- The hybrid cloud model relies on internal IT infrastructure, so it is necessary to ensure redundancy in data centers.

1.11.4 Community Cloud

- The community cloud model enables multiple organizations within the same community or region to share the same cloud environment or cloud systems or cloud services.
- The cloud service shares between different organizations and companies that belong to the same community with similar concerns.
- It can be managed either by third parties or internally.
- Organizations with similar computing concerns and shared interest may share it.
- This type of cloud computing is best appropriate for enterprises, business organizations, tenders and research organizations.
- It benefits the users of Community Cloud to be aware, understand and analyze business needs and demands. The community cloud can be present at either onsite or offsite.
- The example of a community cloud is where there are organizations / firms with financial institutions / banks.

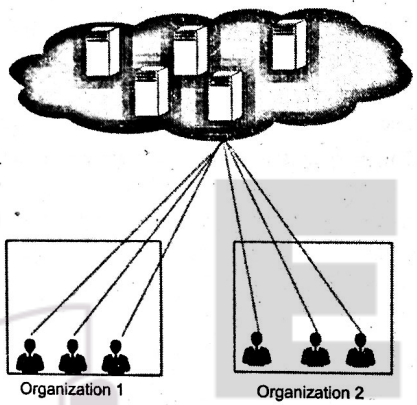

Fig. 1.11.5 : Community Cloud

1.11.4.1 Advantages of Community Cloud

- It is cost effective
- Community cloud is more secure than public cloud but less secure as compare to private cloud.

1.11.4.2 Disadvantages of Community Cloud

- Privacy concerns when multiple organizations share data.
- Allocation of responsibility is also challenging.

Chapter Ends...

❑❑❑

Virtualization

University Prescribed Syllabus

Characteristics of Virtualized Environments. Taxonomy of Virtualization Techniques. Virtualization and Cloud Computing. Pros and Cons of Virtualization. Virtualization using KVM, Creating virtual machines, oVirt - management tool for virtualization environment. Open challenges of Cloud Computing.

2.1 Introduction to Virtualization

GQ. 2.1.1 What is virtualization and what are its benefits ?

UQ. 2.1.2 What is virtualization ? Give the major causes of diffusion of virtualization. **(MU - April 19, 5 Marks)**

UQ. 2.1.3 What are the benefits of virtualization in the context of cloud computing ? **(MU - April 19, 5 Marks)**

- 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 is a large umbrella of technologies and concepts that are meant to provide an abstract environment whether virtual hardware or an operating system to run applications.
- Virtualization technologies provide a virtual environment for not only executing applications but also for storage, memory, and networking.
- So, its inception, virtualization has been sporadically explored and adopted, but in the last few years there has been a consistent and growing trend to leverage this technology.
- This technology have gained renewed interested recently due to the confluence of some phenomena:
  (a) Increased performance and computing capacity. Almost all these PCs have resources enough to host a virtual machine manager and execute a virtual machine with by far acceptable performance. Nowadays, the average end-user desktop PC is powerful enough to meet most the requirements of everyday computing, with extra capacity that is rarely used.
  (b) Underutilized hardware and software resources. Hardware and software underutilization are occurring due to first increased performance and computing capacity, and second the effect of limited or sporadic use of resources.
  (c) Lack of space. The continuous need for additional capacity, whether storage or compute power, makes data centers grow quickly.
  (d) Greening initiatives. Recently, companies are increasingly looking for ways to reduce the amount of energy they consume and to reduce their carbon footprint.
  (e) Rise of administrative costs. Power consumption and cooling costs have now become higher than the cost of IT equipment. Virtualization can help reduce the number of required servers for a given workload, thus reducing the cost of the administrative personnel.

Benefits of Virtualization

- Increase IT agility, flexibility and scalability whereas creating significant cost savings.
- Greater workload mobility, raised performance and availability of resources, automated operations.
- Reduced capital and operating prices.
- Minimized or eliminated downtime.
- Increased IT productivity, efficiency, agility and responsiveness.

- Faster provisioning of applications and resources.
- Greater business continuity and disaster recovery.
- Simplified data center management.
- Availability of a real Software-Defined Data Center.

2.1.1 Virtualization Basics

- A virtual machine is a software computer that, like a physical computer, runs an operating system and applications.
- The hypervisor serves as a platform for running virtual machines and allows for the consolidation of computing resources.
- Each virtual machine contains its own virtual, or software-based, hardware, including a virtual CPU, memory, hard disk, and network interface card.
- **Example :** A virtual machine can be moved from one physical host to another, or its virtual disks can be moved from one type of storage to another, without affecting the functioning of the virtual machine.
- So, virtual machines are decoupled from specific underlying physical hardware, virtualization allows you to consolidate physical computing resources such as CPUs, memory, storage, and networking into pools of resources that can be dynamically and flexibly created available to virtual machines.
- With appropriate management software, such as vCenter Server, you can also use a number of features that increase the availability and security of your virtual infrastructure.

2.1.2 Virtualization Approaches

- Virtualization has been a part of the IT landscape for decades, it is only recently (in 1998) that VMware delivered the benefits of virtualization to industry-standard x86-based platforms, which now type the majority of desktop, laptop and server shipments.
- A key benefit of virtualization is the ability to run multiple operating systems on a single physical system and share the underlying hardware resources is called as partitioning.
- Virtualization can apply to a range of system layers, including hardware-level virtualization, operating system level virtualization, and high-level language virtual machines.
- Hardware-level virtualization was pioneered on IBM mainframes in the 1970s, and then more recently Unix/RISC system vendors began with hardware-based partitioning capabilities before moving on to software-based partitioning.
- In contrast, a hypervisor hypervisor architecture is the first architecture is the first layer of software installed on a clean x86-based system.
- So it has direct access to the hardware resources, a hypervisor is more efficient than hosted architectures, enabling greater scalability, robustness and performance.

2.1.3 Characteristics of Virtualized Environments

GQ. 2.1.4 What are the characteristics of virtualized environments ?

Following are the Characteristics of Virtualization :

1. Increased security

- The ability to control the execution of a guest in a completely transparent manner opens new possibilities for delivering a secure, controlled execution environment.
- The virtual machine represents an emulated environment in which the guest is executed.
- All the operations of the guest are generally performed against the virtual machine, which then translates and applies them to the host. This is the level of indirection allows the virtual machine manager to control and filter the activity of the guest, thus preventing some harmful operations from being performed.
- Resources exposed by the host can then be hidden or simply protected from the guest.
- Increased security is a requirement when dealing with untrusted code.

