Course Code	Course Name	Credit
ADC501	Cloud Computing	03

Pre-requisite: Operating System	
Course Objectives: To understand cloud computing techniques	
1	To comprehend Characteristics and Concept of cloud techniques.
2	To understand levels of virtualization
3	To correlate the connection of cloud service providers
4	To understand cloud implementation
5	To explore security and risk involved with cloud computing
Course Outcomes: After successful completion of the course, student will be able to:	
1	Differentiate between different cloud computing techniques.
2	Understand virtualization and its key concepts
3	Compare various cloud computing providers/software.
4	Handle open source cloud implementation and administration.
5	Understand risks involved in cloud computing.

Module		Detailed Content	Hours
1		**Introduction to Cloud Computing and virtualization**	06
	1.1	Introduction– Component of CC, Comparing CC with Virtualization, Grids, Utility Computing, client-server model, P to P Computing, Impact of CC on Business, Key Drivers for Cloud Computing, Cloud computing Service delivery model. Cloud Types – Private, Public and Hybrid, when to avoid public cloud, Cloud AP	
	1.2	Introduction & benefit of Virtualization, Implementation Levels of Virtualization, VMM Design Requirements and Providers, Virtualization at OS level, Middleware support for Virtualization, Virtualization structure/tools and mechanisms: Hypervisor and Xen Architecture, Binary Translation with full Virtualization, Para Virtualization with Compiler Support. Virtualization of CPU, Memory and I/O Devices, Hardware support for Virtualization in Intel x86 processor, CPU Virtualization, Memory Virtualization	
2		Cloud computing Services and business value	8
	2.1	XaaS, IaaS, PaaS- Leveraging PaaS for Productivity Languages for PaaS- DBaaS(Database as a services) – SaaS (Software as a service) – Comparison of various cloud computing providers/ Softwares.	
	2.2	Key Business Drivers for CC- Cloud computing and out sourcing – Types of Scalability – Security issues in Cloud Computing- time to Market Benefits- Distribution over Internet – Three levels of Business value from Cloud computing.	

3		Cloud Deployment Techniques	07
	3.1	Factors for Successful Cloud Deployment – Network Requirements – Potential Problem areas in a cloud Network and their Mitigation – Cloud Network Topologies – Automation and Self-service feature in a cloud –cloud performance. Mobile Cloud Computing Introduction, Definition, Architecture, Benefits, challenges in mobile and at cloud shield	
4		**Security**	07
	4.1	Security for Virtualization Platform – Host security for SaaS, 4 PaaS and IaaS – Data Security – Data Security Concerns – Data Confidentiality and Encryption – Data Availability – Data Integrity – Cloud Storage Gateways – Cloud Firewall Security as a service What can security as service offer- Benefits for Security as a service Issues with Security as a Service- Identity Management as a Service	
5		**Cloud Programming**	05
	5.1	Programming Support for Google Apps engine: GFS, Big 4 Tables, Google"s NO SQL System, Chubby, Google Distributed Lock Service, Programming Support for Amazon EC2: Amazon S3, EBS and Simple DB etc	
6		Architecture for Cloud Application:	06
	6.1	Cloud Application requirements- Architecture for traditional Vs Cloud Applications Multi-ties Application Architecture SOA for Cloud applications – Resource oriented SOA – Method –oriented SOA and Event Driven SOA – Parallelization within Cloud Applications – Leveraging In memory Operations for Cloud Application	
	6.2	IIoT : What is the I-IoT? Use cases of the I-IoT,IoT and I-IoT – similarities and differences	

Textbooks:	
1	Cloud computing: concepts, Technology and architecture : The Pearson Service Technology Series from Thomas Erl) 1st Edition
2	Cloud computing for Dummies

References:	
1	Rajkumar Buya," Cloud computing principles and Paradigms", Wiley.
2	Kai Hwang," Distributed and cloud computing", MK Publications.
3	Cloud computing, black book, Dreamtech publication.
4	Using Google Apps engine O"reilly Publication

Internal Assessment:
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

Continuous Assessment:-
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

Sr.no	Rubrics	Marks
1.	*Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC	10 marks
2.	Content beyond syllabus presentation	10 marks
3.	Creating Proof of concept	10 marks
4.	Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion	10 marks
5.	Multiple Choice Questions (Quiz)	5 marks
6.	GATE Based Assignment test/Tutorials etc	10 marks

For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

End Semester Theory Examination:	
1	Question paper will be of 60 marks
2	Question paper will have a total of five questions
3	All questions have equal weightage and carry 20 marks each
4	Any three questions out of five needs to be solved.

Module No.	Module Name	Hours	Marks
1	Introduction to Cloud Computing and virtualization	6	15
2	Cloud computing Services and business value	8	21
3	Cloud Deployment Techniques	7	18
4	Security	7	18
5	Cloud Programming	5	13
6	Architecture for Cloud Application	6	15
Total Hours and Marks		**39**	**100**

Module 1
Introduction to Cloud Computing and virtualization

SUBJECT: CLOUD COMPUTING

MR. AJINKYA VALANJOO

Overview

- Introduction to Cloud Computing
- Cloud characteristics
- Cloud computing components
- Comparing of cloud computing with Peer to peer architecture, Client server, Distributed, Grid
- Cloud Deployment Model – Public, Private, Community, Hybrid
- Service Models – SaaS, PaaS, IaaS

Need of cloud

Suppose you want to host a website, you need following things:

Buy a stack of servers.

High traffic? More servers.

Monitoring and Maintain servers.

Need of cloud

Problems we were facing before cloud computing are:

If you consider costs then this setup is expensive.

Troubleshooting problems can be tedious and may conflict with your business goals.

Since the traffic is varying, your servers will be idle most of the time.

why cloud

Files

music

E-books

Videos

Applications

Podcasts

Introduction to cloud

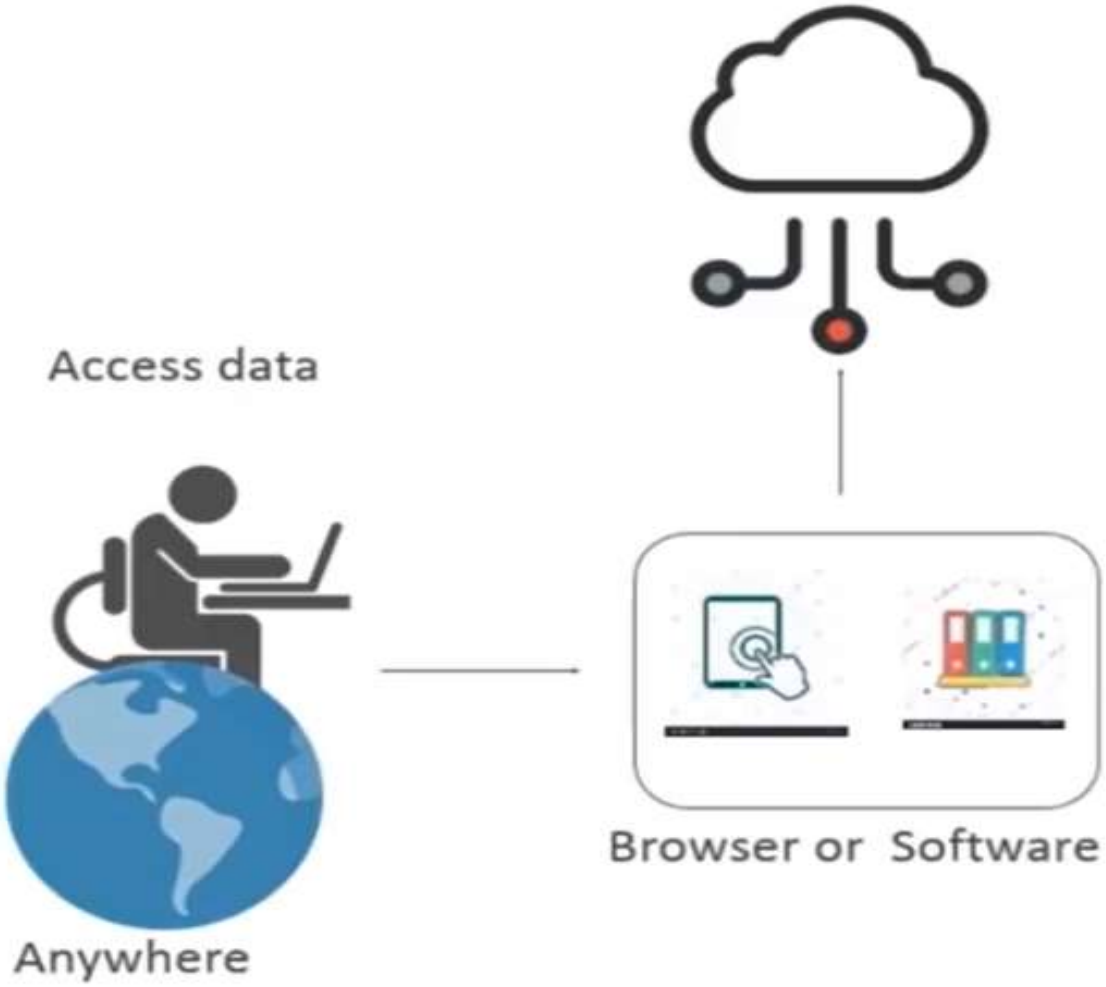
What is Computing?

