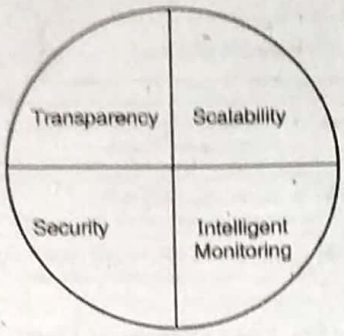

Fig. 1.9.3 : Infrastructure Constraints

1. **Transparency**
   - Virtualization is the main concept to share resources in cloud environment.
   - But it is not difficult to assure the demand with single resource or server. And hence, there must be transparency in resources, load balancing and applications, so that we can scale them on demand.
2. **Scalability**
   - Scaling the whole application delivery solution is difficult task as compared to the scaling of application because it includes the configuration part and sometimes re-architecting the network also required.
   - Hence, application delivery resolution will need to be scalable which requires the virtual infrastructure so that resource can be provisioned and de-provisioned easily.
3. **Intelligent Monitoring**

   For achieving transparency and scalability, application solution delivery will always need to be capable of intelligent monitoring.
4. **Security**
   - The data center in the cloud should be securely architected.
   - Also the control node, an entry point in data center, also needs to be secure.

Syllabus Topic: Advantages of Cloud Computing

1.10 Advantages of Cloud Computing

➔ **(MU - May 17)**

The common benefits of Cloud computing are :

Q. 1.10.1 Define advantages of Cloud computing. (Ref. sec. 1.10)	May 17, 8 Marks

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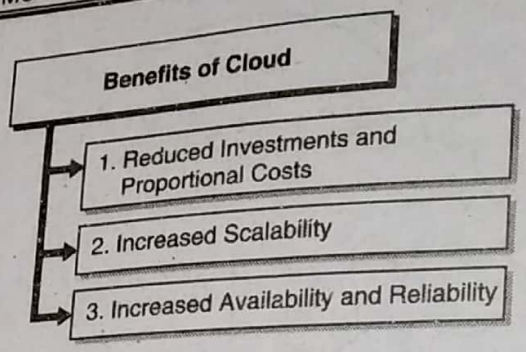

Fig. 1.10.1 : Benefits of Cloud

- **Public Cloud :** In this cloud, general public can access systems and services easily.
- **Private Cloud :** In this cloud the systems and services are accessible within the organizati only.

1. Reduced Investments and Proportional Costs

Q. 1.10.2 Explain the term Reduced Investment and Proportional Cost. (Ref. sec. 1.10(1)) **(2 Marks)**

- Shopping Malls purchase products in bulk with lower prices from companies and make the available to general public in lower prices. Using the same logics, the public cloud provide purchase IT resources in bulk with lower prices and make them available to consumer companies with attractive low priced leasing packages.
- This opens the door for various small scale organizations to gain access to costly stron infrastructure without any need to purchase it.
- For the consumer organizations, the main goal of taking cloud service is to reduce the up-front I investments, for example hardware and software purchases and also the ownership costs.
- Use of cloud replaces the anticipated higher capital expenditures by the lower operationa expenditures.
- This helps to eliminate or minimize the up-front financial costs and allows enterprise owners t start small and accordingly increase IT resource allocation as per the requirement. The saved cos can be redirected to the core business investment.
- In its most basic form, chance to minimize costs are derived from the process of deployment and operation of large-scale data centres by the various major providers of cloud.
- Usually these data centres are deployed in such destinations where availability of IT professionals, network bandwidth, and offices are available at low cost which helps to support both capital and operational savings.
- The same principle is applied to operating systems, middleware or platform software, and application software. Pooled IT resources are made available which can be utilized by the various cloud consumers to implement maximum possible utilization.

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☞ **Common measurable benefits to cloud consumers**

- On-demand access - pay-as-you-go to various types of IT resources on a short-term basis (For example processors by the hour), and the capacity to release these IT resources when there is no longer any need.
- The feeling of unlimited computing resources availability, thereby avoiding the requirement to prepare for provisioning.
- At a fine-grained level it is possible to add or remove the cloud based IT resources, such as updating existing storage disk space by increment of say five gigabytes.
- Infrastructure is abstracted; hence applications are not locked into devices or locations which keep the option open to move the business anytime anywhere.

➜ 2. Increased Scalability

Q. 1.10.3 Explain the term Increased Scalability. (Ref. sec. 1.10(2)) **(2 Marks)**

- Cloud provides pools of IT resources with the support of technologies which can control them collectively. The IT resources can be instantly and dynamically allocated as per the requirement.
- This allows the cloud consumers to scale their cloud-based IT resources to manage the fluctuations in processing and access these resources automatically or manually. In the same manner, it is possible to release cloud-based IT resources automatically or manually if there is decrease in processing demand.
- A simple example of fluctuations in the usage demand in one day is provided in Fig. 1.10.2.
- The built-in feature of clouds to provide flexible option of scaling of IT resources gives effective and proportional cost benefit.