2. Managed execution

- In particular, sharing, aggregation, emulation, and isolation are the most relevant features.
- See in following Fig. 2.1.1.

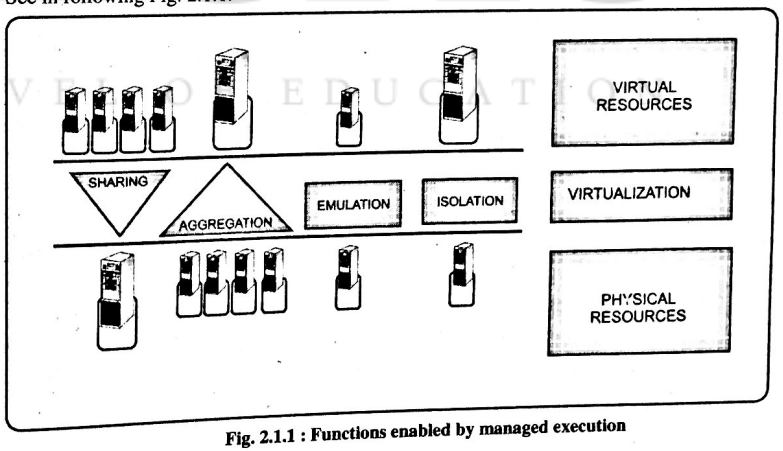

Fig. 2.1.1 : Functions enabled by managed execution

(a) Sharing

- Virtualization allows the creation of separate computing environments within the similar host.
- Sharing is a particularly feature in virtualized data centers, where this basic feature is used to reduce the number of active servers and limit power consumption.

- **(b) Aggregation**
  - Not only is it possible to share physical resource among several guests, but virtualization also allows aggregation, that is the opposite process.
  - This function is naturally implemented in middleware for distributed computing, with a classical example represented by cluster management software, which harnesses the physical resources of a homogeneous group of machines and represents them as a single resource.
- **(c) Emulation**
  - Guest programs are executed in an environment that is controlled by the virtualization layer, which ultimately is a program.
  - This is allows for controlling and tuning the environment that is exposed to guests.
- **(d) Isolation**
  - Virtualization allows providing guests, whether they are operating systems, applications, or other entities with a completely separate environment, in which that they are executed.
  - Isolation brings several benefits, for instance, first is it allows multiple guests to run on the same host without interfering with each other. Second, it provides a separation between the host and the guest.

3. Portability

- The concept of portability applies in various ways according to the specific type of virtualization considered.
- In the case of a hardware virtualization solution, the guest is packaged into a virtual image which, in most cases, can be safely moved and executed on top of different virtual machines.
- Except for the file size, this happens with the same simplicity with which we can display a picture image in different computers.
- Virtual images are generally proprietary formats that require a specific virtual machine manager to be executed.
- In the case of programming-level virtualization, as implemented by the JVM or the .NET runtime, the binary code representing application components (jars or assemblies) can be run without any recompilation on any implementation of the corresponding virtual machine.

2.2 Taxonomy of Virtualization Technique

GQ. 2.2.1 Discuss classification or taxonomy of virtualization at different levels.

UQ. 2.2.2 Discuss classification or taxonomy of virtualization at different levels. (MU - April 19, 5 Marks)

UQ. 2.2.3 Explain various features of KVM. (MU - April 19, 5 Marks)

- Virtualization covers a wide range of emulation techniques that are applied to distinct areas of computing.
- A classification of these techniques helps us better understand their characteristics and use.
- See in following Fig. 2.2.1.

- First classification discriminates against the service or entity that is being emulated.
- Virtualization is mainly used to emulate execution environments, storage, and networks.
- These categories, execution virtualization constitutes the oldest, most popular, and most developed area.

2.2.1 Execution Virtualization

- Execution virtualization includes all techniques which aim to emulate an execution environment that is separate from the one hosting the virtualization layer.
- These techniques concentrate their interest on providing support for the execution of programs, whether these are the operating system, a binary specification of a program compiled against an abstract machine model, or an application.
- Hence, execution virtualization can be implemented directly on top of the hardware by the operating system, an application, or libraries dynamically or statically linked to an application image.

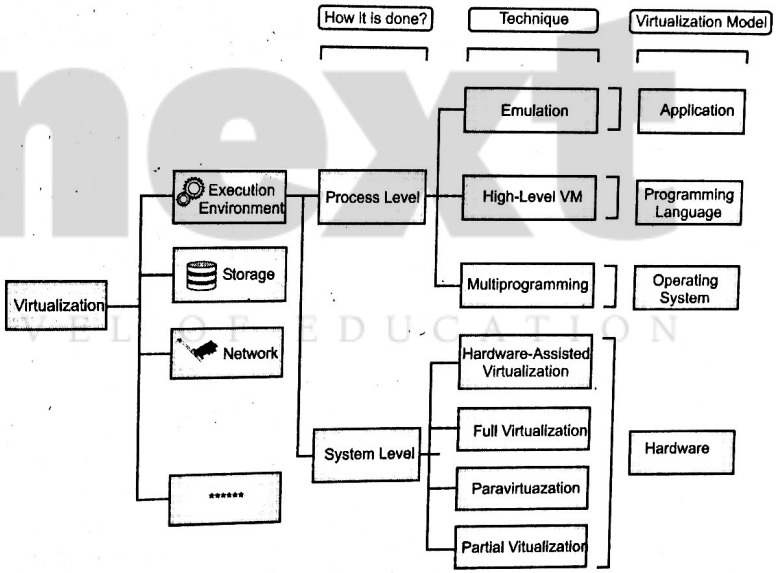

Fig. 2.2.1 : Taxonomy of Virtualization

2.2.1.1 Machine Reference Model

- Virtualizing an execution environment at distinct levels of the computing stack requires a reference model that defines the interfaces between the levels of abstractions that hide implementation details.
- From this perspective, virtualization techniques actually replace one of the layers and intercept the calls that are directed toward it.

- Therefore, a clear separation between layers simplifies their implementation that only requires the emulation of the interfaces and a proper interaction with the underlying layer.