Includes designing and building hardware / software for a wide range of purposes, processing, structuring and managing various kinds of information

- Distributed Computing
- Grid Computing
- Cluster Computing
- Utility Computing
- Cloud Computing

Cloud computing

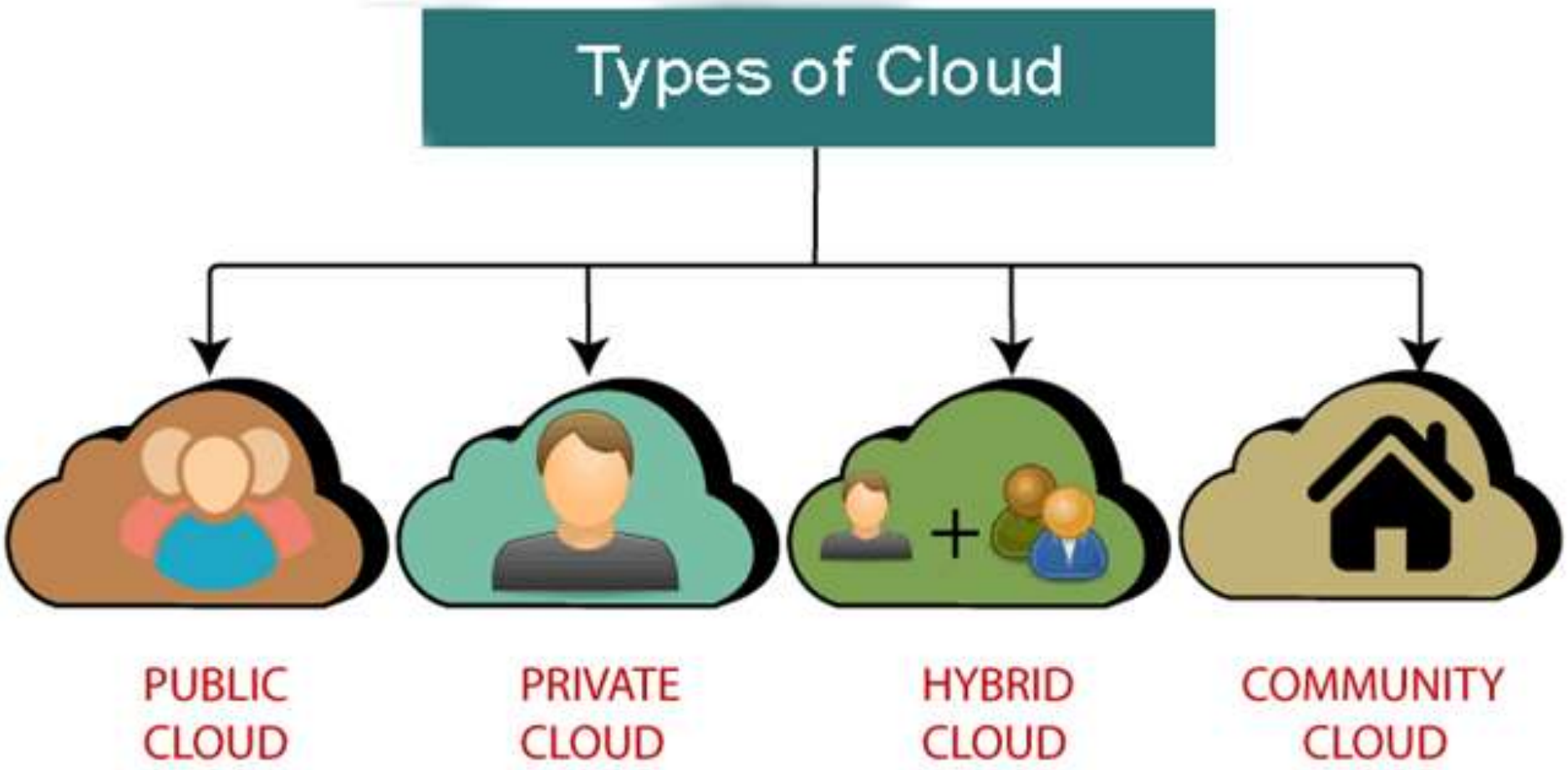
- Storting data/applications on remote servers
- Processing data/applications from servers
- Accessing data/applications via internet



Introduction to cloud

- **The term Cloud refers to a Network or Internet.**
- A cloud is something that exists in a remote area.
- Cloud can provide services over public and private networks, i.e., WAN, LAN or VPN.
- Applications such as e-mail, web conferencing, customer relationship management (CRM) execute on cloud.

Types of Cloud



Cloud Deployment Models

- Public Cloud
- Private Cloud
- Community Cloud
- Hybrid Cloud

1. Public Cloud

- The public cloud infrastructure makes systems and **services available to anyone** with an internet connection.
- **Because of its openness, the public cloud is much less secure.**

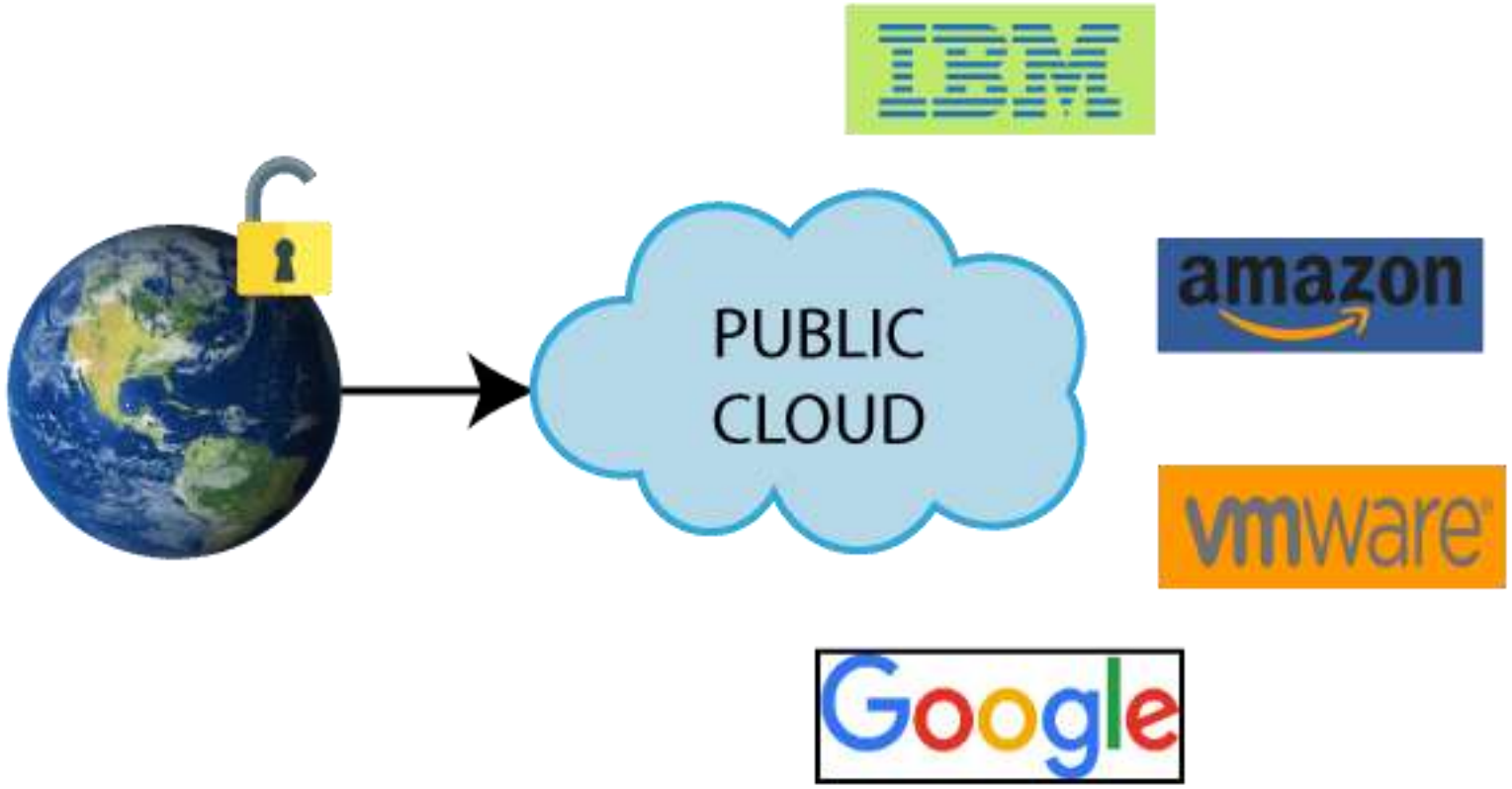
Example: Microsoft, Google App Engine, Windows Azure Services Platform.

Public Cloud

The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.

E.g. Microsoft Azure, AWS, Google clouds etc.

1. Public Cloud



2. Private cloud

- The private cloud infrastructure makes **systems and services available to anyone within an organization.**
- Because of this private characteristic, it is more secure.

Examples: OpenNebula, OpenStack are some examples of this style of deployment.