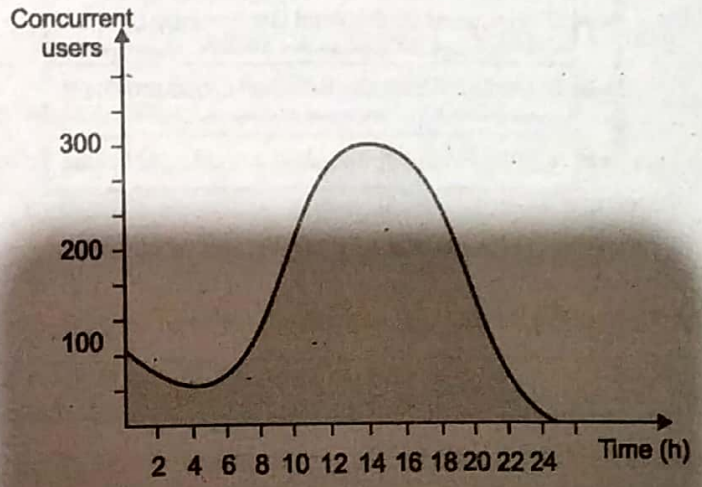

Fig. 1.10.2 : Fluctuations in usage demand

- Besides the financial benefit, it also increase the ability of business to fulfill the unpredictable usage demands of IT resources which avoids a potential loss which may occur because of lack of this ability.

➜ 3. Increased Availability and Reliability

Q. 1.10.4 Explain the term "Increased Availability and Reliability". (Ref. sec. 1.10(3)) **(2 Marks)**

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- The profit of business is completely depends upon the availability and reliability of IT resou If any IT resource is not available then it's unavailability for customers may affect the reve generation of the business. Also runtime failure of any IT resource during high level usage pe may lead to some loss. These issues affect the service provided to the customers.
- The main advantages of cloud based environment is its intrinsic ability to give extensive supp for increasing the availability of IT resource to decrease or even remove outages.
- For improving its reliability so as to decrease the effect of various runtime failure conditions.
- A cloud based IT resource can be accessible for longer periods of time. For example near about hours in a day.
- A cloud based IT resource having increased reliability is able to better avoid and recover in fail condition. The cloud environments have modular architecture which provides a strong failo support to enhance the reliability.

Syllabus Topic : Disadvantages of Cloud Computing

1.11 Disadvantages of Cloud Computing

Though Cloud computing seem to be very useful, it has some challenges also which the clo consumers may have to face. These risks challenges are explained here.

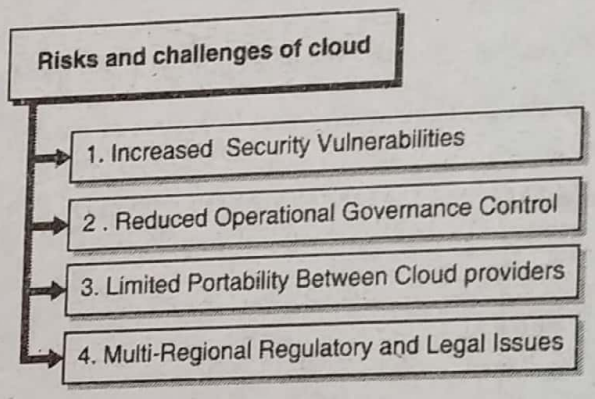

Fig. 1.11.1 : Risks and challenges of cloud

➔ 1. Increased Security Vulnerabilities

Q. 1.11.1 Explain the term "Increased security Vulnerability". (Ref. sec. 1.11(1)) **(2 Marks)**

- When important business data is shifted to cloud, the concern of security get arise. The usage of various IT resources remotely needs a strong trust by the cloud consumer to involve the external cloud. It is little bit complicated to establish such a strong security architecture without introducing vulnerabilities, unless both the cloud consumers as well as providers support the same or compatible security frameworks which is mostly difficult with public clouds.
- Another aspect regarding security is the privileged access of cloud provider to business data of cloud consumer. The level of security is now restricted to the security controls and policies implemented by both the cloud consumer as well as provider. As the cloud provides sharing feature, the security of consumer data is in trouble.

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CHAPTER 2

Module II

Virtualization

Syllabus Topics

Virtualization : Characteristics of virtualized environment, Understanding the importance of Hypervisors, Type I & Type II Hypervisors, Taxonomy of virtualization, Implementation Levels of Virtualization, Virtualization of CPU, Memory and I/O Devices, Virtualization and Cloud Computing, Pros and Cons of virtualization, Technology Examples : KVM, Xen, Vmware and HyperV.

