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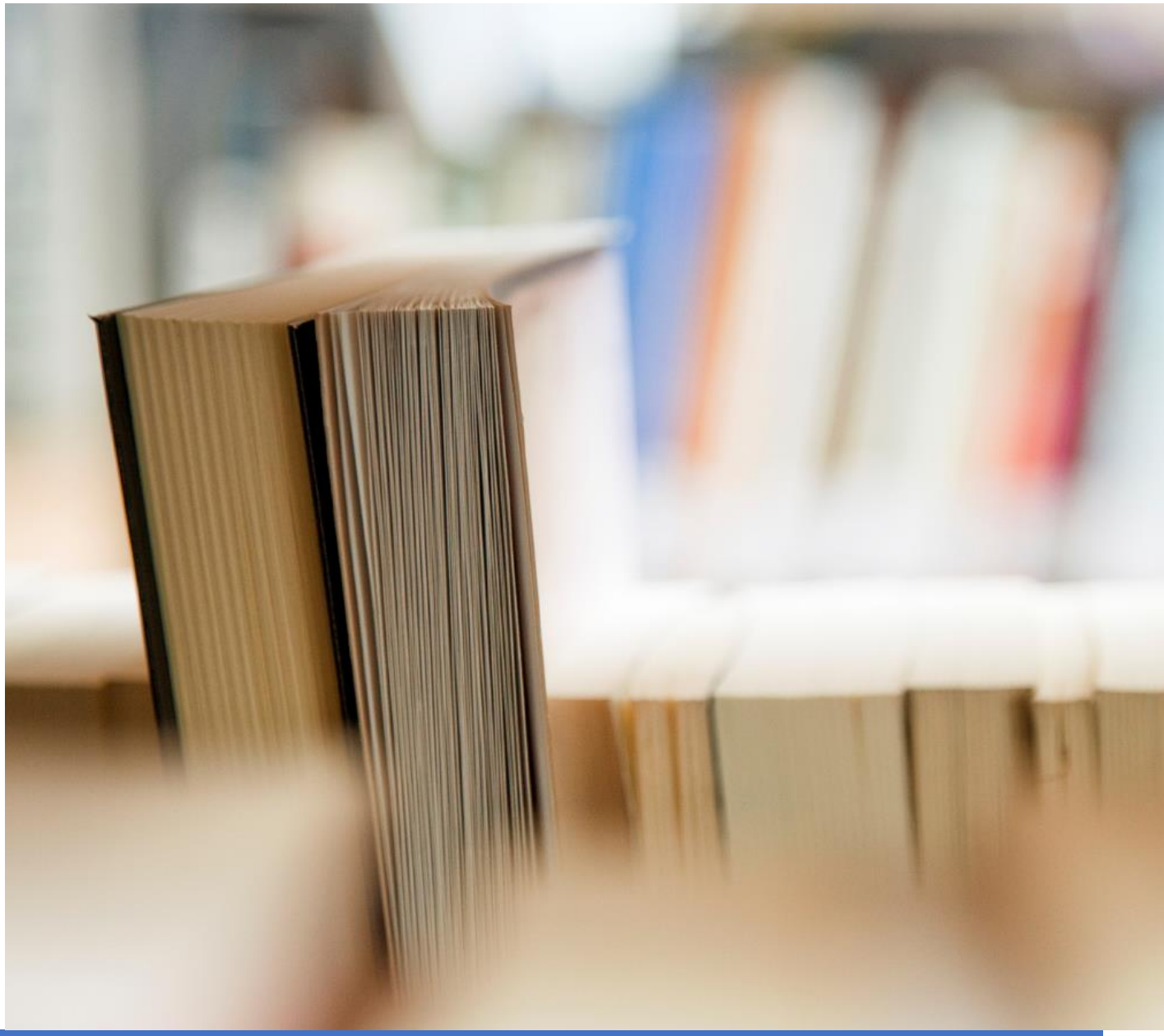

Introduction to Virtualization & Cloud Computing

INTRODUCTION

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1. **Cloud Computing**:

Cloud Computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management by the user.

OR

"Cloud Computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet ("the cloud") to offer faster innovation, flexible resources, and economies of scale.

You typically pay only for cloud services you use, helping lower your operating costs, run your infrastructure more efficiently and scale as your business needs change." – Microsoft.

OR

Simply, Computer Services are delivered over the internet and you pay for what you use. It's efficient and it scales.

2. Top Cloud Service providers:
   I. Amazon Web Services (AWS)
   II. Microsoft Azure
   III. Google Cloud
   IV. Alibaba Cloud
   V. IBM Cloud
   VI. Oracle
   VII. Salesforce
   VIII. SAP
   IX. Rackspace Cloud
   X. VMWare

3. **IBM Bluemix**, rebranded **IBM Cloud** in 2017, is a cloud Platform as a service developed by IBM.

4. As-a-service types or the three models of Cloud Services:

   a) **Software as a Service (SaaS):**
      I. It is also known as **cloud application services**.
      II. SaaS utilizes the internet **to deliver applications**, which are managed by a third-party vendor, to its users.
      III. A majority of SaaS applications **run directly through your web browser**, which means they **do not require any downloads or installations on the client side.**

   b) **Platform as a Service (PaaS):**
      I. PaaS is a cloud computing model where a third-party provider **delivers hardware and software tools** to users over the internet. Usually, **these tools are needed for application development.** A PaaS provider hosts the hardware and software on its own infrastructure.
      II. PaaS delivers a framework for developers that they can build upon and use to create customized applications.

   c) **Infrastructure as a Service (IaaS):**
      I. IaaS allows businesses to **purchase resources on-demand and as-needed instead of having to buy hardware** outright.