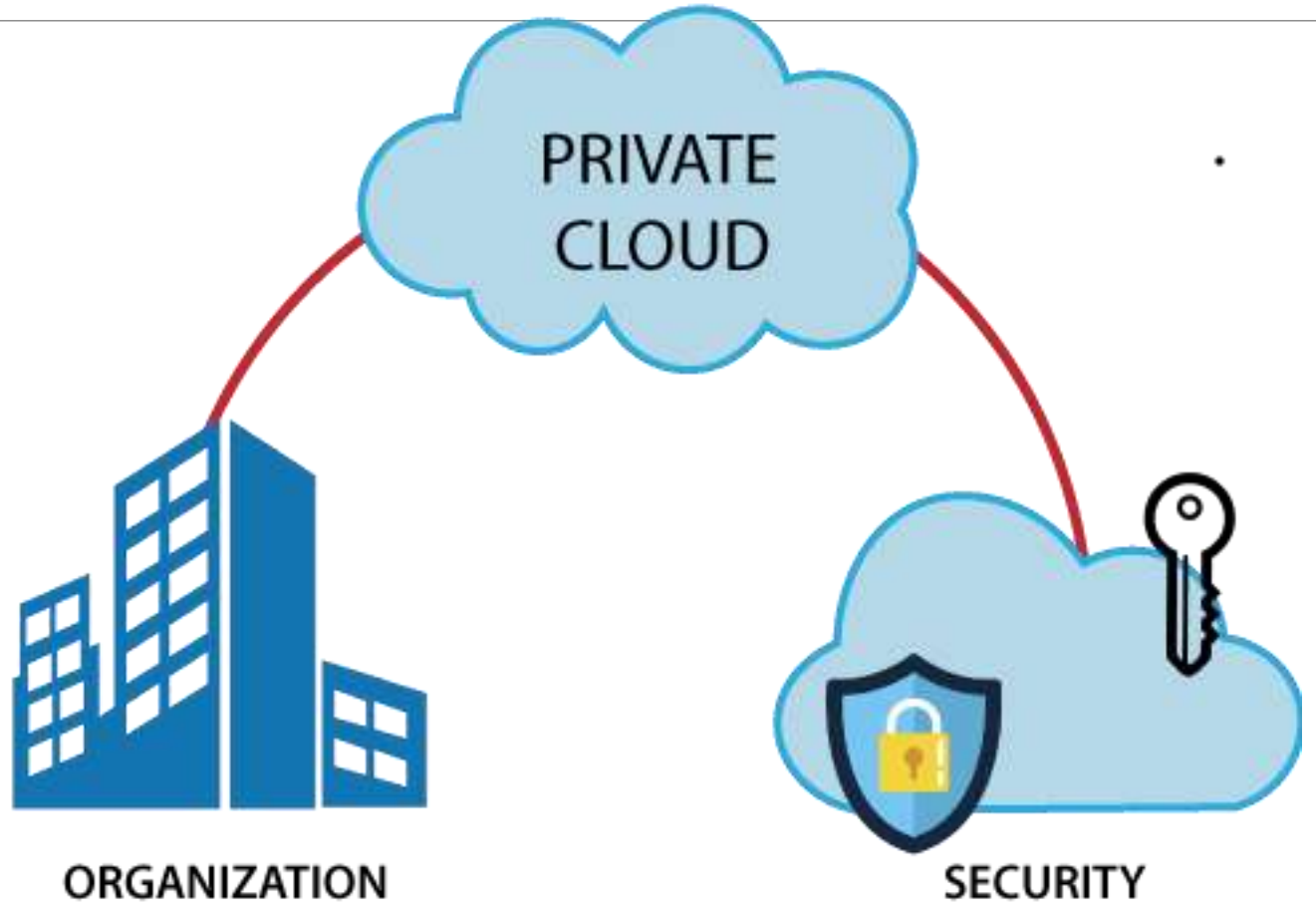
Private Cloud

The cloud infrastructure is operated solely for a single organization. It may be managed by the organization or a third party, and may exist on-premises or off-premises.

It has high level of security and privacy.

E.g. HP data centers

2. Private cloud

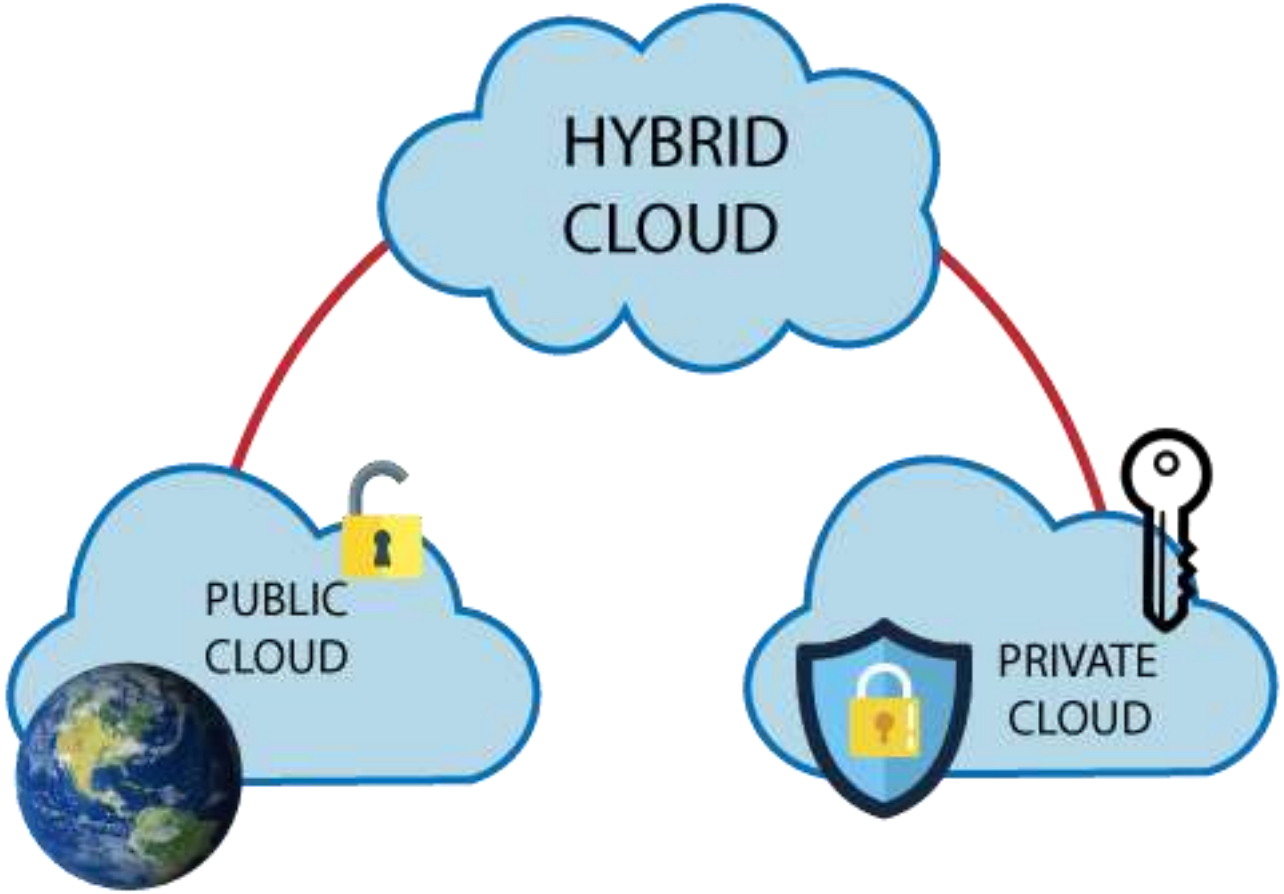


3. Hybrid Cloud

- **Two or more clouds are combined to make up a hybrid cloud infrastructure.**
- **In the majority of cases, public and private clouds blend to make a hybrid cloud, where the private cloud handles crucial tasks and the public cloud handles non-critical tasks.**

Examples: Google Application Suite (Gmail, Google Apps, and Google Drive), Office 365 (MS Office on the Web and One Drive), Amazon Web Services.

3. Hybrid Cloud



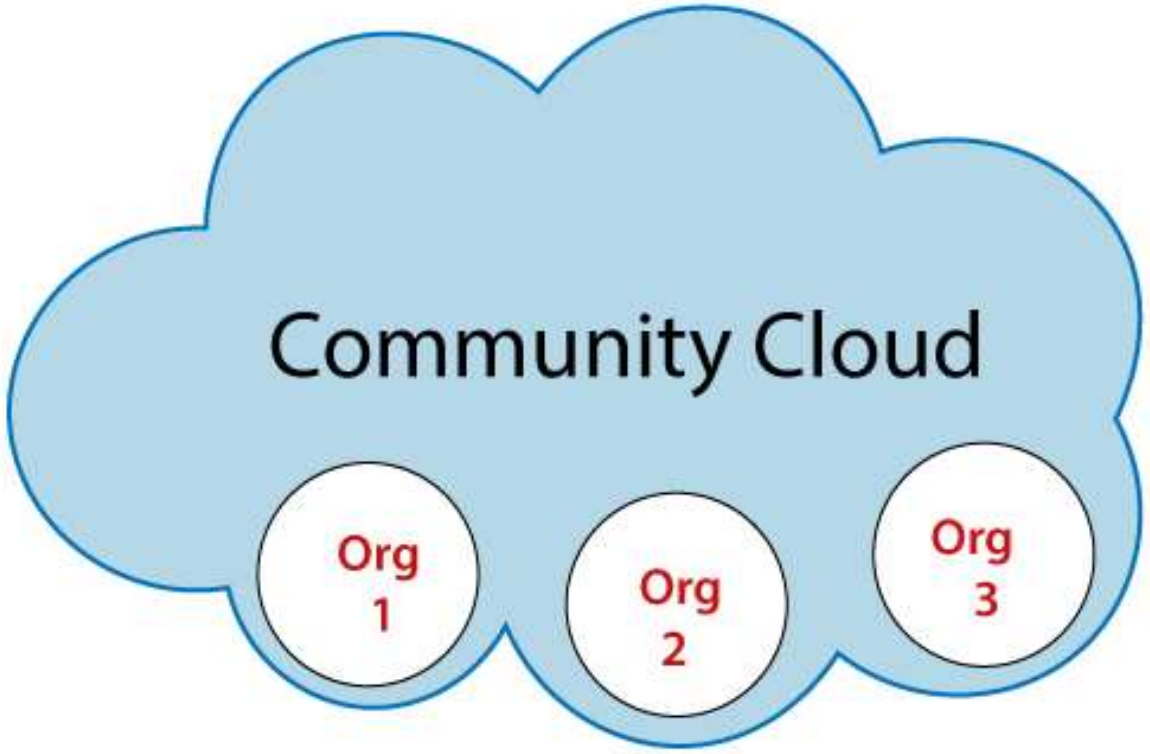
4. Community Cloud

- The community cloud infrastructure makes systems and services available to anyone within a group of organizations.
- It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.
- It allows us to share cloud resources, infrastructure, and other capabilities among various organizations.