Syllabus Topic : Virtualization

2.1 Virtualization

➔ **(MU - Dec. 15, May 16, Dec. 16, May 17, Dec. 17)**

Q. 2.1.1	What is virtualization? (Ref. sec. 2.1)	Dec. 15, May 17, 2 Marks
Q. 2.1.2	Explain benefits of virtualization? (Ref. sec. 2.1)	May 16, 5 Marks
Q. 2.1.3	What is the need of virtualization? (Ref. sec. 2.1)	Dec. 16, 4 Marks
Q. 2.1.4	Explain is the need of virtualization in the context of cloud computing. (Ref. sec. 2.1)	Dec. 17, 5 Marks

☞ ***Definition***

*In computing, **virtualization** refers to the act of creating a virtual (rather than actual) version of something, including virtual computer hardware platforms, storage devices, and computer network resources.*

- Virtualization which is considered as a state-of-art technology is now a great advantage for an IT industry which allows performing more with less.
- The most important goal of virtualization is to centralize the important as well as administrative tasks with parallel management of scalability and work load.
- There are several reasons which show the need of virtualization. These are as follows :

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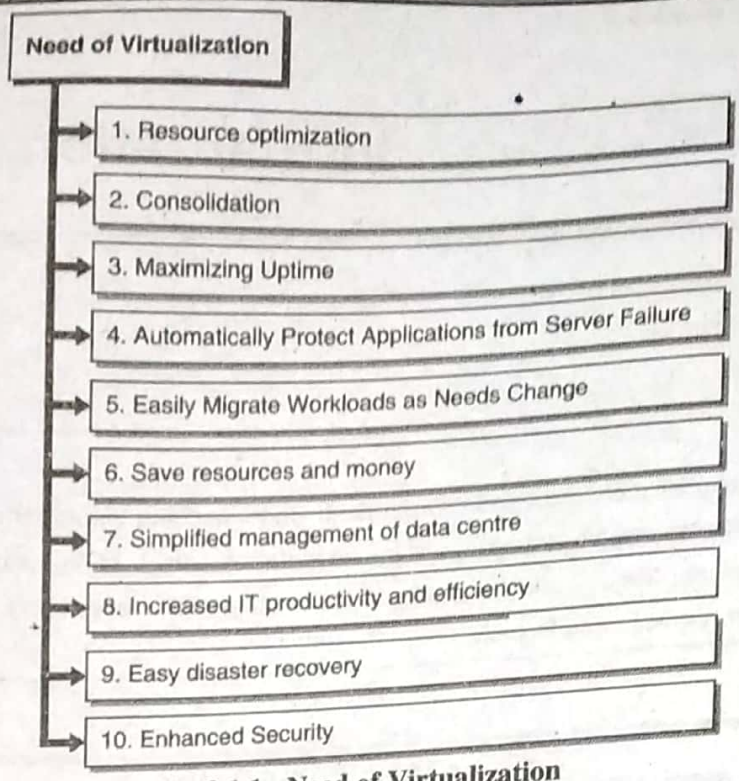

Fig. 2.1.1 : Need of Virtualization

1. Resource optimization

- Now a day, the computer resources are very powerful with excess capacity. The hardware allocating parts of it can be virtualized depending upon the actual requirements of users applications. This leads to much more effective use of available computing power, storage sp as well as the network bandwidth.
- In this case the computers no longer required to be idle or performing lower than th capabilities.
- Isolated, constrained and test environments are made available to software developers by Virtual machines. Instead of buying dedicated physical hardware, virtual machines can generated on the available hardware.

2. Consolidation

- Usually individual computers are dedicated to a single application. If small amount of process power is used by the several applications, then it is possible to consolidate multiple compu into single server executing several virtual environments.
- In case of organizations which needs thousands of servers, consolidation can effectively minim the requirement of floor space, HVAC, A/C power as well as the co-location resources. This le to significant decrease in cost of ownership, as less physical servers, floor as well as rack sp are needed.

3. Maximizing Uptime

- Agility is the capacity to respond to frequently changing requirements in a quick and flexi manner.
- Virtualization provides new openings to data center administration, which allow users to have

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- Assured uptime of servers and applications; very fast disaster recovery in case of large scale failures.
- Template images helps to deploy new virtual machines as well as aggregated pools of virtual machines
- Elasticity ; On demand provision of resources.
- Reconfiguration of computing environments which are executing without affecting the users.

➜ **4. Automatically Protect Applications from Server Failure**

- Virtualization helps to implement redundancy without any need to buy additional hardware. Redundancy, is the mechanism of running single application on several servers, is a safety measure: if there is failure of server. Another server which is executing the same application takes the control by itself, which avoids the interruption in service. In Virtual machines, such type of redundancy works in two ways :
- In case of failure of one virtual system, another virtual system takes over.
- Against physical hardware failure, better protection can be provided by running the redundant virtual machines on different physical hardware.