5. **Gartner**, is a global research and advisory firm providing information, advice, and tools for leaders in IT, finance, HR, customer service and support, communications, legal and compliance, marketing, sales, and supply chain functions.

   Gartner provide invaluable research.

   Gartner even provide Ranking to Cloud Services Provider.

6. **Gartner Magic Quadrant** is a series of market research reports published by IT consulting firm Gartner that rely on proprietary qualitative data analysis methods to demonstrate market trends, such as direction, maturity and participants.

Figure 1: Magic Quadrant for Cloud Infrastructure and Platform Services

Source: Gartner (July 2021)

7. **Infrastructureless Computing:**
   a) no infrastructure required or needs to be installed!
   b) It is completely a new service i.e., a next generation of **Serverless Computing**
   c) It allows companies to reclaim their existing infrastructure's computing power by harnessing idle CPU and GPU resources across their entire organization to act like a single, decentralized mesh supercomputer.

   There is no additional infrastructure to add or manage. Simply install 15MB Computes (It is a company) nanocore agent on all of your workstations, servers, and VMs and start mesh computing!

   Links:
   I. https://www.youtube.com/watch?v=EWbBo3Xvk98
   II. https://blog.computes.com/serverless-vs-new-infrastructureless-computing-a3fc08e6fc2a

d) According to Microsoft, there are 4 major types of cloud computing:

a) Infrastructure as a Service (IaaS)
b) Platform as a Service (PaaS)
c) Software as a Service (SaaS)
d) Serverless

They're commonly referred to as the "**cloud computing stack**."

e) Serverless Computing:

"Serverless" is a bit of a misnomer or, at least, a somewhat **misleading label**, because somewhere in the world in enormous warehouses, there are definitely actual servers powering "Serverless" computing.

Serverless, simply means **you don't have to think about the server at all**. So, in effect, it's "serverless,"

MainPoint: **THE SERVER DISAPPEARS FROM YOUR LIST OF CONCERNS.**

The setup, capacity planning, and server management are invisible to you because they're handled by the cloud provider means Serverless applications don't require you to provision, scale, and manage any servers.

Need for Serverless: Traditionally, if you were a developer, you'd need to do quite a bit of work to set up and maintain a server for a new app or website. This process can be frustrating and time-consuming if you're not a sysadmin by trade. Worse, if you make a mistake and configure something incorrectly it can lead to serious consequences — like a security breach, downtime, or an inefficient use of resources (**you end up paying more than you have to for hosting**).
So, in Serverless Computing, all server-related concerns are taken off your plate and handled by the Serverless cloud architecture.

Advantages of Serverless Computing:

a. No need to manage or interact with a server
b. Computing resources are supplied as needed to scale a site automatically
c. Resources are allocated precisely rather than in chunks
d. You pay only for the resources that are consumed

8. **Green Computing:** Cloud Computing is also known as Green Computing because it is the environmentally responsible and eco-friendly use of computers and their resources.

It used to achieve not only efficient processing and utilization of computing infrastructure, but also **minimize energy consumption**.

9. **Utility Computing:** Utility computing or The Computer Utility is a service provisioning model in which **a service provider makes computing resources and infrastructure management available to the customer as needed**, and **charges them for specific usage** rather than a flat rate.

OR

Utility computing is a model in which computing resources are provided to the customer **based on specific demand**.

10. **Cloud** in "Cloud Computing", depicts **accessibility**. We can access it anywhere at any time.

11. **Virtualization:** It is 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 technique, which allows to share a single physical instance of a resource or an application among multiple customers and organizations.

    Hardware virtualization or **platform virtualization** refers to the creation of a virtual machine that acts like a real computer with an operating system.

    For example, a computer that is running Microsoft Windows may host a **virtual machine** that looks like a computer with the Ubuntu Linux operating system.

    In hardware virtualization, the **host machine** is the machine that is used by the virtualization and the **guest machine** is the virtual machine.

    The words **host** and **guest** are used to distinguish the software that runs on the physical machine from the software that runs on the virtual machine.

    The software or firmware that creates a virtual machine on the host hardware is called a **hypervisor** or **virtual machine monitor**.
    Examples of Hypervisor:
    I. Virtualbox (by Oracle)
    II. VM Ware
    III. Qemu
    IV. KVM

12. **<u>Hypervisors</u>:**

- The hypervisor manages shared the physical resources of the hardware between the guest operating systems and host operating system.
- Also known as Virtual Machine Monitor (VMM) or Virtual Machine Manager.
- Hypervisors are Resource Managers.

- **<u>Types of Hypervisors</u>:**

    1. **Type – 1** (or **Bare Metal**)**:**
        - It acts like a lightweight operating system and runs directly on top of hardware.

        - Examples:
            - VMware ESXi
            - Citrix XenServer
            - Microsoft Hyper-V hypervisor.

- These hypervisors are most commonly used or deployed i.e., most enterprise companies choose bare-metal hypervisors for data center computing needs.
    - **Reason:**
        - **Bare Metal Hypervisors** or Virtualization Software is installed directly on the hardware where the operating system is normally installed. Because bare-metal hypervisors are isolated from the attack-prone operating system, they are extremely secure.
        - **Bare Metal Hypervisors**, generally perform better and more efficiently than hosted hypervisors because of **low latency**.
        - **Lower Latency** than Hosted Hypervisors because virtualization software is installed directly on the hardware so there is direct communication between the hardware and the hypervisor.