Example: Health Care community cloud

4. Community Cloud

Community clouds are multi-tenant platforms and make it possible for various companies to function on a shared platform.



Community Cloud

The cloud infrastructure is made available to multiple organizations where they share resources and services based on common operational and regulatory requirements.

E.g. IBM SoftLayer cloud

Cloud Computing

“The cloud computing service has grown nearly 80% year-over-year in the last two quarters, and is on pace to hit $7.8 billion in revenue in 2015, four times the 2012 sales of $1.8 billion.”

Cloud Computing

NITS (National Institute of Standards and Technology) defines Cloud Computing as;

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

Characteristics

- **On-demand self-service:**

A consumer can unilaterally provision computing capabilities, such as server time and network storage, **as needed automatically without requiring human interaction with each service provider**

- **Broad network access:**

Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client **platforms (e.g., mobile phones, tablets, laptops, and workstations).**

- **Resource pooling**

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**

Continue..

- **Rapid elasticity:**

- Capabilities can be rapidly and elastically provisioned - in some cases automatically - **to quickly scale out; and rapidly released to quickly scale in.**

-To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time

- **Measured service:**

-**Cloud systems automatically control and optimize resource usage** by leveraging a metering capability at some level of abstraction appropriate to the type of service

- **Resource usage can be monitored, controlled, and reported - providing transparency for both the provider and consumer of the service**

Some other common characteristics

- Massive scale
- Resilient computing
- Homogeneity
- Geographic distribution
- Virtualization
- Service orientation
- Low cost software
- Advanced security

Client Server model vs. Cloud model

Client server model

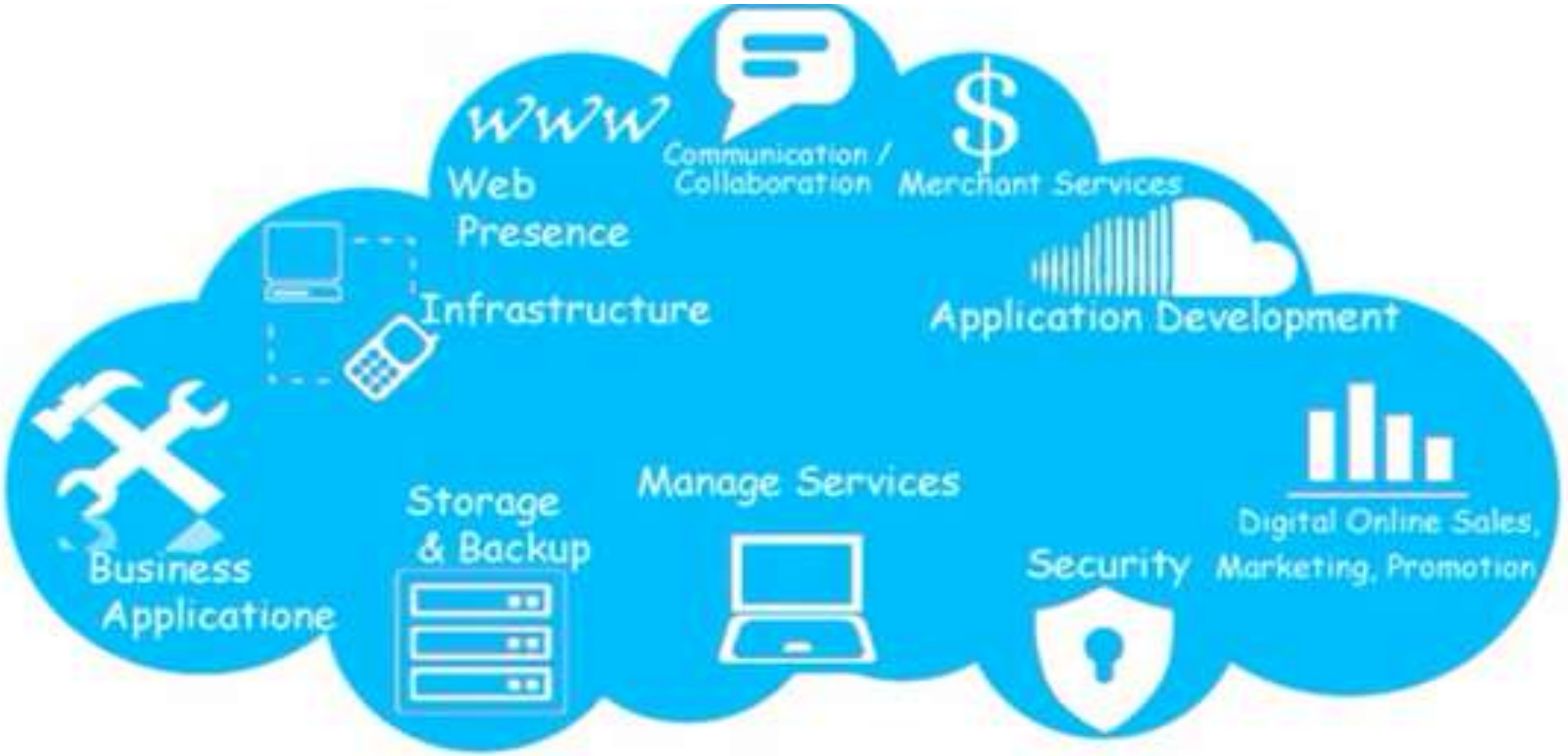
- Simple service model where server services client requests
- May/may not be load balanced
- Scalable to some extent in a cluster environment.
- No concept of virtualization

Cloud computing model

- Variety of complex service models, such as, IaaS, PaaS, SaaS can be provided
- Load balanced
- Theoretically infinitely scalable
- Virtualization is the core concept

Cloud Services

Cloud services covers a wide range of services that a service provider delivers to the customer via the internet.



Cloud Service models

Three main cloud services:

Software as a Service

Platform as a Service

Infrastructure as a Service

Types of Service model

It stands for 'Software as a Service'

- On demand service
- Independent Platform
- No need to install on PC
- Resources Managed by vendor

Who Uses It?

- End Customers

Types of Service model

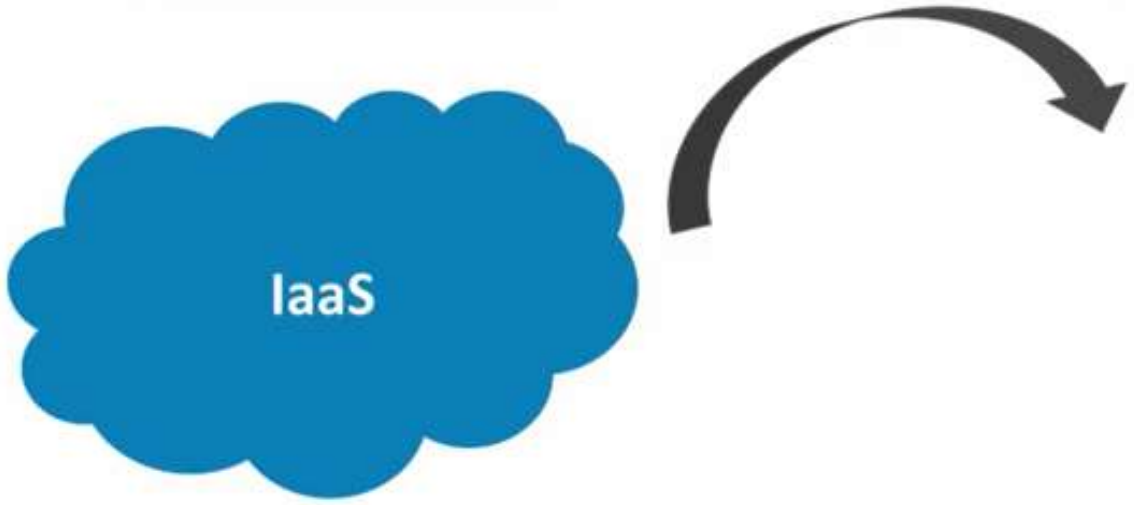
It stands for 'Platform as a Service'

- Programming language + OS + Server + Database
- Provides Encapsulation
- Build, compile & run programs
- Users manage data & application resources

Who Uses It?