2.2.1.2 Hardware-level Virtualization

- Hardware-level virtualization is a virtualization technique that provides an abstract execution environment in terms of computer hardware on top of which a guest operating system can be run.
- The guest is represented by the operating system, the host by the physical computer hardware, the virtual machine by its emulation, and the virtual machine manager by the hypervisor.
- Hardware-level virtualization is also called system virtualization, since it provides e Instruction Set Architecture (ISA) to virtual machines, which is the representation of the hardware interface of a system.
- The benefits of hardware virtualization decrease the overall cost of cloud users and increase the flexibility.

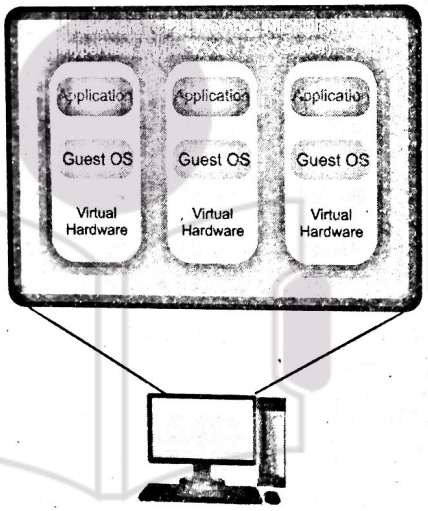

Fig. 2.2.2 : Hardware virtualization

The advantages are

- **Lower Cost :** Because of server consolidation, the cost decreases; now it is possible for multiple OS to exist together in a single hardware. This minimizes the quantity of rack space, reduces the number of servers and eventually drops the power consumption.
- **Efficient resource utilization :** Physical resources can be shared among virtual machines. The unused resources allocated by one virtual machine can be used by another virtual machine in case of any require.
- **Increase IT flexibility :** The quick development of hardware resources became possible became possible using virtualization and the resources can be managed consistently also.

- **Advanced Hardware Virtualization features :** With the advancement of modern hypervisors highly complex operations maximize the abstraction of hardware & ensure maximum uptime, and this technique helps to migrate an ongoing virtual machine from one host to the another host is dynamically.

2.2.1.3 Programming Language-level Virtualization

- It is mostly used to achieve ease of deployment of applications, managed execution, and portability across different platforms and operating systems.
- It consists of a virtual machine executing the byte code of a program, which is the result of the compilation process.
- The characteristics of this architecture vary from implementation to implementation.
- These virtual machines constitute a simplification of the underlying hardware instruction set and provide some high-level instructions that map some of the features of the languages compiled for them.

2.2.1.4 Application-level Virtualization

- It is a technique allowing applications to be run in runtime environments that do not natively support all the features required by such applications.
- In this scenario, applications are not installed in the expected runtime environment yet are run as though they were.
- In general, these techniques are mostly concerned with partial file systems, libraries, and operating system component emulation.
- Such emulation is performed by a thin layer a program or an operating system component which is in charge of executing the application.

Benefits to application virtualization include,

- Requiring fewer resources compared to using a separate virtual machine.
- Allowing incompatible applications to run on a local machine simultaneously.
- Maintaining a standard, more efficient, and cost-effective OS configuration across multiple machines in a given organization, independent of the applications being used.
- Facilitating more rapid application deployment.
- Facilitating security by isolating applications from the local OS.
- Easier tracking of license usage, which may save on license costs.
- Allowing applications to be copied to portable media and used by other client computers, with no need for local installation.
- Increasing ability to handle high and diverse/variable work volume
- There are limitations to application virtualization. Not all applications can be virtualized, like applications requiring device drivers and 16-bit applications running in shared memory space. Some applications must become closely integrated with the local OS, such as anti-virus programs, as they are very difficult to run with application virtualization.

- Application virtualization is used in a wide variety of applications, including banking, business scenario simulations, e-commerce, stock trading, and insurance sales and marketing.

2.2.2 Other Types of Virtualization

Other types of virtualization provide an abstract environment to interact with. These mainly cover storage, networking, and client/server interaction.

2.2.2.1 Storage Virtualization

- It is a system administration practice that allows decoupling the physical organization of the hardware from its logical representation.
- Using this technique, users do not have to be worried about the specific location of their data, which can be identified using a logical path.
- Storage virtualization allows us to harness a wide range of storage facilities and represent them under a single logical file system.
- There are different techniques for storage virtualization, one of the most popular being network-based virtualization by means of storage area networks (SANs).
- SANs use a network-accessible device through a large bandwidth connection to provide storage facilities
- This is widely used in data centers where you have a big storage and it helps you to create, delete, allocated storage to different hardware. This allocation is done through network connection.
- The leader on storage is SAN. A schematic example is given below:

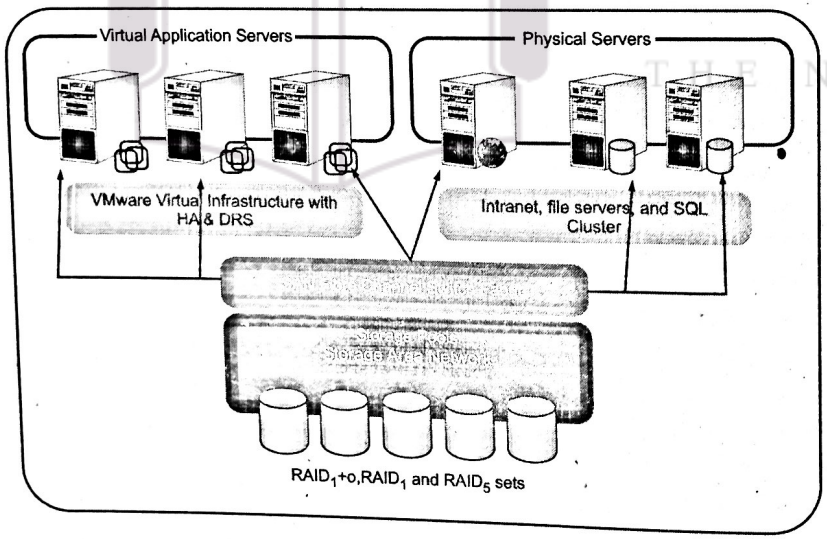

Fig. 2.2.3 : Storage Virtualization example

SNIA Storage Virtualization Taxonomy

- The SNIA (Storage Networking Industry Association) storage virtualization taxonomy (see Fig. 2.2.2.2) provides a systematic classification of storage virtualization, with three levels defining what, where, and how storage can be virtualized.
- "First level" of storage virtualization taxonomy addresses "what" is made. It state the types of virtualization: block virtualization, file virtualization, disk virtualization, tape virtualization, or any other device virtualization. Block-level and file-level virtualization these two are the core focus areas covered later in this chapter.
- "Second level" describes "where" the virtualization can takes place. This need a multilevel approach that characterizes virtualization at all three levels of the storage environment: server, storage network, and storage. Path redirection, path failover, data access, and distribution or load-balancing capabilities should be moved to the switch or the network.
- "Third level" of storage virtualization taxonomy state the network level virtualization methodology, in-band or the out-of-band.