➜ **5. Easily Migrate Workloads as Needs Change**

- Migration means shifting the server environment to another location. In virtualization, it is easy to move a virtual machine from one physical machine to another physical machine.
- In case of physical servers, this migration is possible only if both physical machines are running on the common hardware, operating system and processor.
- In the virtual world, the migration of server is possible in between physical hosts which may have completely different hardware configurations.
- The purpose of migration is to improve reliability as well as availability in case of failure in the hardware, it is possible to move the guest system c to a healthy server with limited downtime, if any.
- It is also helpful in the situation when a virtual machine is required to scale beyond the physical capabilities of the existing host.

➜ **6. Save resources and money**

Profit is the most important aspect of any organization. Saving expenses can also be termed as profit. Virtualization minimizes or may completely omit the need of maintaining servers, desktop and data storage machines. Hence all the costing which may be required for the maintenance of these multiple resources is directly cut down.

➜ **7. Simplified management of data centre**

Just by managing few resources, virtualization helps to handle huge amount of data. There is no need to manage multiple hard drives and data cables.

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➜ **8. Increased IT productivity and efficiency**

Now without any hassle as well as wariness of IT management for big firms, all advancements in technical and software areas can be implemented with more efficiency.

➜ **9. Easy disaster recovery**

If any event regarding system crash occurs, then with virtualization it is very simple to detect loophole because of the simplification of network or data system in just 2-3 layers instead complicated web of hard wires and connection.

➜ **10. Enhanced Security**

As the level of complexity is dropped, the security level enhancement is easy to implement effectively.

Syllabus Topic : Characteristics of Virtualized Environment

2.2 Characteristics of Virtualized Environment

Q. 2.2.1 Explain Characteristics of Virtualized Environment. (Ref. sec. 2.2) (10 Marks)

- Virtualization is a practically considered as a very broad concept which is related with generation of a virtual version of some entity such as hardware, a software environment, stora or a network.
- In the environment of virtualization three components are important : guest, host, virtualization layer.
- The guest corresponds to the system component which communicates with the virtualiza layer instead of the host, as would usually happen.
- The host corresponds to the original environment in which the guest should be managed.
- The virtualization layer has the responsibility to regenerate the similar or a differ environment in which the guest will operate.
- This type of general abstraction encounters several applications and then implementations of respective virtualization technology.
- Hardware virtualization is used to represent the most intuitive as well as popular environm which also comprise the original realization of the virtualization concept.
- In the context of hardware virtualization, system image is used to represent the guest. T image constitutes an OS and installed applications.
- Installation of these elements is done on the top of virtual hardware which is controlled managed by the respective virtualization layer, which is also known as the virtual mach manager.
- Physical hardware represents the

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Syllabus Topic : Type I & Type II Hypervisors

2.3.1 Type I & Type II Hypervisors

→ **(MU - Dec. 17)**

Q. 2.3.1 Compare Type 1 and Type 2 Virtualization. (Ref. sec. 2.3.1) **Dec. 17, 4 Marks**

- **There are two types of hypervisors**

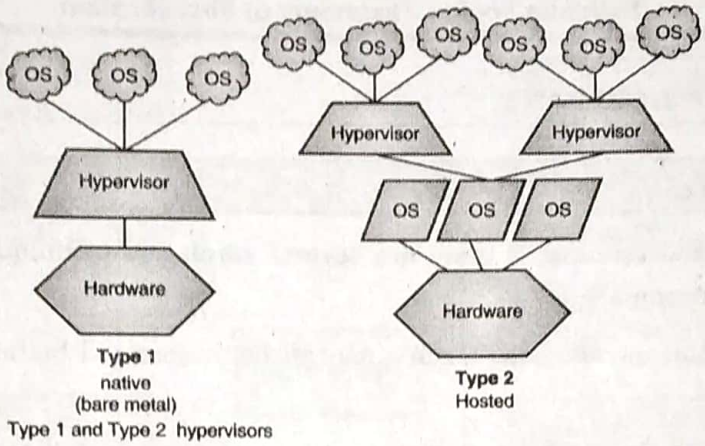

Fig. 2.3.2 : Types of Hypervisors

- **Type-1, native or bare-metal hypervisors : Features**
  - Type-1 Hypervisor is also called as Bare Metal or Embedded or Native Hypervisor.
  - It works directly on the hardware of the host and can monitor operating systems that run above the hypervisor.
  - It is totally independent of the Operating System.
  - The size of this hypervisor is small because its main function is to share and manage hardware resources between various operating systems.
  - A major advantage in using Type-1 hypervisor is that any problems occurred in one virtual machine or guest operating system are not going to affect the other guest operating systems running on the hypervisor.
- **Examples**
  (i) VMware ESXi Server
  (ii) Microsoft Hyper-V
  (iii) Citrix/Xen Server
- **Type-2 or hosted hypervisors : Features**
  - Type-2 Hypervisor is also known as Hosted Hypervisor.
  - These hypervisors run on a conventional operating system (OS) just as other computer programs do. A guest operating system runs as a process on the host. Type-2 hypervisors abstract guest operating systems from the host operating system.
  - It is totally depends upon the host Operating System for its operations.