- Developers

Types of Service model



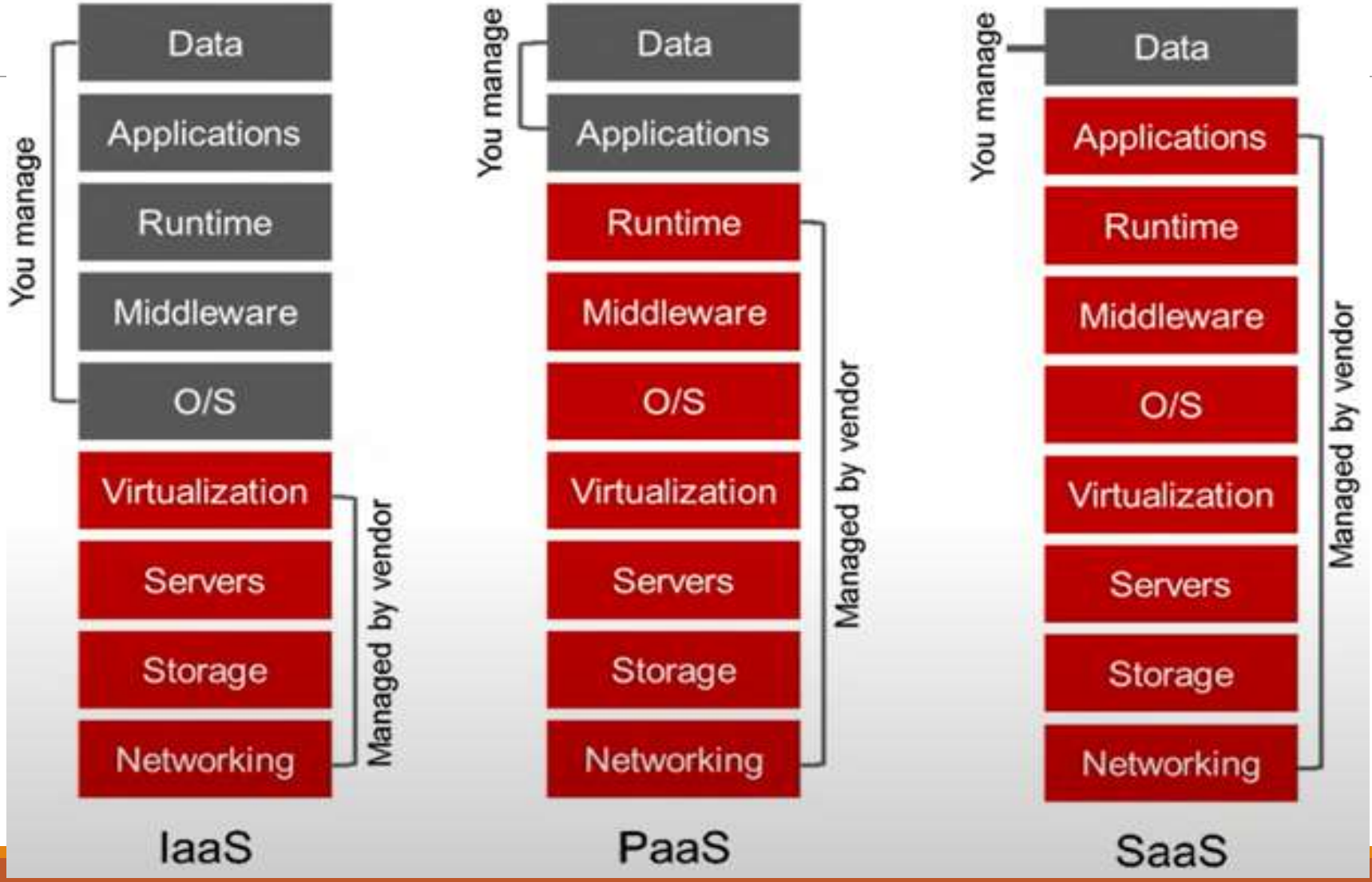
It stands for 'Infrastructure as a Service'

- Provides Computing Architecture & Infrastructure
- Data storage + Virtulization + Servers + Networking
- Vendors manage above resources
- Users handle data & middleware

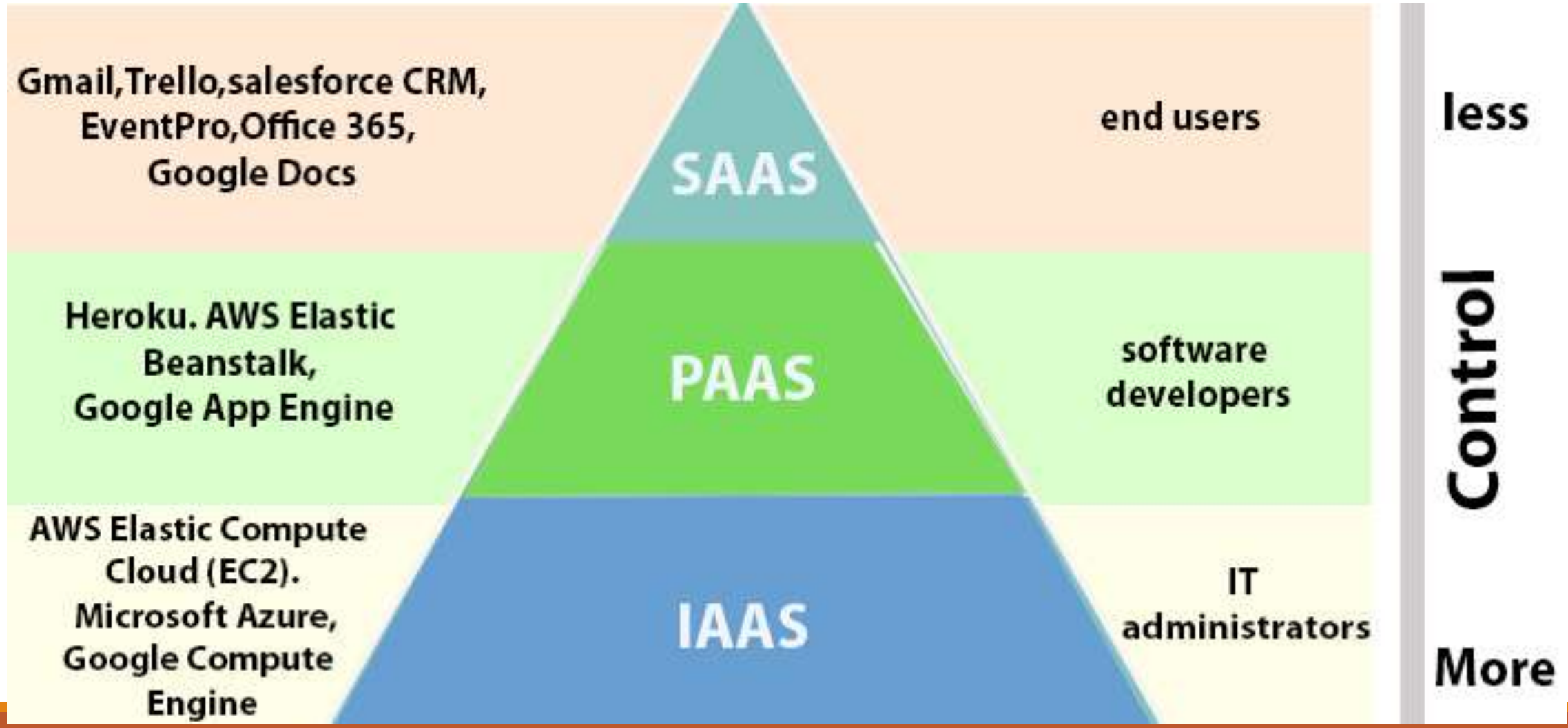
Who Uses It?

- System administrators

Types of Cloud Services



Types of Service model



Cloud Service Models

1. Cloud **S**oftware as a Service (**S**aaS)
2. Cloud **P**latform as a Service (**P**aaS)
3. Cloud **I**nfrastructure as a Service (**I**aaS)

	Services	Description
Application Focused	Services	Services – Complete business services such as PayPal, OpenID, OAuth, Google Maps, Alexa
	Application	Application – Cloud based software that eliminates the need for local installation such as Google Apps, Microsoft Online
	Development	Development – Software development platforms used to build custom cloud based applications (PAAS & SAAS) such as SalesForce
Infrastructure Focused	Platform	Platform – Cloud based platforms, typically provided using virtualization, such as Amazon ECC, Sun Grid
	Storage	Storage – Data storage or cloud based NAS such as CTERA, iDisk, CloudNAS
	Hosting	Hosting – Physical data centers such as those run by IBM, HP, NaviSite, etc.