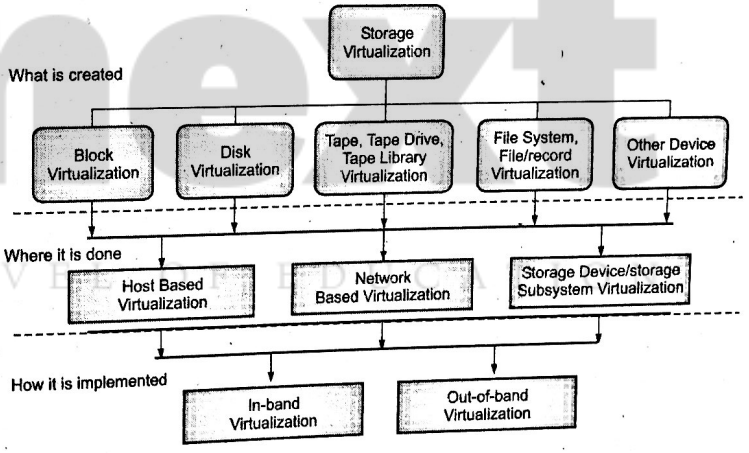

Fig. 2.2.4 : SNIA Storage Virtualization Taxonomy

Storage Virtualization Challenges

- Storage networking and feature-rich intelligent storage arrays have addressed and provided specific solutions to business problems. As an enabler, virtualization should add value to the existing solution, but introducing virtualization into an environment adds new challenges.
- The storage virtualization solution should be capable of addressing issues such as scalability, functionality, manageability, and support.

- **Scalability**
  - The scalability of an environment with no virtualization. This environment might have several storage arrays which provide storage separately of each other, the infrastructure which is implemented both at a physical level and from a virtualization perspective must be able to acceptably handle the workload, which may consist of different types of processing and traffic distribution.
  - Greater care should be exercised to ensure that storage devices are performing to meet the appropriate requirements.
- **Functionality**
  - Functionality is another challenge in storage virtualization. Currently, the storage array provides a wide range of advanced functionality necessary for meeting an application's service levels.
  - This includes local replication, extended-distance remote replication and the capability to provide application consistency across multiple volumes and arrays. It should protect the existing investments in processes, skills, training, and human resources.
- **Manageability**
  - The management of the storage infrastructure in a virtualized environment is an important consideration for storage administrators.
  - A key advantage of today's storage resource management tools in an environment without virtualization is that they provide an end-to-end view, which integrates all the resources in the storage environment. These are provide efficient and effective monitoring, reporting, planning, and provisioning services to the storage environment
- **Support**
  - Virtualization is not a stand-alone technology but something that has to work within an existing environment. This environment might contain multiple vendor technologies, such as switch and storage arrays, adding to complexity.
  - Addressing such complexities often need multiple management tools and introduces interoperability issues. Without a virtualization solution, most companies try to consolidate products from a single vendor to ease these challenges. So, supportability issues in a virtualized heterogeneous environment introduce challenges in coordination and compatibility of products and solutions from different manufacturers and vendors

2.2.2.2 Network Virtualization

- It combines hardware appliances and specific software for the creation and management of a virtual network.
- Network virtualization can aggregate different physical networks into a single logical network (external network virtualization) or provide network like functionality to an operating system partition.
- Result of external network virtualization is generally a virtual LAN (VLAN).

- A VLAN is an aggregation of hosts that communicate with each other as though they were located under the similar broadcasting domain.
- Internal network virtualization is generally applied together with hardware and operating system-level virtualization, in which the guests obtain a virtual network interface to communicate with.
- There are several options for implementing internal network virtualization: The guest can share the same network interface of the host and use Network Address Translation (NAT) to access the network; the virtual machine manager can emulate, and install on the host, an additional network device, together with the driver; or the guest can have a private network only with the guest.
- It is a part of virtualization infrastructure, which is used especially if you are going to visualize your servers.
- It helps you in creating multiple switching, Vlans, NAT-ing, etc. The following example shows the VMware schema.

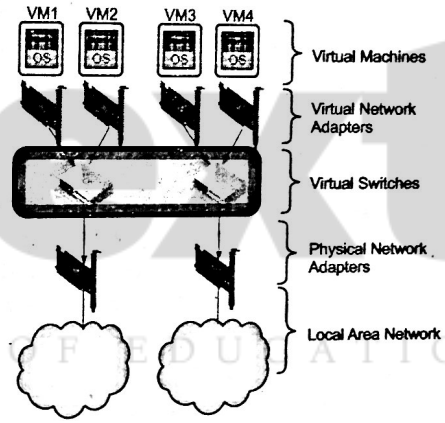

Fig. 2.2.5 : VMware schema.

Types of network virtualization

- Virtual networks exist in two forms; internal and external.
- Both of these terms refer to inside or outside the server.
- External virtualization will use tools such as switches, adapters or a network to combine one or more networks into virtual units.
- Internal virtualization mention to using network-like functionality in software containers on a single network server. Internal software allows VMs to exchange information on a host without using an external network.

2.2.2.3 Desktop Virtualization

Desktop virtualization abstracts the desktop environment available on a personal computer in order to provide access to it using a client/server approach.

- Desktop virtualization provides the same More productive IT environments (i.e., efficient scaling).
- Improved security and recovery times.
- Faster in application delivery.
- More efficient networks.
- Reduced overall costs.

Disadvantages

1. Increased upfront costs (investing in virtualization software).
2. Need to license software.
3. There may be a learning curve if IT managers are not experienced.
4. Not every application and server will work in a virtualized environment.
5. Availability can be an issue if an organization can't connect to their virtualized data

- Outcome of hardware virtualization but serves a different purpose.
- To the hardware virtualization, desktop virtualization makes accessible a different system as though it were natively installed on the host, but this system is remotely stored on a different host and accessed through a network connection.
- So, desktop virtualization addresses the problem of making the same desktop environment accessible from everywhere. Even though the term desktop virtualization strictly refers to the ability to remotely access a desktop environment, generally the desktop environment is stored in a remote server or a data center that provides a high-availability infrastructure and ensures the accessibility and persistence of the data.
- The advantages of desktop virtualization are high availability, persistence, accessibility, and ease of management.
- This is similar to server virtualization, but this time is on the user's site where you virtualized their desktops. We change their desktops with thin clients and by utilizing the datacenter resources. The following fig shows the desktop virtualization.