2. **Type – 2** (or **Hosted**)**:**
    - It runs as a software layer on an operating system, like other computer programs.
    - The Virtualization Software is installed directly on the Operating System layer like other computer programs.
    - Hosted hypervisors run within the OS, additional (and different) operating systems can be installed on top of the hypervisor.
    - Hypervisor asks the operating system to make hardware calls.
    - **Latency is very high** because communication between the hardware and the hypervisor must pass through the extra layer of the OS.
    - Hosted hypervisors are sometimes known as **Client Hypervisors** because they are most often used with end users and software testing, where higher latency is less of a concern.
    - Examples:
        - VMware Player
        - Virtual Box
        - Parallels Desktop

13. <u>Types Of virtualization</u>:

1) <u>Hardware Virtualization</u>:

a) When the virtual machine software or virtual machine manager (VMM) or hypervisor software is directly installed on the hardware system is known as **hardware virtualization**.

b) **Virtualization means abstraction** & hardware virtualization is achieved by abstracting the physical hardware part using Virtual Machine Monitor (VMM) or hypervisor.

c) Hardware Virtualization is the abstraction of computing resources from the software that uses those resources.
The abstracted hardware is represented as actual hardware.

d) Hardware virtualization, when done for server platforms, is also called **server virtualization**.
e) Hardware virtualization, also known as **hardware assisted virtualization**.

f) How hardware virtualization works?

- Hardware virtualization installs a hypervisor or virtual machine manager (VMM), which creates an abstraction layer (called Virtual Layer) between the software and the underlying hardware.
- Once a hypervisor is in place, software relies on **virtual representations of the computing components**, such as virtual processors rather than physical processors

g) Usage:

Hardware virtualization is mainly done for the server platforms, because controlling virtual machines is much easier than controlling a physical server.

2) Operating system Virtualization:

a) When the virtual machine software or virtual machine manager (VMM) is installed on the Host operating system instead of directly on the hardware system is known as operating system virtualization.

b) Usage:
Operating System Virtualization is mainly used for testing the applications on different platforms of OS.

3) Server Virtualization:

a) When the virtual machine software or virtual machine manager (VMM) is directly installed on the Server system is known as server virtualization.
b) Server virtualization is the process of dividing a physical server into multiple unique and isolated virtual servers by means of a software application.
Each virtual server can run its own operating systems independently.

c) Usage:

1) Server virtualization is done because a single physical server can be divided into multiple servers on the demand basis and for balancing the load.
2) Server virtualization is a cost-effective way to provide web hosting services.
3) Server Virtualization effectively utilize existing resources in IT infrastructure. Without server virtualization, servers only use a small part of their processing power. This results in servers

sitting idle because the workload is distributed to only a portion of the network's servers.
Data centers become overcrowded with under-utilized servers, causing a waste of resources and power.

4) Storage Virtualization:

a) Storage virtualization is the process of grouping the physical storage from multiple network storage devices so that it looks like a single storage device.
b) Storage virtualization is also implemented by using software applications.

c) Usage:
Storage virtualization is mainly done for back-up and recovery purposes.

5) Network Virtualization:

a) Network Virtualization (NV) refers to abstracting network resources that were traditionally delivered in hardware to software.
b) NV can combine multiple physical networks to one virtual, software-based network, or it can divide one physical network into separate, independent virtual networks.

c) **Usage:**
Network virtualization helps organizations achieve major advances in speed, agility, and security by automating and simplifying many of the processes that go into running a data centre network and managing networking and security in the cloud.

d) **Example:**
VPNs are useful for creating the illusion of being within a different physical network and thus accessing the resources in it, which would otherwise not be available.

14. Benefits of Virtualization:

I. **Consolidation –** It is this ability to run multiple virtual machines, with their operating systems and applications, on a single physical platform.
It leads to
   a. Increase cost efficiency i.e., decreases cost
      - Fewer Electric bills
      - Fewer admin
      - Fewer space needed
      - Don't have to maintain many servers
      - Save on maintenance costs
   b. Improve manageability
      - Managing several machines is very difficult and problematic task. But with many VMs on single machine, it becomes easy.

II. **Migration** or **Portability –** When the operating system and its applications are nicely encapsulated in a VM, and decoupled (means to separate two or more things) from the actual physical hardware.

When any host fails, it becomes easier to migrate the OS and the applications from one physical machine to another physical machine or even to copy and clone them onto multiple physical machines at the same time. It leads to:

a. **Availability** of system and services i.e., decreases downtime.
b. **Reliability**, as we don't have to worry about system failure, if it occurs, we can migrate the VMs to other machines.

SOME IMPORTANT TERMS:

- Encapsulation - A virtual machine can be represented (and even stored) as a single file, so you can identify it easily based on the service it provides.
- Decoupled - to separate two or more things

III. **Security –** Since the applications are nicely encapsulated in a virtual machine, it becomes more easy to contain any kinds of bugs, or any kinds of malicious behaviour, to those resources that are available or allocated to the virtual machine only, and not to potentially affect the entire hardware system.

IV. **Debugging –** Virtualization has become a very important platform for operating systems research. It lets systems researchers quickly introduce new operating system feature and has them in the OS that's encapsulated in the VM. And then they have ability to more quickly view the effects of that and debug it as opposed to a more traditional cycle, which would have included hardware restarts of the machines and then searches through the log files or the error files, etc.

- The **log file** records errors and other information. Error log files are deleted after five days.
  - Depending on your operating system, the location for the log file varies.
  - For any Windows operating system, you can go to Start > Run on the computer running the Desktop client. Type %TEMP% and then click OK to open an Explorer window with the temp directory opened.