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- If any problems arise in the base operating system, then it affects the entire system.

Examples

(i) VMware Workstation

(ii) Microsoft Virtual PC

(iii) Oracle Virtual Box

Syllabus Topic : Taxonomy of Virtualization

2.4 Taxonomy of Virtualization

Q. 2.4.1 Write a note on Taxonomy of virtualization. (Ref. sec. 2.4) **(10 Marks)**

- In the context of virtualization there are several emulation techniques which are applicable different areas of computing.
- Characteristics and use of those techniques can be understood better by the way of classifying them.
- The initial classification is based upon the service or entity which is being emulated.
- The main aim of virtualization is to emulate execution environments, storage, as well networks.
- In those categories, the execution virtualization consists of the most previous, most admired, most developed area.
- Hence, there is need of key investigation and advanced categorization. Specifically it is possible divide these execution virtualization techniques into two broad categories by taking consideration the type of host they need.
- The implementation of **Process-level techniques** is done on the top of present OS, which complete control of the hardware.
- The implementation of **System-level techniques** is done straightforwardly on hardware and not need or need a very small amount of support from an existing OS.
- Under those two categories it is possible to list several techniques which offer the guest another type of virtual computation environment: bare hardware, OS resources, low-level programming language, and application libraries.

2.4.1 Execution Virtualization

- In Execution virtualization there exist all the techniques which aspire to emulate an execution environment which is independent from the one which has been hosting the virtualization layer.
- The main aim of all these techniques is to provide support for the programs execution. The programs may be OS, a binary specification of a program, or
- Hence it is possible to

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- Hardware virtualization is not the same as hardware emulation. In hardware emulation, a piece of hardware imitates another, while in hardware virtualization, a hypervisor (a piece of software) imitates a particular piece of computer hardware or the entire computer.
- Furthermore, a hypervisor is not the same as an emulator; both are computer programs that imitate hardware, but their domain of use in language differs.

Syllabus Topic: Implementation Levels of Virtualization

2.5 Implementation Levels of Virtualization

→ (MU - May 17, Dec. 17)

Q. 2.5.1	What are the levels used for virtualization? (Ref. sec. 2.5)	May 17, 5 Marks
Q. 2.5.2	List the implementation level of Virtualization.(Ref. sec. 2.5)	Dec. 17, 10 Marks

- Usually any traditional computer runs under the control of its operating system which basically tailored for its hardware architecture. (Refer Fig. 2.5.1)
- After the implementation of virtualization, various user applications which are handled by their own operating systems (called as guest OS) can be executed on the same hardware, independent of the host OS.
- This is usually implemented by introducing additional software, called a virtualization layer as shown in Fig. 2.5.3. This virtualization layer is called as **hypervisor** or VMM (virtual machine monitor).
- The VMs are displayed in the boxes at top position, where applications execute with their own guest OS over the virtualized CPU, memory, and I/O resources.

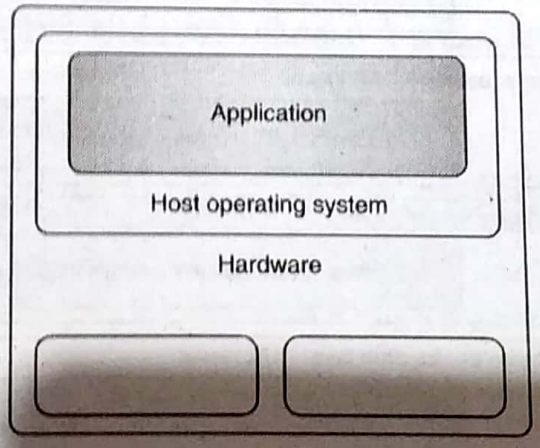

Fig. 2.5.1 : Traditional Machine

- The important functionality of the software layer in the process of virtualization is to virtualize the physical hardware owned by the host machine in the form of virtual resources to be utilized by the VMs.