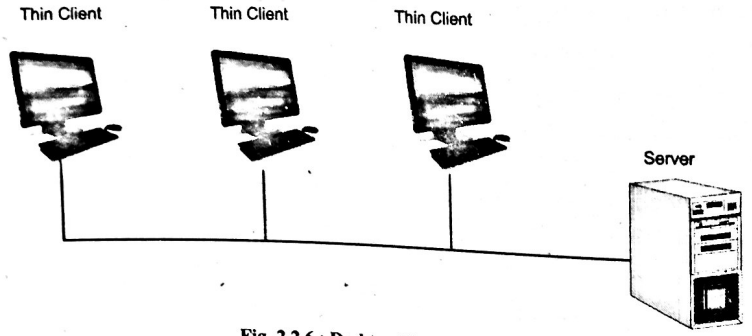

Fig. 2.2.6 : Desktop Virtualization

- The benefits to both IT and the business are :
- Improved centralization and security of data Bring corporate data firmly back into the hands of the IT department, while minimizing the threats posed by lost or stolen devices, rogue usage and security breaches.
- Lower support and administration costs. The ability to make changes (patches or introduction of new applications) centrally and roll them out to entire user groups, thereby reducing local support visits.
- The deployment of low-function devices in place of conventional units too dramatically reduces the incidence of device failure at end user side.
- Increased user productivity Tailor the user experience to the needs and characteristics of the end user and role, while simultaneously reducing the likelihood of downtime caused by IT failure.
- Improved flexibility Business agility can be boosted thanks to the ability to provision / de-provision users more quickly than previously possible, thereby improving the speed at which the business can complete mergers, acquisitions and divestitures.
- Enhanced business continuity and disaster recovery capability User profiles and data can be backed up quickly and independently of what happens on, or to, the end user device, thereby dramatically reducing the downtime implied by unanticipated disruptions.

2.2.2.4 Application Server Virtualization

- Application server virtualization abstracts a collection of application servers that provide the same services as a single virtual application server by using load-balancing strategies,
- And providing a high-availability infrastructure for the services hosted in the application server.
- Application server virtualization is a particular form of virtualization and serves the same purpose of storage virtualization: providing a better quality of service rather than emulating a different environment.
- The virtualization technology isolates applications from the underlying operating system and from other applications, in order to increase compatibility and manageability. For example : Docker can be used for that purpose. The following fig shows the application virtualization.

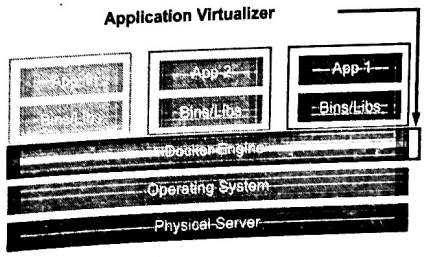

Fig. 2.2.7 : Application Virtualization

2.3 Virtualization and Cloud Computing

- Virtualization has important role in cloud computing since it allows for the appropriate degree of customization, security, isolation, and manageability that are fundamental for delivering IT services on demand. Virtualization technologies are primarily used to supply configurable computing environments and storage.
- Network virtualization is less popular and, in most cases, is a complementary feature, which is naturally needed in build virtual computing systems.
- Particularly the role of virtual computing environment and execution virtualization techniques.
- From these, hardware and programming language virtualization are the techniques adopted in cloud computing systems.
- Hardware virtualization is an enabling factor for solutions in the Infrastructure-as-a-Service (IaaS) market segment, while programming language virtualization is a technology leveraged in Platform-as-a-Service (PaaS) offerings.
- In these cases, the capability of offering a customizable and sandboxed environment constituted an attractive business opportunity for companies featuring a large computing infrastructure that was able to sustain and process huge workloads.
- Also, virtualization allows isolation and a finer control, thus simplifying the leasing of services and their accountability on the vendor side.
- Virtualization also gives the opportunity to design more efficient computing systems by means of consolidation, which is performed transparently to cloud computing service users.
- If the underlying resources are capable enough, there will be no evidence of such sharing. This opportunity is particularly attractive when resources are underutilized, because it allows reducing the number of active resources by aggregating virtual machines over a smaller number of resources that become fully utilized.
- This practice is called as server consolidation, while the movement of virtual machine instances is called virtual machine migration (see Fig. 2.3.1).
- So, virtual machine instances are controllable environments, consolidation can be applied with a minimum impact, either by temporarily stopping its execution and moving its data to the new resources or by executing a finer control and moving the instance while it is running.
- The second techniques is called as live migration and in general is more complex to implement but more efficient since there is no disruption of the activity of the virtual machine instance.

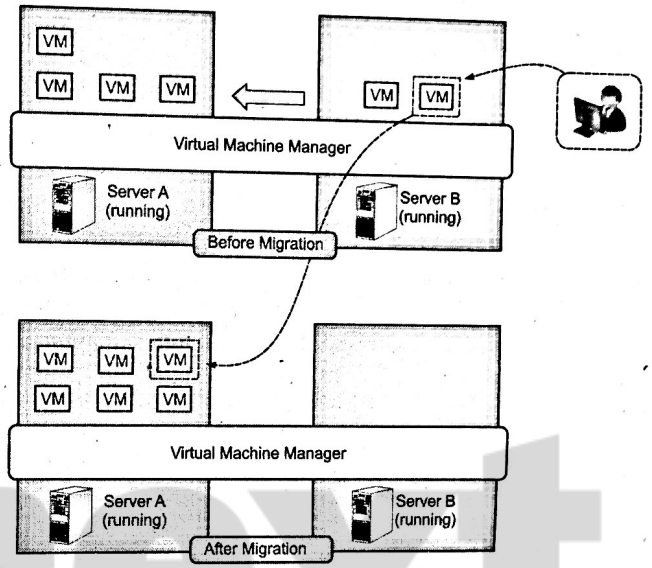

Fig. 2.3.1 : Live migration and server consolidation

- Server consolidation and virtual machine migration are principally used in the case of hardware virtualization, even though they are also technically possible in the case of programming language virtualization.
- Storage virtualization constitutes an interesting opportunity given by virtualization technologies, often complementary to the execution of virtualization.
- In this case, vendors backed by large computing infrastructures featuring huge storage facilities can harness these facilities into a virtual storage service, easily partitionable into slices.
- These slices can be dynamic and offered as a service.
- A second time, opportunities to secure and protect the hosting infrastructure is available, as are methods for easy accountability of such services.
- So, cloud computing revamps the concept of desktop virtualization, initially introduced in the mainframe era.
- The ability to recreate the entire computing stack from infrastructure to application services on demand opens the path to having a complete virtual computer hosted on the infrastructure of the provider and accessed by a thin client over a capable Internet connection.