15. Colocation Facilities:

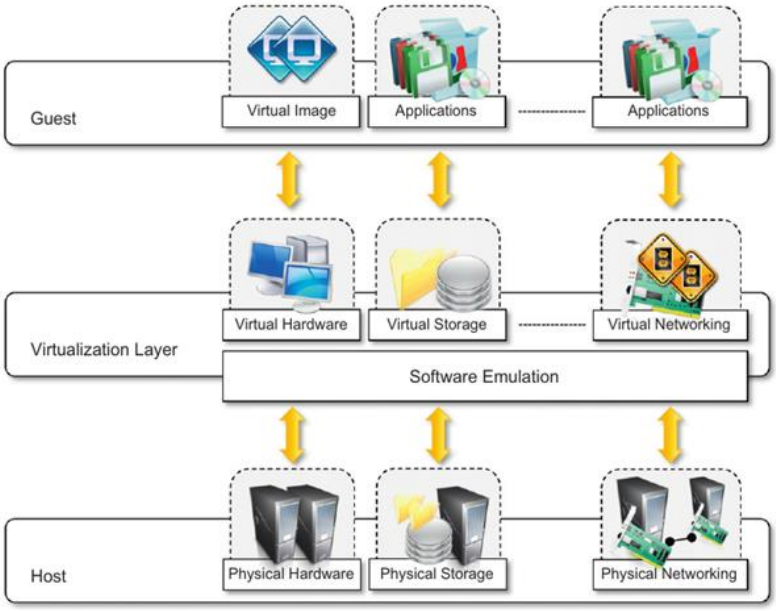
a. Also known as Colo (or) Colocation Centre (or) Colo Site (or) Carrier Hotel.
b. It is a type of data centre where equipment, space, and bandwidth are available for rental to retail customers.

OR

It is a data centre facility in which a business **can rent space** for servers and other computing hardware.

c. Typically, a Colo provides the building, cooling, power, bandwidth and physical security.
While the customer provides servers and storage.

16. <u>The Virtualization Reference Model</u>:



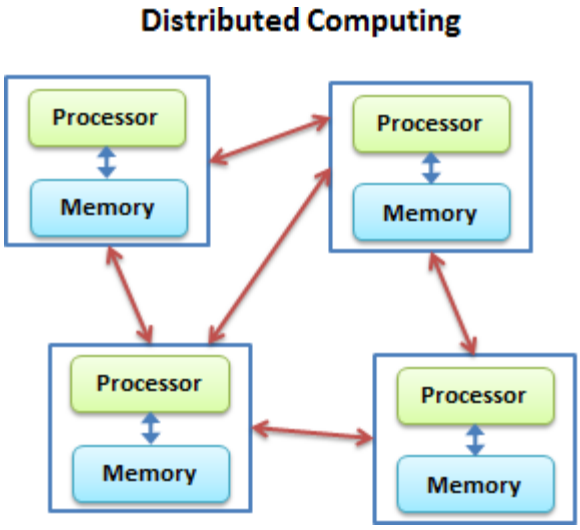
- The **guest** represents the system component that interacts with the virtualization layer rather than with the **host**, as would normally happen.
- The **host** represents the original environment where the **guest** is supposed to be managed.
- The **virtualization layer** is responsible for recreating the same or a different environment where the **guest** will operate.
- In the case of hardware virtualization,
    - The **guest** is represented by a system image comprising an operating system and installed applications.
      These are installed on top of virtual hardware that is controlled and managed by the **virtualization layer**, also called the virtual machine manager.
    - The **host** is instead represented by the physical hardware, and in some cases the operating system, that defines the environment where the virtual machine manager is running.

It is in similar way for storage virtualization and network virtualization.

The main common characteristic of all these different implementations is the fact that the virtual environment is created by means of a software program i.e., **software emulation**. The ability to use software to emulate such a wide variety of environments creates a lot of opportunities.

17. Distributed Computing:

- A distributed system is a system whose components are located on different networked computers, which communicate and coordinate their actions by passing messages to one another from any system.
- A distributed computer system consists of multiple software components that are on multiple computers, but run as a single system.
- The computers that are in a distributed system can be physically close together and connected by a local network, or they can be geographically distant and connected by a wide area network.
- Distributed computing (or distributed processing) is the technique of linking together multiple computer servers over a network into a cluster, to share data and to coordinate processing power. Such a cluster is referred to as a "**distributed system**."



18. Difference b/w Cloud Computing and Distributed Computing:

Cloud Computing	Distributed Computing
Cloud computing uses a client-server architecture to deliver computing resources such as servers, storage, databases, and software over the cloud (Internet) with pay-as-you-go pricing.	**Grid computing** is also called as "distributed computing." It links multiple computing resources (PC's, workstations, servers, and storage elements) together and provides a mechanism to access them.
The goal of cloud computing is to provide on demand computing services over internet on pay per use model.	The goal of distributed computing is to distribute a single task among multiple computers and to solve it quickly by maintaining coordination between them.
In simple cloud computing can be said as a computing technique that delivers hosted services over the internet to its users/customers.	In simple distributed computing can be said as a computing technique which allows to multiple computers to communicate and work to solve a single problem.