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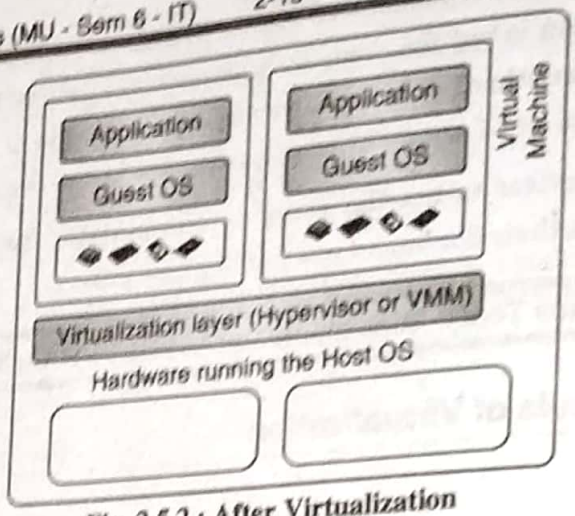

Fig. 2.5.2 : After Virtualization

- This functionality is implemented at different operational levels. The virtualization soft generates the abstraction of VMs by inserting a virtualization layer at different levels computer system.
- Usually the virtualization layers includes following levels :
  - Instruction set architecture (ISA) level
  - Hardware level
  - Operating system level
  - Library support level
  - Application level.

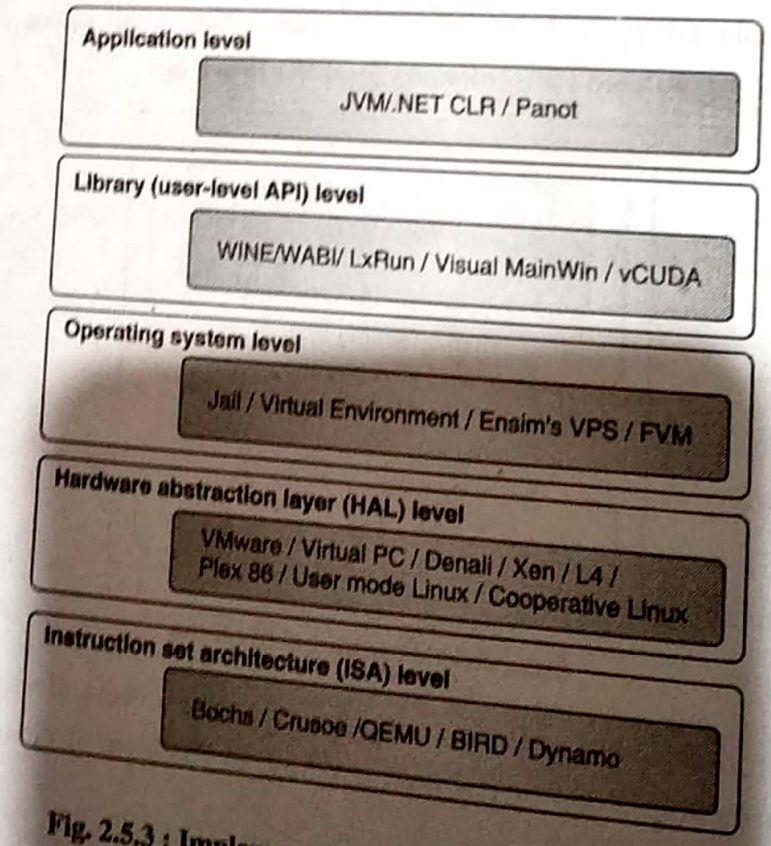

Fig. 2.5.3 : Implementation Levels of Virtualization

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1. **Instruction Set Architecture Level (ISA)**

- In the ISA level, the given ISA is emulated by the ISA of the host machine to carry out the virtualization. For example, we can execute MIPS binary code on an x86-based host machine by the use of ISA emulation.
- This approach helps to execute plenty of legacy binary code which is written for various processors on any given new hardware host machine. The virtual ISAs are generated on any hardware machine by the Instruction set emulation.
- Code interpretation is the basic mechanism for emulation. The source code is interpreted one by one by the interpreter program. To perform its function, there may be need of hundreds of native target instructions for a single source instruction. Hence this process is relatively slow.
- Dynamic binary translation is required for the better performance. The basic blocks of dynamic source instructions are translated to target instructions.
- For increasing the efficiency, it is also possible to extend the basic block to program traces or super blocks.
- There is need of binary translation and optimization for the emulation of instruction set. In this way, virtual instruction set architecture (V-ISA) needs inclusion of a processor-specific software translation layer to the compiler.

2. **Hardware Abstraction Level**

- Hardware-level virtualization process is carried out right on top of the bare hardware. With the help of this approach, two things can be achieved; first a virtual hardware environment is generated for a VM and second underlying hardware can be managed through virtualization.
- The main aim of this approach is to virtualized different resources of a computer like its processors, memory, and I/O devices. It can lead to up gradation of hardware utilization rate by the multiple users simultaneously.