2.3.1 Why Choose Virtualization ?

- Many from us are familiar with cloud-based systems to some degree and are using them in one way or another.
- Still, the cloud is just part of a bigger picture a technology that has become increasingly popular known as virtualization. Adopted as a solution by many businesses, the question is what virtualization is and when if ever should it be implemented.

How is it different from other systems ?

- With virtualization, you can instantly access nearly limitless computing resources which allow for faster and broader business capabilities. It gets rid of haphazard IT rooms, cables, and bulky hardware; reducing your overall IT overhead as well as management costs.
- While many looks at virtualization as the cloud, in reality the cloud is just a part of virtualization. The important function of virtualization is the capability of running multiple operating systems and applications on a single computer or server. This means increased productivity achieved by fewer servers.
- Virtualization can usually improve overall application performance due to technology that can balance resources and provide only what the user needs.

When to virtualize ?

- Virtualization can be a solution for many businesses, but not for all. The key is to be informed exactly when to virtualize. Here are 4 situations where a business could virtualize systems :
- Virtualize if you rely on technology – Companies that rely on technology often use several servers and technology from hardware like laptops and networks.
- Primarily if your company needs technology to operate, virtualization can help you reduce the overall operation costs.
- Virtualize if your company exceeds 20 employees – Many tech experts agree that there is no need for virtualization if you have a business with less than 10-20 employees. Traditional servers are usually greater than enough to cater to your needs.
- Virtualize if you can cover the costs – While virtualization is meant to reduce costs, like any modern technology it requires an initial investment. The cost of virtualization can be high for smaller businesses to implement; though you do have an option of working with an IT partner like us. We can assist you realize cost-savings or even a Return On Investment (ROI). For business with servers in place, virtualization can be as simple as installing a free program.
- Virtualize if you want space – Certain business operators throw away a big chunk of their money on an extra room to house large server racks, wires or even IT personnel to maintain them. The issue are the cost of maintenance, as well as limited office space. In that situation, virtualization can help out to make better use of space while reducing hardware costs.
- There are several reasons as to why many businesses look into virtualization. Like any type of technology, it's a trade-off between practicality and money.

2.3.2 Virtualization Versus Cloud Computing

UQ. 2.3.1 What are the benefits of virtualization in the context of cloud computing ? (MU - April 19, 5 Marks)

- Virtualization is a software that virtualizes your hardware into multiple machines while Cloud computing is the combination of multiple hardware devices.
- In Virtualization, a user gets dedicated hardware while in Cloud computing multiple hardware devices provide one login environment for the user.
- Cloud computing is best to access from outside the office network while Virtualization meant to access from office only.
- The cloud environment is accessible through URL so it can be accessed outside work premises (Depending upon permission).
- Virtualization doesn't depend upon cloud computing environment while without virtualization cloud computing can't exist.
- Cloud computing works on IaaS (Infrastructure as a Service) while virtualization is based upon SaaS (Software as a Service).
- Shared computing resources like software and Hardware provide you a cloud computing environment while Virtualization comes into existence after Machine/Hardware manipulation.
- Cloud Computing provides you flexibility such as pay as you go, self-service, etc. while access to a virtualized environment won't allow you to such features.
- Cloud computing is good for selling your service/software to external users while Virtualization is best for setting up Data Center within the company network.
- Storage capacity is limitless in the Cloud network while in a Virtualization its depend upon Physical server capacity.
- Single machine failure won't impact the cloud infrastructure while in virtualization single node failure can impact 100s of virtual machines.
- If Physical Hardware/Machine is not configured in High Availability

2.4 Pros and Cons of Virtualization

2.4.1 Pros of Virtualization

GQ. 2.4.1 What are the advantages and disadvantages of virtualization? (MU - April 19, 5 Marks)

UQ. 2.4.2 Explain the pros and cons of virtualization.

It is cheaper

- Virtualization doesn't require actual hardware components to be used or installed, IT infrastructures realize it to be a cheaper system to implement.

- There is no longer a require to dedicate large areas of space and huge monetary investments to create an on-site resource. You purchase the license or the access from a third party provider and begin to work, just while if the hardware were installed locally.

☞ Keeps costs predictable

As third-party providers typically provide virtualization options, individuals and corporations could have predictable costs for their information technology needs.

☞ Reduces the workload

- Most virtualization providers automatically update their hardware and software that will be utilized.
- Instead of sending a people to do these updates locally, they are installed by the third-party provider.
- This allows local Information Technology professionals to focus on other tasks and saves even more money for individuals or corporations.

☞ Offers a better uptime

Thanks to virtualization technologies, uptime has improved dramatically. Some providers offer an uptime that is 99.9999%. Even budget-friendly providers offer uptime at 99.99% today.

☞ Allows for faster deployment of resources

- Resource provisioning is fast and also simple when virtualization is being used.
- There is no longer a require to set up physical machines, create local networks, or install other information technology components.
- There is at least one point of access to the virtual environment, that can be spread to the rest of the organization.

☞ Promotes digital entrepreneurship

- Before virtualization occurred on a large scale, digital entrepreneurship was virtually impossible for the average a person.
- Thanks to various platforms, servers, and storage devices which are available today, almost a person can start their own side hustle or become a business owner.
- Sites like Fiverr and Up Work make it possible for anyone to set a shingle and begin finding some work to do.

☞ Provides energy savings

- For many individuals and corporations, virtualization is the energy-efficient system. So, there are not local hardware or software options being utilized, energy consumption rates can be lowered.
- Instead of paying for the cooling costs of a data center and the operational costs of equipment, funds can be used for other operational expenditures over time to improve virtualization's overall ROI.