Software as a Service (SaaS)

- The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure.
- The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email).
- The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

Platform as a Service (PaaS)

- The capability provided to the consumer is to deploy onto the cloud infrastructure consumer created or acquired applications created using programming languages and tools supported by the provider

- The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations

Infrastructure as a Service (IaaS)

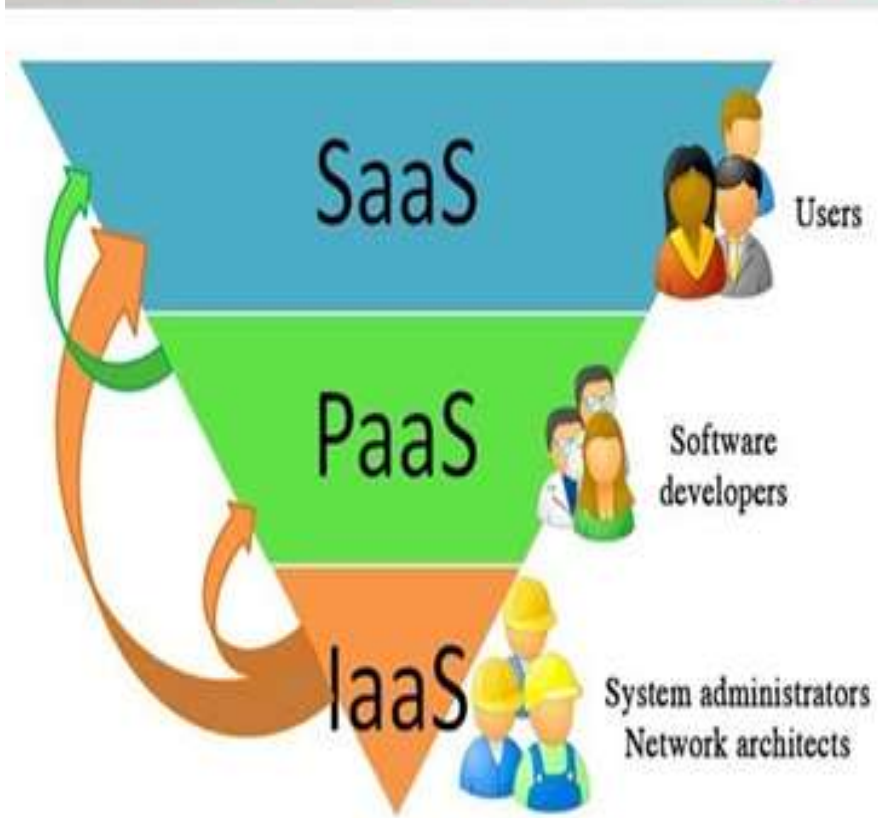
- The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources.

- Consumer is able to deploy and run arbitrary software, which can include operating systems and applications

- The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls)


On Premises
Infrastructure as a Service
Platform as a Service
Software as a Service
APPLICATIONS
DATA
RUNTIME
MIDDLEWARE
O/S
VIRTUALIZATION
SERVERS
STORAGE
NETWORKING
YOU MANAGE
OTHERS MANAGE

Cloud Computing Services Models



Software as a Service (SaaS)

Google
Gmail
facebook

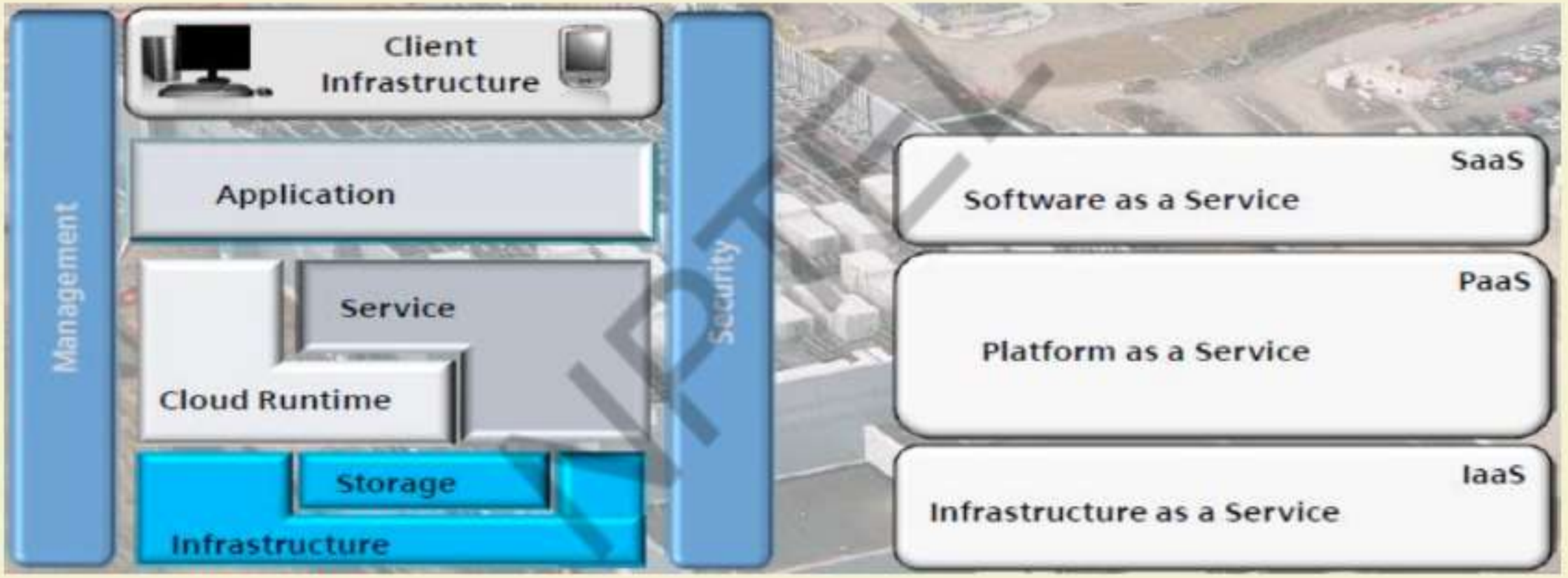
Platform as a Service (PaaS)

Google App Engine
force.com platform as a service
Windows Azure

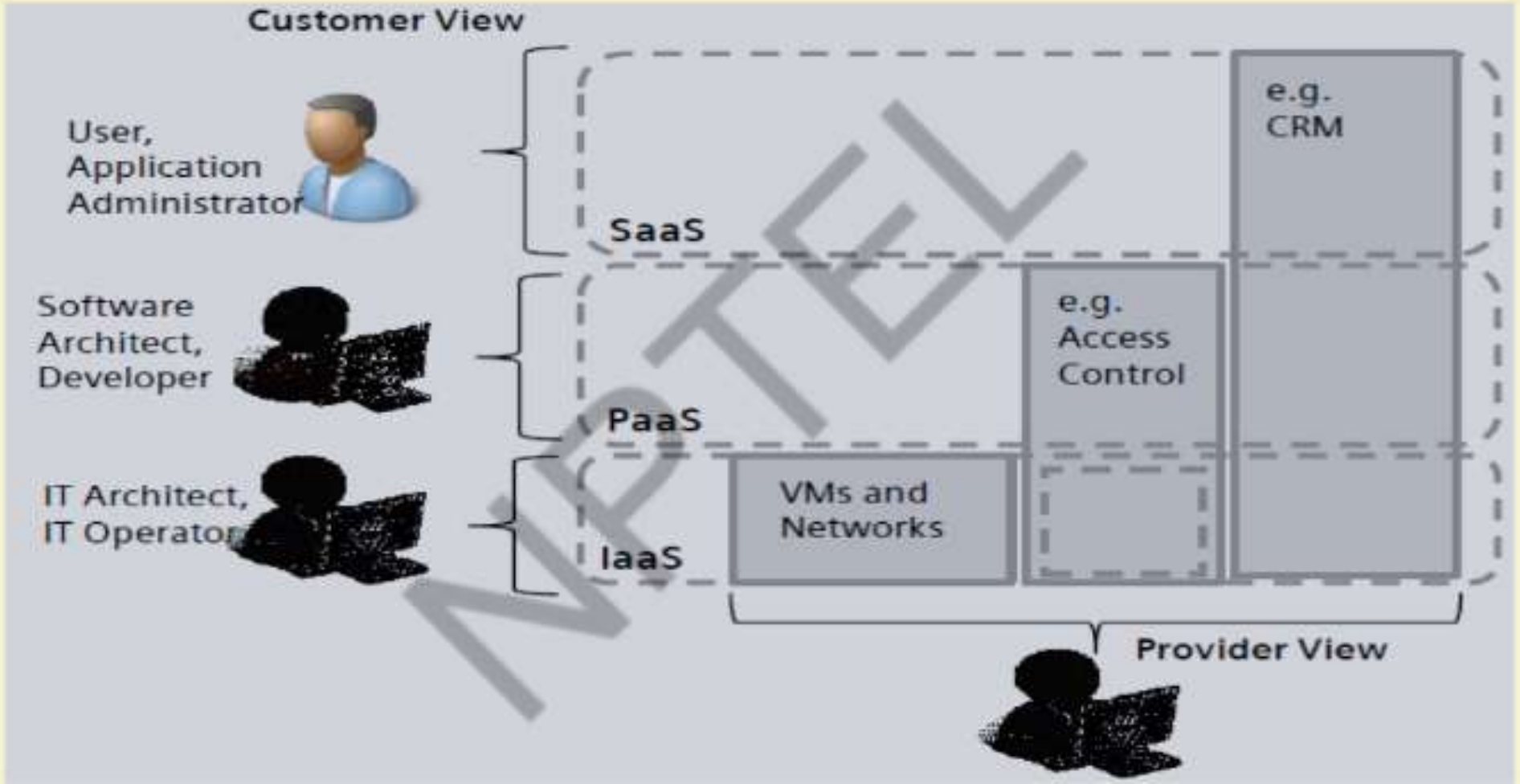
Infrastructure as a Service (IaaS)

at&t
amazon web services
Rackspace cloud

Cloud Computing Architecture - XaaS



XaaS Stack views: Customer view vs Provider view



Architecture for elasticity

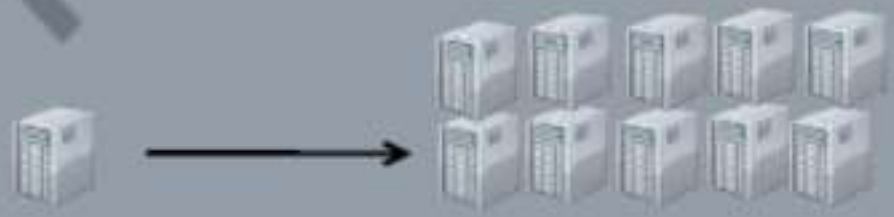
Vertical Scale Up

- Add more resources to a single computation unit i.e. Buy a bigger box
- Move a workload to a computation unit with more resources