Cloud computing provides services such as hardware, software, networking resources through internet.	Distributed computing helps to achieve computational tasks more faster than using a single computer as it takes a lot of time.
Scalability is **high**.	Scalability is normal.
Cloud Computing is **more flexible** than grid computing.	Grid Computing is less flexible than cloud computing.
Cloud operates as a centralized management system.	Grid operates as a decentralized management system.
Cloud computing uses services like IaaS, PaaS, and SaaS.	Grid computing uses systems like distributed computing, distributed information, and distributed pervasive.

- **Centralized Management System** is the organizational structure where a small handful of individuals make most of the decisions in a company.

  Centralized organizations have all decisions coming from the same place.

  A common example is **Apple Inc.**, within Apple, much of the decision-making responsibility lies with the Chief Executive Officer (CEO), Tim Cook.

- A **Decentralized Management System**/Structure is one in which decision-making authority is delegated to the lower level throughout the organization rather than limiting it to a few top executives.

  Under a strong decentralized organization, the lower level managers and employees have power to make decisions.

  Decentralized organizations have decisions coming from all levels of management towards the same goal

  A common example is **Subway**, they gives local stores control over hiring .

19. <u>Taxonomy of virtualization techniques</u>:

- Virtualization covers a wide range of emulation techniques that are applied to different areas of computing.
- Virtualization is mainly used to emulate execution environments, storage, and networks.
- Execution virtualization techniques can be divided into two major categories by considering the type of host they require.
  a. **Process-level** techniques are implemented on top of an existing operating system, which has full control of the hardware.
  b. **System-level** techniques are implemented directly on hardware and do not require support from an existing operating system.

- We will discuss about different virtualization techniques in file name called "Virtualization Techniques" provided in the same folder in which this file was situated.

20. Managed Execution Functions:

- Virtualization of the **execution environment** not only allows increased security, but a wider range of features also can be implemented.
    - An **execution environment (EE)** is an **execution platform**, such as **an operating system** or a database management system, which is used for running applications.
- In particular, **sharing**, **aggregation**, **emulation**, and **isolation** are the most relevant features.

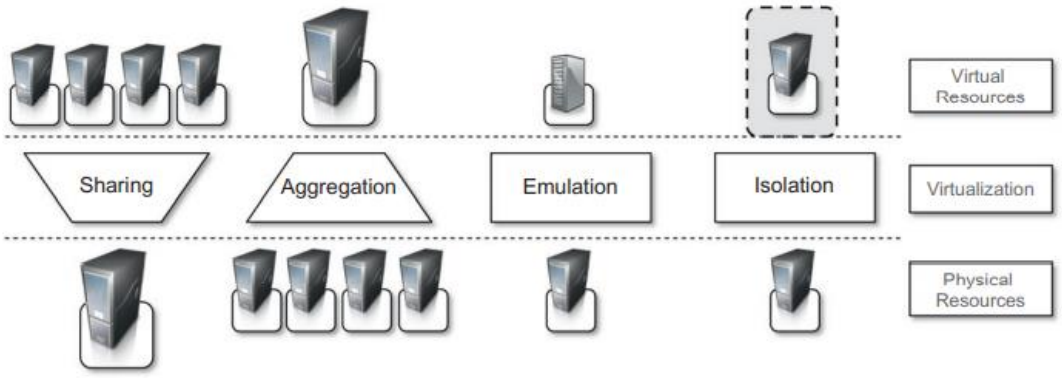


Fig: Functions Enabled by Managed Execution

a) Sharing:

- Virtualization allows the creation of a separate computing environments within the same host.
- In this way it is possible to fully exploit the capabilities of a powerful guest, which would otherwise be underutilized.
- Sharing 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, which is the opposite process.
- A group of separate hosts can be tied together and represented to guests as a single virtual host.
- This function is naturally implemented in middleware for distributed computing.

c) Emulation:

- It is a technique in which Virtual machines emulates complete hardware in software.

  OR

  It emulates the functions of one system on another. Thus, the second system behaves like the original system, attempting to exactly reproduce the external behaviours of the first system.

- Emulation is the process of imitating a hardware/software program/platform on another program or platform. This makes it possible to run programs on systems not designed for them.
- It is very useful when designing software for various systems.

d) Isolation:

- Virtualization allows providing guests—whether they are operating systems, applications, or other entities—with a completely separate environment, in which they are executed.
- The guest program performs its activity by interacting with an abstraction layer, which provides access to the underlying resources.

- Isolation brings several benefits:
  - It allows multiple guests to run on the same host without interfering with each other.
  - It provides a separation between the host and the guest. The virtual machine can filter the activity of the guest and prevent harmful operations against the host.

21. Difference between Emulation and Simulation:

Simulation	Emulation
A simulator creates an environment that mimics the behaviour and configurations of a real device.	An emulator duplicates all the hardware and software features of a real device.
A simulator **mimics the basic behaviour** of a device or environment.	An emulator **duplicates the thing exactly** as it exists in real life.

It simulates the basic behaviour but doesn't necessarily follow all the rules of the real environment.	Emulation means basically a complete imitation of the real thing. It just operates in a virtual environment instead of the real world.
It mimics the internal behaviour of the device.	It duplicates the device hardware, software, and operating system.
Faster compared to emulators.	Slower due to latency since it involves binary translation.

22. <u>VMware vCenter Converter</u>:

- Building a virtual machine from scratch can take several hours, as we have to perform very time consuming configurations and installations, like –
  I. Setting up the hardware parameters
  II. Installing the operating system
  III. Adding third-party applications to the OS

  We can reduce the amount of time spent creating and configuring virtual machines by cloning and importing physical or virtual systems to our hypervisors.
- VMware vCenter Converter is an application developed to migrate systems.
- VMware vCenter Converter converts local and remote physical machines into virtual machines without any downtime.
  - **Downtime**: Time during which production is stopped especially during setup for an operation or when making repairs.