2.4.2 Cons of Virtualization

GQ. 2.4.3 What are the advantages and disadvantages of virtualization?

UQ. 2.4.4 Explain the pros and cons of virtualization. (MU - April 19, 5 Marks)

☞ It can have a high cost of implementation

- The cost for the average individual or work when virtualization is being considered will be quite low. For the providers of a virtualization environment, though the implementation costs can be quite high.
- Hardware and software are required at few point and which means devices must either be developed, manufactured, or purchased for implementation.

☞ It still has limitations

- Not every application or server which is going to work within an environment of virtualization. Which means an individual or corporation may require a hybrid system to function properly.
- This is quite save time and money in the long run, since not every vendor supports virtualization and some might stop supporting it after initially starting it, there is always a level of uncertainty when fully implementing this type of system.

☞ It creates a security risk

- Information is our modern currency. If you have it, you can make money. If you don't have it, you'll be ignored. So data is crucial to the success of a business, it is targeted frequently.
- The average cost of a data security breach in 2017, according to a report published by the Ponemon Institute, was $3.62 million. For perspective: the chances of being struck by lightning are about 1 in a million.
- The chances of experiencing a data or information breach while using virtualization?

☞ It creates an availability issue

- The primary concern that many have with virtualization is what will happen to their work should their assets not be available.
- If an business cannot connect to their data for an extended period of time, they will struggle to compete in their industry. And, availability is controlled by third-party providers, the ability to stay connected in not in one's control with virtualization.

☞ It creates a scalability issue

- Although you can grow a business/work or opportunity quickly because of virtualization, you may not be able to become as large as you'd like.
- You may also be required to be larger than you want to be when first starting out. So, many entities share the same resources, growth creates lag within a virtualization network.
- One large presence can take resources away from several smaller businesses and there would be nothing anybody could do about it.

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

- If you have local equipment, then you are in full control of what you could do. With virtualization, you lose which control because several links must work together to perform the same task. Let's using the illustration of saving a document file.
- With a local storage device, like a flash drive or HDD, you can save the file immediately and even create a backup.
- Using virtualization, your ISP connection would require to be valid. Your LAN or Wi-Fi would require to be working. Your online storage option would require to be available. If any of those aren't working, then you're not saving that file.

It takes time

- Even though you save time during the implementation phases of virtualization, it costs users time over the long-run when compared to local systems.
- That is because there are extra steps which may be followed to generate the desired result.

2.5 Virtualization using KVM

UQ. 2.5.1 What is KVM ? (MU - Apr. 19 - 1 Mark)

- KVM (for Kernel-based Virtual Machine) is a full virtualization solution for Linux on x86 hardware containing virtualization extensions (Intel VT or AMD-V).
- It consists of a loadable kernel module, kvm.ko, that provides the core virtualization infrastructure and a processor specific module, kvm-intel.ko or kvm-amd.ko.
- KVM also requires a modified QEMU although work is underway to get the required changes upstream.
- Using KVM, one can run multiple virtual machines running unmodified Linux or Windows images.
- Each virtual machine has private virtualized hardware: a network card, disk, graphics adapter, etc.
- With KVM, multiple virtual machines can run under the unmodified Linux or Windows images.
- Every single virtual machine has it's virtualized hardware, containing network interface card (NIC), storage device, graphical user interface (GUI), etc.
- It is compare with VMware and Hyper-V and KVM is open source software.
- The kernel component of KVM is included in mainline Linux, as of 2.6.20.
- KVM is open source software.

Benefits

(a) KVM supports any kind of guest OS.
(b) Efficient code.
(c) KVM is open source and flexible.
(d) User doesn't have to pay for licence.

2.6 Creating Virtual Machine

2.6.1 To Create a Virtual Machine Using VMware Workstation

(a) Launch VMware Workstation.
(b) Click on the New Virtual Machine.
(c) Select the type of virtual machine you want to create and click Next:

Note : Your choice depends partially on the hardware version you want your virtual machine to have.

- **Custom :** This gives you an option to create a virtual machine and choose its hardware compatibility. You can select from Workstation 14.x, Workstation 12.x, Workstation 11.x, Workstation 10.x, Workstation 9.x, Workstation 8.x, Workstation 6.5 -7.x, Workstation 6, Workstation 5, and Workstation 4.
- **Typical :** This creates a virtual machine which has the same hardware version as the version of Workstation you are using. If you are using Workstation 8.x, it make a virtual machine with hardware version 8. If you are using Workstation 6.5.x or 7.x, a virtual machine with hardware version 7 is created.

(a) Click on Next.
(b) Select your guest operating system (OS), and then click Next. You can install the OS using:
  - An installer disc (CD/DVD)
  - An installer disc image file (ISO)
(c) Click on Next.
(d) Enter your Product Key.
(e) Create a user name and password.
(f) Click on Next.
(g) Enter a virtual machine name and specify a location for virtual machine files to be saved, click on Next.
(h) Establish the virtual machine's disk size, select whether to store the virtual disk as a single file or split the virtual disk into 2GB files, click Next.
(i) Verify the other configuration settings for your virtual machine:
  - **Memory :** change the amount of memory allocated to the virtual machine.
  - **Processors :** change the number of processors, number of cores per processor, and the virtualization engine.
  - **CD / DVD :** with advanced settings where you can choose between SCSI, IDE.
  - **Network adapter :** configure it to bridge, NAT, or Host-only mode, or customize where you can choose between 0 to 9 adapters.
  - USB Controller.
  - Sound card.
  - **Display :** enable 3D graphics.

(j) Click on Finish.

(k) When the virtual machine is powered on, the VMware Tools installation starts. You are prompted to restart your virtual machine once the Tools installation completes.

2.7 oVirt - Management Tool for Virtualization Environment

GQ. 2.7.1 Write a short note on oVirt.

- oVirt is a free, open-source virtualization management platform. It founded by Red Hat as a community project on which Red Hat Enterprise Virtualization is based.
- It allows centralized management of virtual machines, compute, storage and networking resources, from an easy-to-use web-based front-end with platform independent access.
- The overall architecture of oVirt; So we need to know the components of a platform and their purpose.
- It's especially important when troubleshooting.
- oVirt consists of several components, from which each responsible for a part of the work.