For small scenarios scale up is probably cheaper - code "just works"

Horizontal Scale Out

- Adding additional computation units and having them act in concert
- Splitting workload across multiple computation units
- Database partitioning

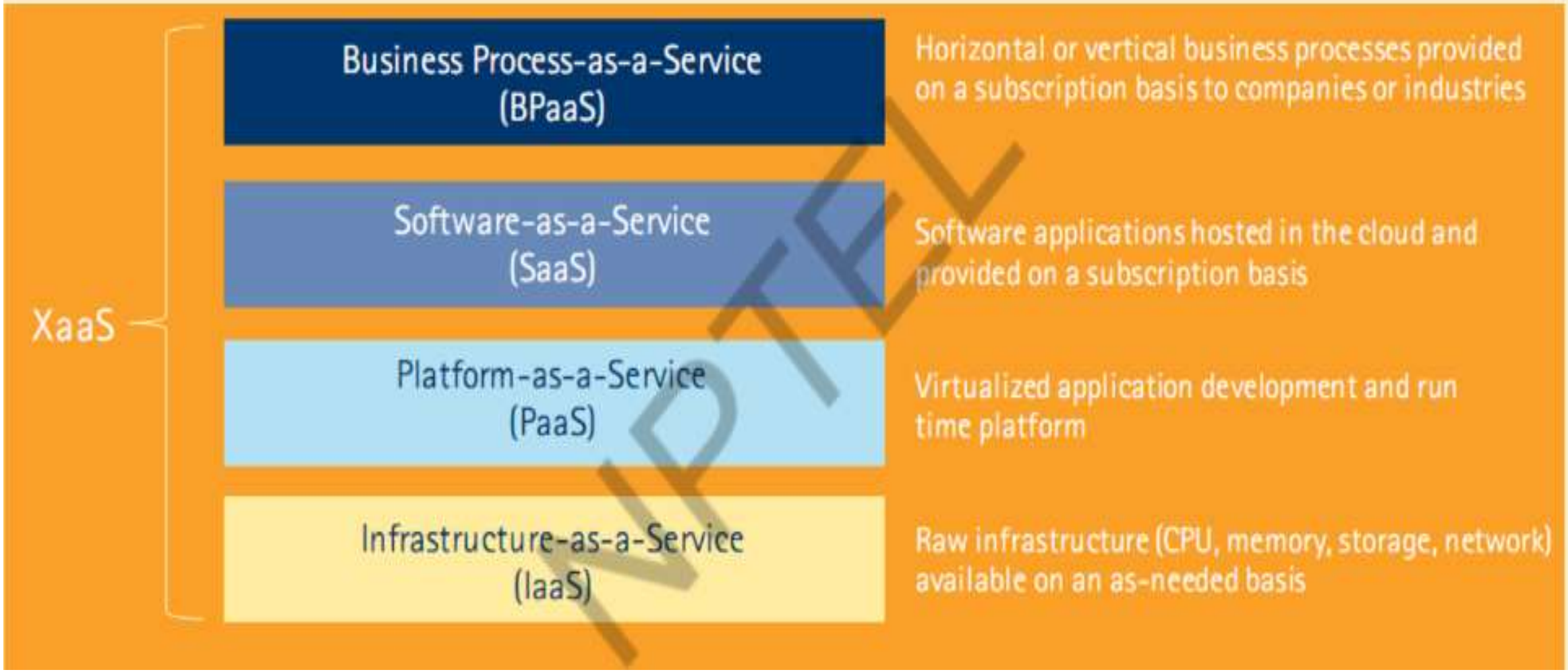


For larger scenarios scale out is the only solution
1x64 Way Server much more expensive that 64x1 Way Servers

Service Models (XaaS)

- Combination of Service-Oriented Infrastructure (SOI) and cloud computing realizes to XaaS.
- X as a Service (XaaS) is a generalization for cloud-related services
- XaaS stands for "anything as a service" or "everything as a service“
- XaaS refers to an increasing number of services that are delivered over the Internet rather than provided locally or on-site
- XaaS is the essence of cloud computing.

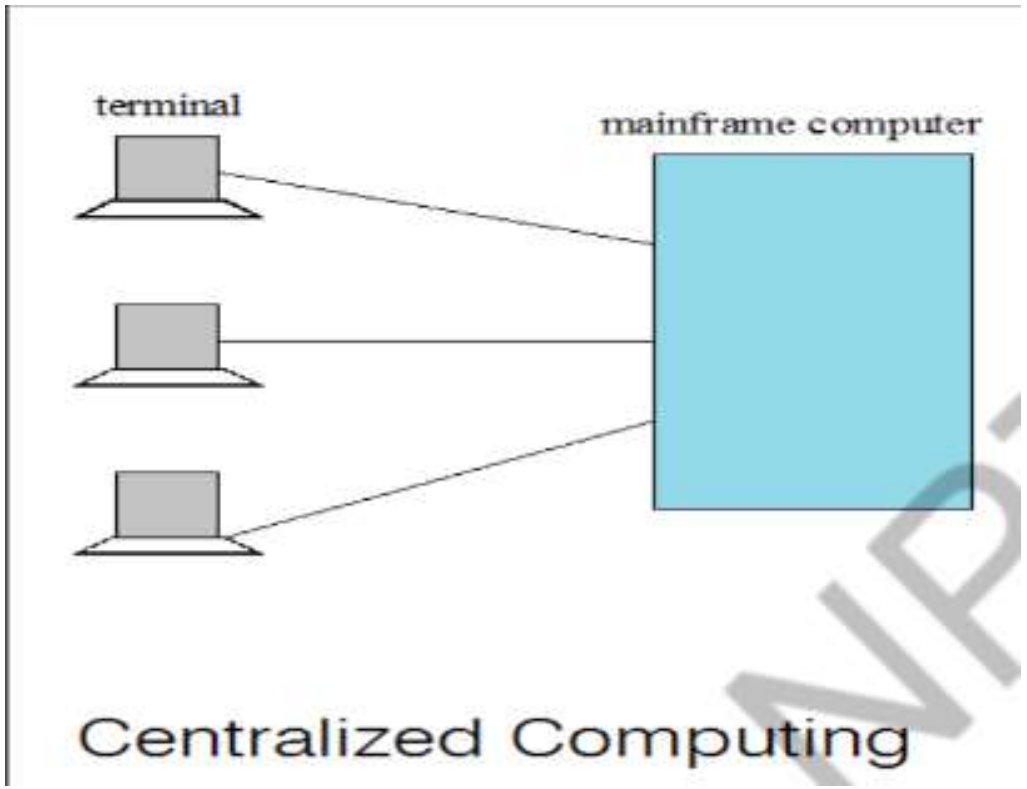
Service Models (XaaS)

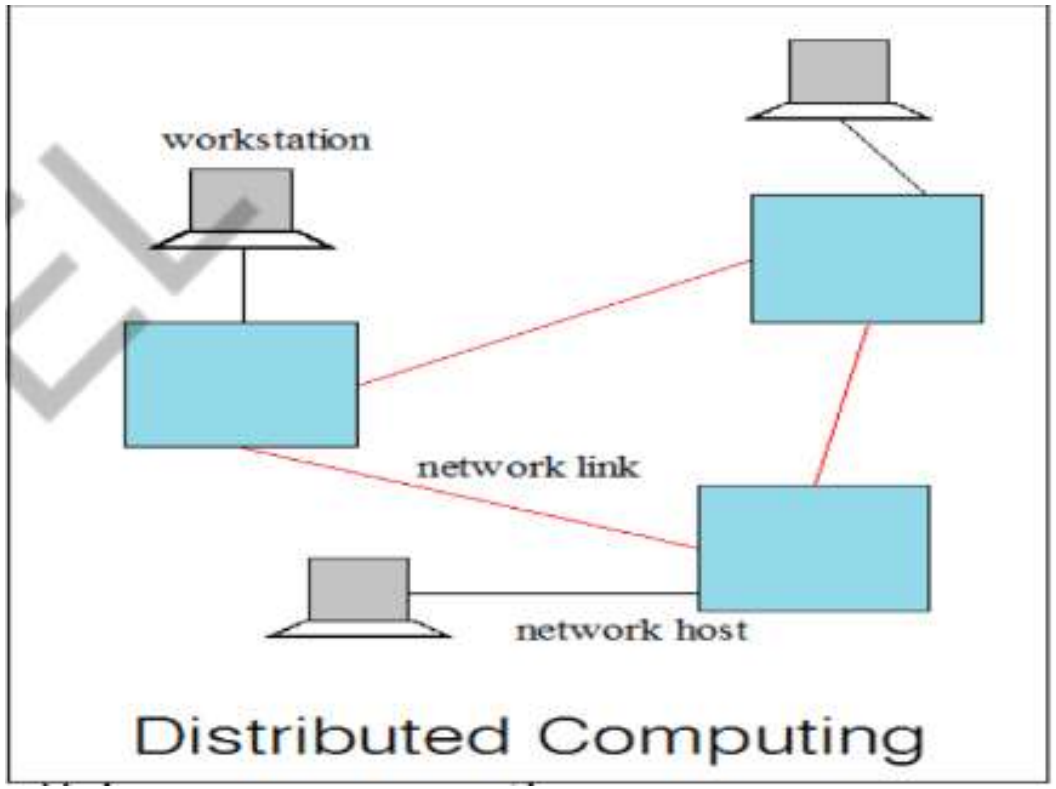


Requirements of CSP (Cloud Service Provider)