3. **Operating System Level**

Q. 2.5.3 Write a short note on OS level of virtualization. (Ref. sec. 2.5(3)) (2 Marks)

- This approach basically refers to an abstraction layer among traditional OS and the user applications. Isolated containers are created on a single physical server by the Operating System level virtualization.
- It also creates OS instances which are used to utilize the hardware and software available in data centres.
- The behaviour is just like as they are real servers. The Operating System level virtualization is generally used in the creation of virtual hosting environments for the purpose of allocating hardware resources among a large number of mutually distrusting users.
- Rarely it can also be used for consolidation of server hardware by shifting services on separate hosts into various types of containers or VMs on one server.

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4. **Library Support Level**
   - Mostly applications use APIs which are exported by user-level libraries instead of lengthy calls by the OS. As there are well-documented APIs in most of the systems, they can be an interface for virtualization.
   - Virtualization using library interfaces is achievable by controlling the communication between applications and the rest of a system. This is done with the help of API hooks approach is implemented by the software tool WINE for the support of Windows applications top of UNIX hosts.

5. **User-Application Level**

Q. 2.5.4 Write a short note on application level of virtualization. (Ref. sec. 2.5(5)) (2 Marks)

- In the User-Application Level approach, an application is virtualized as a VM. Usually application executes as a process on traditional OS. Hence the User-Application virtualization is also called process-level virtualization.
- In User-Application Level, the virtualization layer resides as an application program on top of OS. This layer exports an abstraction of a VM which can execute applications written compiled for specific abstract machine definition.
- Any program which is written in the High Level Languages and compiled for this VM can executed on it. Two good examples are; Microsoft .NET CLR and Java Virtual Machine (JVM).

Syllabus Topic : Virtualization of CPU, Memory and I/O Devices

2.6 Virtualization of CPU, Memory and I/O Devices

Q. 2.6.1 Explain CPU, Memory and I/O virtualization techniques in cloud computing. (Ref. sec. 2.6) (10 Marks)

- For supporting the concept of virtualization, processors like x86 uses a special running mode instructions, called as hardware-assisted virtualization.
- The Virtual Machine Manager (VMM) and guest OS are executed in different modes. The VMM traps all the sensitive instructions of the guest OS and its applications.
- Hardware completes the mode switching to the save processor states.

2.6.1 Applications of Virtualization

Q. 2.6.2 Explain applications of virtualization. (Ref. sec. 2.6.1) (5 Marks)

Virtualization can be applied broadly to just about everything that you could imagine :

- Hardware
- Memory
- I/O
- Networks
- Storage
- Operating systems

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Syllabus Topic: Pros and Cons of Virtualization

2.8 Pros and Cons of Virtualization

→ (MU - Dec. 15)

Pros of virtualization

Q. 2.8.1 What are benefits of virtualization? (Ref. sec. 2.8) **Dec. 15, 6 Marks**

– Benefits of virtualization are categorized as follows :

Benefits for Companies

1. Removal of special hardware and utility requirements.
2. Effective management of resources.
3. Increased employee productivity as a result of better accessibility.
4. Reduced risk of data loss, as data is backed up across multiple storage locations.

Benefits for Data Centers

1. Maximization of server capabilities, thereby reducing maintenance and operation costs.
2. Smaller footprint as a result of lower hardware, energy and manpower requirements.