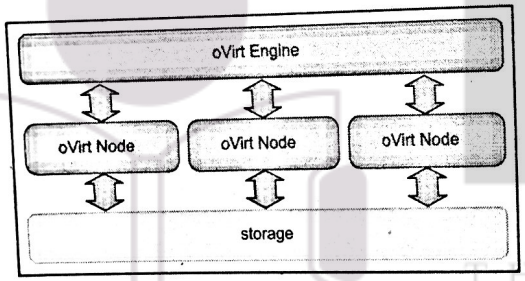

Fig. 2.7.1 : oVirt Architecture

The oVirt platform consists of the following three logical components :

(a) oVirt Engine

- It is a control unit used for administrative tasks related to the management of the global configuration of the entire virtualization infrastructure, the management of virtual machines, storage, and network settings.
- oVirt Engine is a set of software and services that implement the functionality of the central control infrastructure.
- This control unit is platform's core and provides an interface for other infrastructure components.
- Using oVirt Engine interfaces, the administrator can run the whole setup inside oVirt.
- So with the help of oVirt Engine, we achieve one of the main goals of oVirt: centralized management.

(b) oVirt Nodes

- It computes virtualization units that directly run the virtual machines.

- Virtualization hosts (oVirt Nodes) are servers using Linux x86_64 with the installed libvirt daemon and VDSM (Virtual Desktop and Server Manager) (host-agent) service.
- These are the set of packages and support services that are required for the rapid deployment of virtualization.
- The most supported and preferred distributions to build the nodes is CentOS or Red Hat Linux.
- So, we can use oVirt Node a special stripped Fedora Linux minimalistic distribution containing only the necessary packages for integration into the oVirt platform.

(c) Storage and network infrastructure (external disk capacity units)

- These can be direct or Network Attached Storage (DAS/NAS) or high-performance Storage Area Networks (SAN).
- Disk capacity units hold virtual machine images and OS installation images. Network devices, such as switches, provide connectivity between engines, nodes, and storage.

oVirt Engine provides the following functions

- Virtual machines' full life cycle management.
- Authentication with LDAP providers (Active Directory or IPA)
- Network configuration management is used for the creation of logical networks and connecting them to the hosts.
- Storage management is used to manage domain's storage (NFS, iSCSI, Fibre Channel, GlusterFS, or Local) and disk images of virtual machines.
- High availability functions to automatically restart virtual machines on other nodes if there is hardware or network failure of the source host.
- Live migration manages the movement of VMs between physical servers without downtime.
- System Scheduler is used for the implementation of load balancing of virtual machines based on resource usage policies.
- Image Management is used for allocation based on templates, thin provisioning, and snapshots.
- It uses objects' platform monitoring, such as monitoring virtual machines, hosts, network environment, and storage.

2.7.1 Goals of the oVirt

- It built a community around all levels of the virtualization stack, hypervisor, manager, GUI, API etc.
- To deliver both a cohesive complete stack and discretely reusable components for virtualization management.
- It Provide a release of the project on a well-defined schedule.
- Focus on management of the KVM hypervisor, with exception guest support beyond Linux.
- It provide a venue for user and developer communication and collection.

2.8 Open Challenges of Cloud Computing

GQ. 2.8.1 List some of the challenges in cloud computing.

UQ. 2.8.2 List some of the challenges in cloud computing. (MU - April 19, 5 Marks)

- Cloud computing, an emergent technology, has placed challenges in various aspects of data and information handling.
- Cloud computing is used for enabling global access to mutual pools of resources such services, apps, data, servers, and computer networks. It is done on either a 3rd-party server located in a data center or a privately-owned cloud.
- This makes data-accessing contrivances more reliable and efficient, with nominal administration effort.
- So, cloud technology depends on the allocation of resources to attain consistency and economy of scale, similar to a utility, it is also fairly cost-effective, making it the choice for many small businesses and firms.
- There are also many challenges involved in cloud computing, here are common challenges that every organization must consider before implementing cloud computing technology.

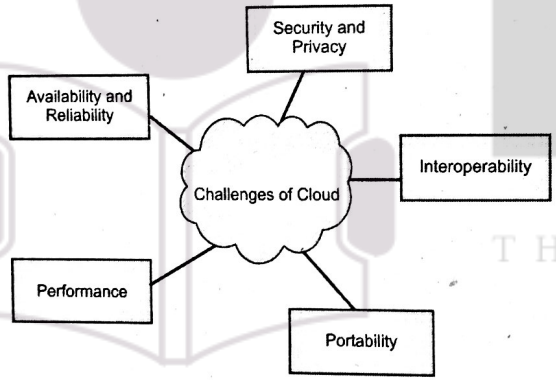

Fig. 2.8.1 : Challenges in Cloud computing

(a) Security and Privacy

- Security and privacy of data are the important challenge in cloud computing. These challenges can reduce by using security applications, encrypted file systems, data or info loss software.
- Sensitive and personal information that is kept in the cloud should be defined as being for internal use only, not to be shared with third parties.
- Businesses must have a plan to securely and efficiently manage the data they gather.
- Industrious password supervision plays a vital role in cloud security.
- So, the more people you have accessing your cloud account, the less secure it is. Someone aware of your passwords will be able to access the information you store there.

- Businesses must employ multi-factor authentication and make sure that passwords are protected and altered regularly, particularly when staff members leave. Access rights related to passwords and usernames should only anyone allocated to those who require them.

(b) Interoperability

- The application on one platform must have anyone able to incorporate services from the other platform. This is called as Interoperability.
- It is becoming possible through web services, but to develop such web services is complex.

(c) Portability

- The applications running on one cloud platform can be moved to new cloud platform and it must operate correctly without making any changes in design, coding.
- The portability is not possible. So, each of the cloud provider's uses different standard languages for their platform.

(d) Computing Performance

- High network bandwidth is needed for data intensive applications on cloud, that result in high cost.
- In cloud computing, low bandwidth does not meet the desired computing Performance. Cloud computing itself is affordable, but tuning the platform according to the company needs can be expensive.
- The expense of transferring the data to public clouds can prove to be a problem for short- lived and small scale projects.

(e) Reliability and Availability

- Many of the businesses are dependent on services provided by third-party so it is mandatory for the cloud systems to be reliable and robust.
- The capacity and capability of a technical service provider are as important as price.
- The service provider must be available when you need them.
- The main concern must anyone is service provider's sustainability and reputation.
- Make sure you comprehend the techniques via which a provider observes its services and defends dependability claims.

Chapter Ends...