- **<u>P2V and V2V Migration</u>:**

  vCenter Converter performs both **physical-to-virtual (P2V)** and **virtual-to-virtual (V2V)** migrations.

  - In a **P2V migration**, the operating system running on a physical system is copied to a virtual machine.
  - In a **V2V migration**, an existing virtual machine running on one virtualization platform is copied to a virtual machine running on another virtualization platform.

- **<u>Hot vs Cold Migrations</u>:**

  VMware vCenter Converter is capable of accomplishing both **hot migrations** and **cold migrations**.

  - **Hot migrations** are those which occur while the source system is in a running state.
    - Hot migrations are recommended for systems where local data remains static i.e., data that is not regularly updated or altered.

  - **Cold migrations** occur while the source system is offline.

- Cold migrations are ideal for systems (like SQL servers and mail servers) that have data that is regularly updated or altered.

NOTE: In IVCC Lab, we performed P2V Hot Migration.

23. Servers:

- A **server** is a software or hardware device that accepts and responds to requests made over a network.
  The device that makes the request, and receives a response from the server, is called a client.
- A **server** is a computer or system that provides resources, data, services, or programs to other computers, known as **clients**, over a network.

  They are called that because they "serve" another computer, device, or program called "client" to which they provide functionality.

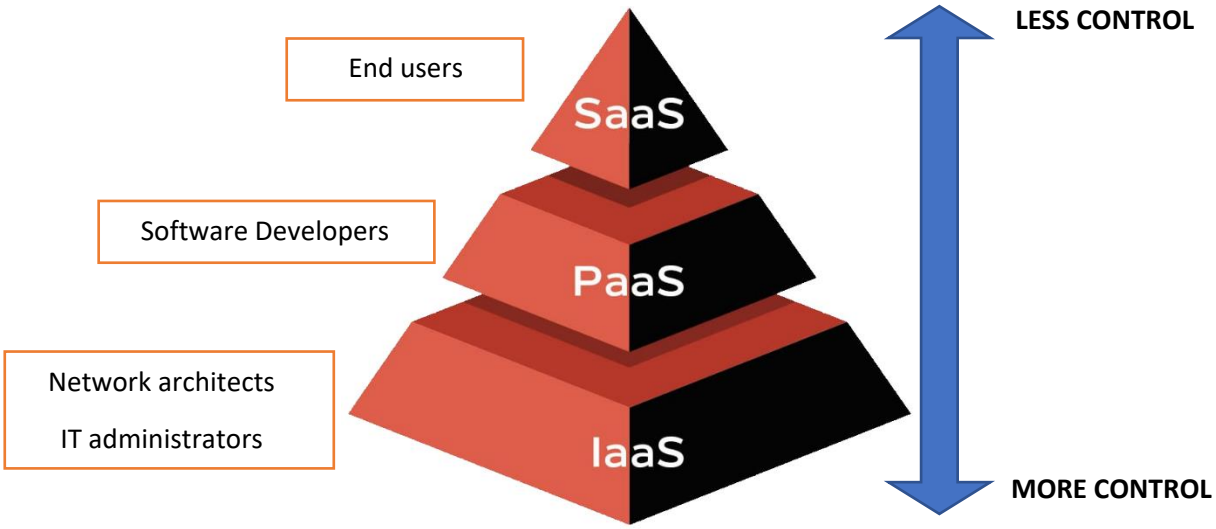
- In theory, whenever computers share resources with client machines, they are considered servers.
- **Servers manage network resources.**
- An individual system can provide resources and can also use resources from another system at the same time. This means that **a device could be both a server and a client at the same time**.

24. Client – Server Model:

- The Client-server model is a **distributed application structure** that partitions task or workload between the providers of a resource or service, called servers, and service requesters called clients.
  - A **distributed application** is a structure or an architecture in which components are hosted on different platforms and communicate through a network
- The client-server model describes how a server provides resources and services to one or more clients.
- In the client-server architecture, when the client computer sends a request for data to the server through the internet, the server accepts the requested process and deliver the data packets requested back to the client.

  Clients do not share any of their resources.

25. Cloud Pyramid:



26. Cloud Computing Service Models:

There are three main models for cloud computing. Each model represents a different part of the cloud computing stack.

1. **Infrastructure as a Service (IaaS):**
   - IaaS is also known as **Hardware as a Service (HaaS)**.
   - IaaS provides a completely virtualized computing infrastructure of virtual servers, network, operating systems and data storage drives that is provisioned and managed over the internet.
   - IaaS delivers customizable infrastructure on demand.
   - An IaaS provider manages the physical end of the infrastructure (servers, data storage space, etc) in a data center, but allows customers to fully customize those virtualized resources to suit their specific needs.
   - Customers are provided with virtualized hardware and storage on top of which they can build their infrastructure.
   - It is the **lowest level of the cloud services in the Cloud Pyramid**, where the IT administrators work.
   - IaaS eliminates the capital expense of building up in-house infrastructure.
   - IaaS allows businesses to purchase resources on-demand and as-needed instead of having to buy hardware outright.
   - Infrastructure as a Service provides you with the highest level of flexibility and management control over your IT resources.
   - **Example:**

     Amazon EC2 and S3 Bucket, Windows Azure, Rackspace, Google Compute Engine.