Cons of Virtualization

Q. 2.8.2 Discuss undesirable effects of virtualization. (Ref. sec. 2.8) **(6 Marks)**

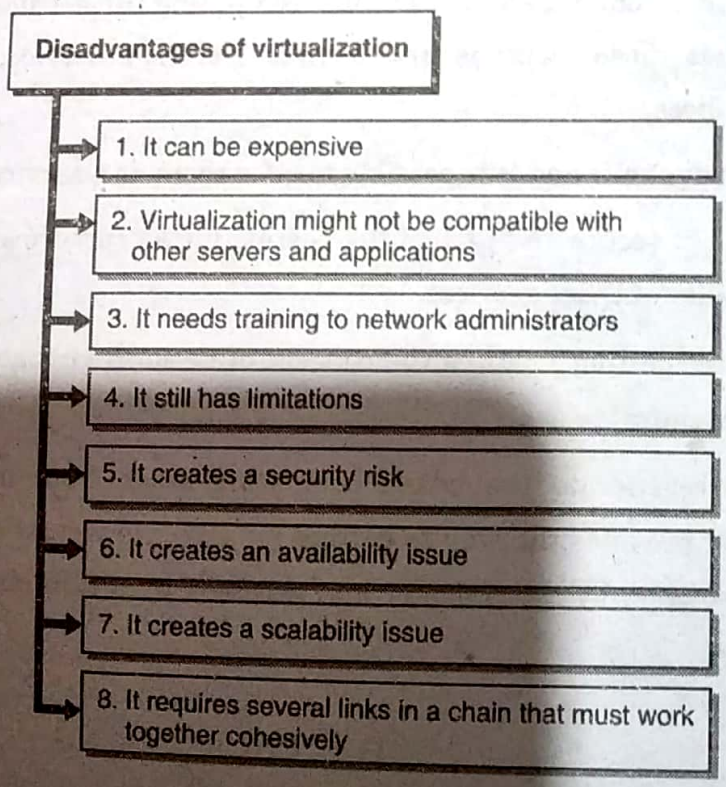

Fig. 2.8.1 : Disadvantages of virtualization

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1. It can be expensive

One of the important things in case of virtualization is the cost. Virtualization can be quite a pricey investment upfront. For installing the virtual server one-time heavy investment is required which is more than the cost of a traditional server.

2. Virtualization might not be compatible with other servers and applications

This is another drawback of virtualization. It may be possible that not all servers and applications are virtualization friendly. This can be a big headache when an investment has already been made on number of servers or if the software used in the business process is not an upgraded version which allows for virtualization.

3. It needs training to network administrators

Another drawback of virtualization is the necessity to spend for training purpose of the network administrator which is an additional expense.

4. It still has limitations

It is not possible that all applications or servers can work within an environment of virtualization. Hence there is need of hybrid environment to function properly. Since not all the vendors support virtualization and few may stop supporting it later on, there is always a level of uncertainty to implement this system completely.

5. It creates a security risk

In virtualization system, sometimes the maintaining security of data gets difficult.

6. It creates an availability issue

It is little bit uncertain that every time there will be availability of resources, hence at crucial point if resources not get available, then it affect work efficiency as well as the credential of company.

7. It creates a scalability issue

Sudden demand or access of large number of virtualized resources by ay growing business may affect the availability of resources for other small businesses.

8. It requires several links in a chain that must work together cohesively

There is need of proper functioning of all the links in a chain of virtualization otherwise simple task like saving file may also become tedious for user.

Syllabus Topic : Technology Examples - KVM, Xen, Vmware and HyperV.

2.9 Technology Examples - KVM, Xen, Vmware and HyperV.

In this section we are going to learn some technology examples such as KVM, Xen, Vmware and HyperV.

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- Xen is an open source hypervisor program which is developed by Cambridge University.
- Xen hypervisor is of type microkernel, which is used to separate the policy from the mechanism.
- All the mechanisms are implemented by the Xen hypervisor, and policy handling is the responsibility of Domain 0 as shown in Fig. 2.9.3.

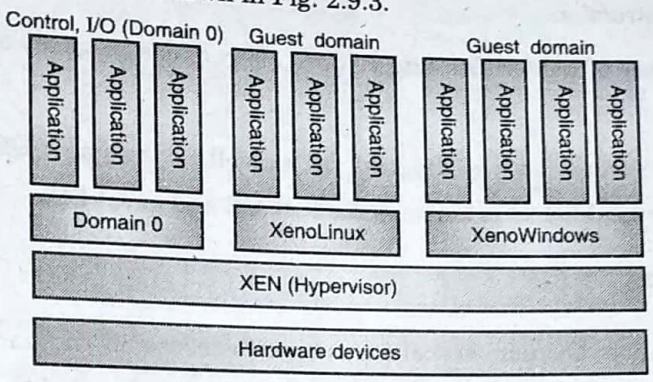

Fig. 2.9.3 : Xen Architecture

- In Xen, no device drivers are included natively. Just a mechanism is provided by Xen with the help of which the guest OS can have direct access to the physical devices. This helps to keep the size of Xen hypervisor effectively small.
- A virtual environment is provided by Xen between the hardware and the OS.
- Now a day there are number of vendors who are in process of developing commercial Xen hypervisors. Some of them are Citrix XenServer and Oracle VM.
- The most important components of a Xen system are considered as the hypervisor, kernel, and applications. These three components should be organized in proper manner.
- Like different virtualization systems, number of guest operating systems can be executed on top of the hypervisor. However, not all guest operating systems are created with similar functionality, and one in particular situation can control the others.
- The guest OS, which can control other operating systems is known as Domain while the others are known as Domain U.
- Domain 0 is considered as a privileged guest OS of Xen. Initially Domain 0 is loaded when Xen boots without the availability of any file system drivers.
- The basic aim behind design of Domain 0 is to access hardware directly as well as manage devices. Hence allocating and mapping hardware resources for the guest domains (Domain-U) is responsibility of Domain 0.

2.9.3 Vmware

Q. 2.9.3 What is Binary translation with full virtualization? (Ref. sec. 2.9.3) (10 Marks)

- Hardware virtualization can be classified into two categories based on the implementation technologies : full virtualization and host-based virtualization.

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