   - IaaS provider provides the following services -

a. **Compute:** Computing as a Service (CaaS) includes virtual central processing units and virtual main memory for the VMs that is provisioned to the end- users.
b. **Storage:** IaaS provider provides back-end storage for storing files.
c. **Network:** Network as a Service (NaaS) provides networking components such as routers, switches, and bridges for the VMs.
d. **Load balancers:** It provides load balancing capability at the infrastructure layer.

2. <u>Platform as a Service (PaaS)</u>:

- Platform as a Service (PaaS) provides a runtime environment.

OR

Platform-as-a-Service (PaaS) solutions provide a development and deployment platform for running applications in the cloud.

- It allows programmers to easily create, test, run, and deploy web applications without worrying about the OS, storage or updates.
- In PaaS, backend scalability is managed by the cloud service provider, so end-users do not need to worry about managing the infrastructure.
- It is at the **middle level of the cloud services in the Cloud Pyramid**, where the Programmers work.
- PaaS includes infrastructure (servers, storage, and networking) and platform (middleware, development tools, database management systems, business intelligence, and more) needed to create software applications.
- PaaS providers provide:
  a. Programming languages - Java, PHP, Ruby, Perl, and Go.
  b. Application **frameworks** - Node.js, Drupal, Joomla, WordPress, Spring, Play, Rack, and Zend.
     - **Framework** - a platform for developing software applications.
  c. Databases - ClearDB, PostgreSQL, MongoDB, and Redis.
  d. Other tools - Tools that are required to develop, test, and deploy the applications, these tools provide extensive pre-coded applications built into the platform, which can greatly reduce coding time and help companies get their products to market faster.
- **Examples:**

  AWS Elastic Beanstalk, Microsoft Azure, AWS Elastic Beanstalk, Force.com by Salesforce, Google App Engine, Rackspace Cloud Sites, OpenShift, and Apache Stratos.

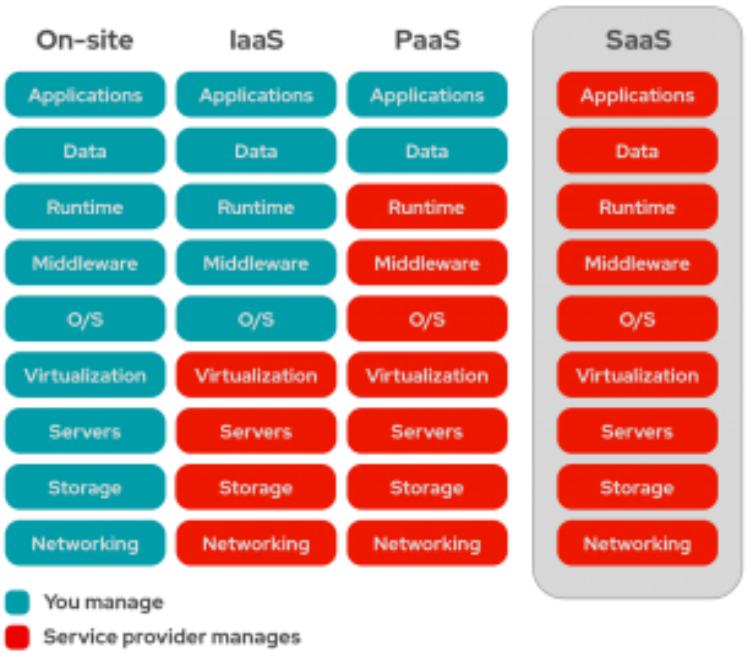
3. **Software as a Service (SaaS):**
   - SaaS is also known as "On-Demand Software".
   - Software as a Service (SAAS) is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network.
   - Typically, SaaS apps are web applications or mobile apps that users can access via a web browser.
   - A majority of SaaS applications run directly through your web browser, which means they do not require any downloads or installations on the client side.
   - It is the **top most level of the cloud services in the Cloud Pyramid**, where the end users work.
   - In this cloud service model, software is hosted online and made available to customers on a subscription basis or for purchase.
   - Examples:

     Microsoft Office 365, Google Drive, Gmail.

To sum up:

1. the **IaaS** model offers the computing resources companies need to host, build and run their services
2. the **PaaS** model provides an environment for developers to build and deploy applications
3. the **SaaS** model delivers software to users and companies over the Internet

So, that they do not need to worry about its management and maintenance.



27. Types of Cloud (or) Cloud Deployment:

1. Public Cloud:

- A public cloud is an environment made available over the internet, that anyone can subscribe to and then access.
- Companies provide both services and infrastructure, which are shared by all customers.
- Public clouds typically have massive amounts of available space, which translates into easy scalability.
- A public cloud is often recommended for software development and collaborative projects.
- **Example:** Amazon Web Services, Microsoft Azure, Google Cloud Platform.

- **Advantages of public clouds:**
    - **Lower costs** — no need to purchase hardware or software and you pay only for the service you use.
    - **No maintenance** — your service provider provides the maintenance.
    - **Near-unlimited scalability** — on-demand resources are available to meet your business needs.
    - **High reliability** — a vast network of servers ensures against failure.

2. Private Cloud:

- A private cloud, as the name implies, is the infrastructure used by just one organization.
- A private cloud consists of cloud computing resources used exclusively by one business or organisation.

- The private cloud can be physically located at your organisation's on-site datacenter or it can be hosted by a third-party service provider.

  But in a private cloud, the services and infrastructure are always maintained on a private network and the hardware and software are dedicated solely to your organisation.

- Private clouds are often used by government agencies, financial institutions, any other mid- to large-size organisations with business-critical operations seeking enhanced control over their environment.
- **Example:** Amazon Virtual Private Cloud (VPC)

- **Advantages of a private cloud:**

- **More flexibility** — your organisation can customise its cloud environment to meet specific business needs.
- **More control** — resources are not shared with others, so higher levels of control and privacy are possible.
- **More scalability** — private clouds often offer more scalability compared to on-premises infrastructure.

3. **Hybrid Cloud:**
   - A hybrid cloud is a type of cloud computing that combines on-premises infrastructure i.e., a private cloud with a public cloud.
   - **Hybrid cloud = Public cloud + Private cloud**
   - They are designed to allow the two platforms to interact seamlessly, with data and applications moving smoothly from one to the other.
   - A hybrid cloud is a seemingly single IT environment created from multiple environments (i.e., Public cloud and Private cloud) connected through local area networks (LANs), wide area networks (WANs), virtual private networks (VPNs), and/or APIs, so that they can interact seamlessly.
   - Hybrid clouds allow data and apps to move between the two environments.
   - This type of cloud deployment is used so that the companies can operate confidential operations like financial reporting on a **private cloud** and high-volume, less sensitive workloads like web-based email or even temporary workloads such as development and test on a **public cloud**.

   - **Advantages of the hybrid cloud:**
     - **Control** — your organisation can maintain a private infrastructure for sensitive assets or workloads that require low latency.
     - **Flexibility** — you can take advantage of additional resources in the public cloud when you need them.
     - **Cost-effectiveness** — with the ability to scale to the public cloud, you pay for extra computing power only when needed.
     - **Ease** — transitioning to the cloud does not have to be overwhelming because you can migrate gradually—phasing in workloads over time.

28. Multiclouds:

- Multiclouds are a cloud approach made up of more than 1 cloud service, from more than 1 cloud vendor — public or private.
- All hybrid clouds are multiclouds, but not all multiclouds are hybrid clouds.
- Multi-clouds always include more than one public cloud service, which often perform different functions. Multi-clouds do not have to include a private cloud component, but they can, in which case they can be both multi-cloud and hybrid cloud.

- It is a complex cloud solution; it demands a great level of management and security which isn't accessible to all companies.

NOTE: **Cloud Orchestration** is the process of automating the tasks needed to manage connections and operations of workloads on private and public clouds.

29. Cloud Bursting:

- Cloud bursting is an application deployment technique in which an application runs in a private cloud or data center and bursts into a public cloud when the demand for computing capacity spikes.
- In cloud computing, cloud bursting is a configuration which is set up between a private cloud and a public cloud to deal with peaks in IT demand.

  If an organisation using a private cloud reaches 100 percent of its resource capacity, the overflow traffic is directed to a public cloud so there is no interruption of services.

- Once the spike in resource demands diminish, the application is moved back to the private cloud or on-premises infrastructure.
- We call it "bursts" because it can be triggered automatically and quickly in reaction to high demand usage or by a manual request.
- In addition to flexibility and self-service functionality, the key advantage to cloud bursting is economical savings. You only pay for the additional resources, you used.

30. Multi-tenancy:

- In cloud computing, multitenancy means that multiple customers of a cloud vendor are using the same computing resources.
- Despite the fact that they share resources, cloud customers aren't aware of each other, and their data is kept totally separate.

31. Resource Pooling:

- Resource Pooling is the grouping together of resources for the purposes of maximizing advantage or minimizing risk to the users.
- The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.
- Resource pooling is when cloud providers offer provisional and scalable services to multiple clients or customers.

In other words, space and resources are pooled to serve multiple clients at one time.

Depending on a client's resource consumption, usage can be set to provide more or less at any given time.

32. Application Service Providers (ASPs):

- An application service provider (ASP) is a company that offers individuals or enterprises access to applications and related services over the internet.
- An application service provider (ASP) is defined as an enterprise that delivers application functionality and associated services across a network to multiple customers using a rental or usage-based transaction-pricing model.
- The term "ASPs" has largely been replaced by software as a service (SaaS) provider, although in some parts of the world, companies still use the two labels interchangeably.

NOTE:

1. **Benjamin Black**, the man who wrote a short paper that outlined a way to restructure Amazon's infrastructure, and at the end "mentioned the possibility of selling virtual servers as a service."

This resulted in the formation of Amazon Web Services, which started as an IaaS provider.

Today, the same company has generated a revenue of 13.5 billion for Q1 2021 and had generated 45 billion U.S. dollars in 2020.

Benjamin Black, the man whose idea made Jeff Bezos richest man on the planet.

2. **Microsoft** started as SaaS provider.

33. IT System Integrators:

- A **systems integrator** is an individual or business that builds computing systems for clients by combining hardware, software, networking and storage products from multiple vendors.
- Some major System Integrators are:
    a. **Anderson Consulting**, which was acquired and rebranded as "**Accenture**" in 2001.

b. In 1982, the U.S. Army awarded its landmark $656 million Project Viable contract to **Electronic Data Systems (EDS)**. That 10-year deal established EDS as a systems integrator.
c. **SHL Systemhouse** was acquired by **MCI Communications** and was subsequently sold to **Electronic Data System (EDS)** in 1999. EDS was purchased by **Hewlett Packard Enterprise** in 2008 for $13.9 billion and became **HP Enterprise Services**.
d. In 2017, **Computer Science Corp. (CSC)** merged with HP Enterprise Services to create DXC Technology.

34. <u>Cloud Broker</u>:

- A **cloud broker** is a third-party individual or business that acts as an intermediary between the purchaser of a cloud computing service and the sellers of that service.

- In general, a broker is someone who acts as an intermediary between two or more parties during negotiations.