- Increase productivity
- Increase end user satisfaction
- Increase innovation
- Increase agility

Centralized Vs Distributed Computing



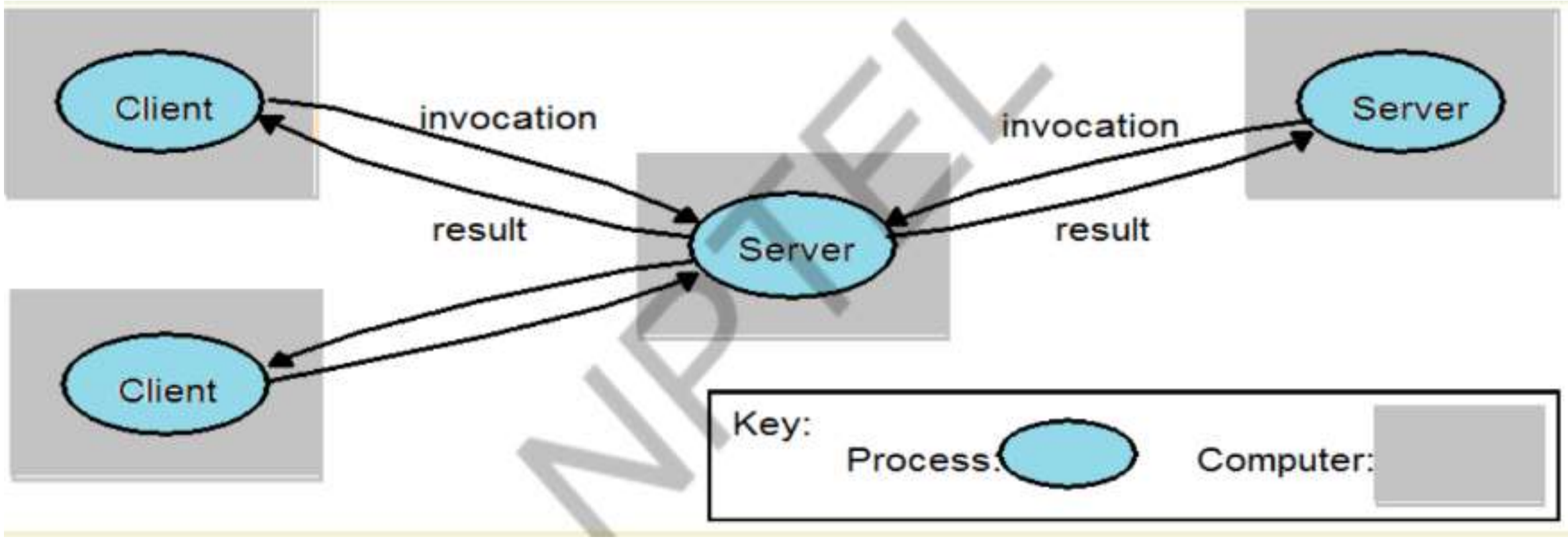


Distributed computing

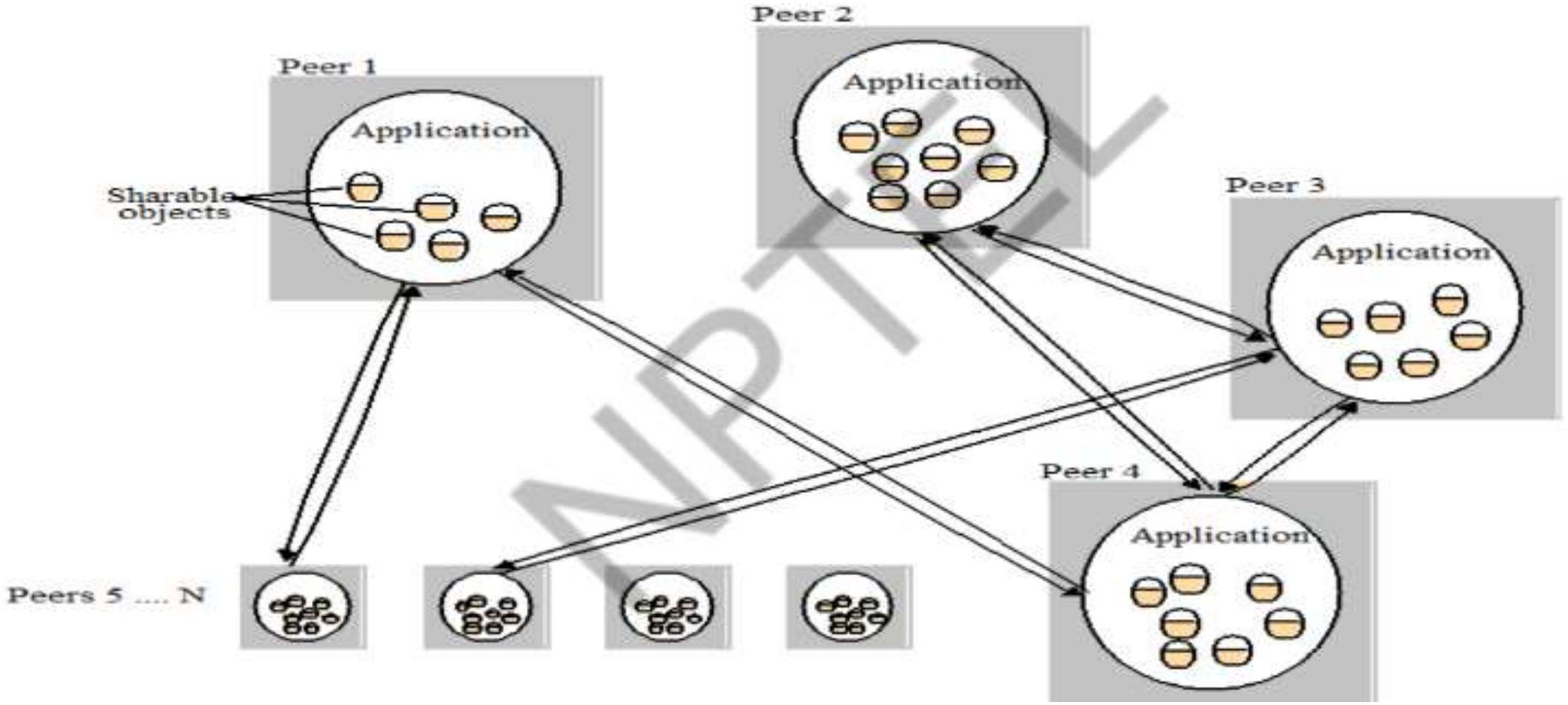
- Controlling and managing is distributed
- Uni processor is not a concept
- Distributed Processor carries its own local memory and storage
- It provides computing services in distributed manner
- Each processor communicates with another processor through high speed lines
- Components: Workstations, Servers, Personal assistant devices
- Examples: Internet, ATM machines, Intranet

Distributed applications

1. Clients invoke individual servers



2. A typical distributed application based on peer processes



Grid Computing

- Grid computing harnesses unused processing cycles of all computers in a network for solving problems too intensive for any stand-alone machine

Electrical Power Grid

- Users (or electrical appliances) get access to electricity through wall sockets with no care or consideration for where or how the electricity is actually generated.
- **"The power grid"** links together power plants of many different kinds

Grid

- Users (or client applications) gain access to computing resources (processors, storage, data, applications, and so on) as needed with little or no knowledge of where those resources are located or what the underlying technologies, hardware, operating system, and so on are
- **"The Grid"** links together computing resources (PCs, workstations, servers, storage elements) and provides the mechanism needed to access them.

Application of Grid computing

- Today's Science/Research is based on computations, data analysis, data visualization & collaborations
- Computer Simulations & Modelling are more cost effective than experimental methods
- Scientific and Engineering problems are becoming more complex & users need more accurate, precise solutions to their problems in shortest possible time
- Data Visualization is becoming very important
- Exploiting under utilized resources

Cluster Computing

- A cluster is a type of parallel or distributed computer system, which consists of a collection of inter-connected stand-alone computers working together as a single integrated computing resource
- Key components of a cluster include multiple standalone computers (PCs, Workstations, or SMPs), operating systems, high-performance interconnects, middleware, parallel programming environments, and applications.
- Clusters are usually deployed to improve speed and/or reliability over that provided by a single computer
- Basic building blocks of clusters are broken down into multiple categories:

• Cluster Nodes

• Cluster Network

• Network Characterization

Utility Computing

- Utility Computing is purely a concept which cloud computing practically implements
- Utility computing 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.
- Some highlights:

a) Pay-for-use Pricing Business Model

b) Data Center Virtualization and Provisioning

c) Solves Resource Utilization Problem

d) Outsourcing

e) Web Services Delivery

f) Automation

- **Drawbacks: Data Backup , Data Security, Partner Competency, Defining SLA**

Advantages

- Lower Computer cost
- Improved software updates
- Improved document format capabilities
- Unlimited storage capacity
- Increased data reliability
- Universal information access
- Latest version availability
- Easier group collaboration
- Device independance

Drawback

- Requires constant internet connection
- Does not work well with low speed
- Features might be limited
- Can be slow
- Security
- Stored data can be lost

Virtualization

Introduction to Virtualization

- Virtualization is the process of creating a virtual environment of something which may include hardware platforms, storage devices, OS, network resources, etc.

- It is the process of creating a virtual instance of a device, such as a virtual server or virtual operating system.

Need of Virtualization

Virtualization

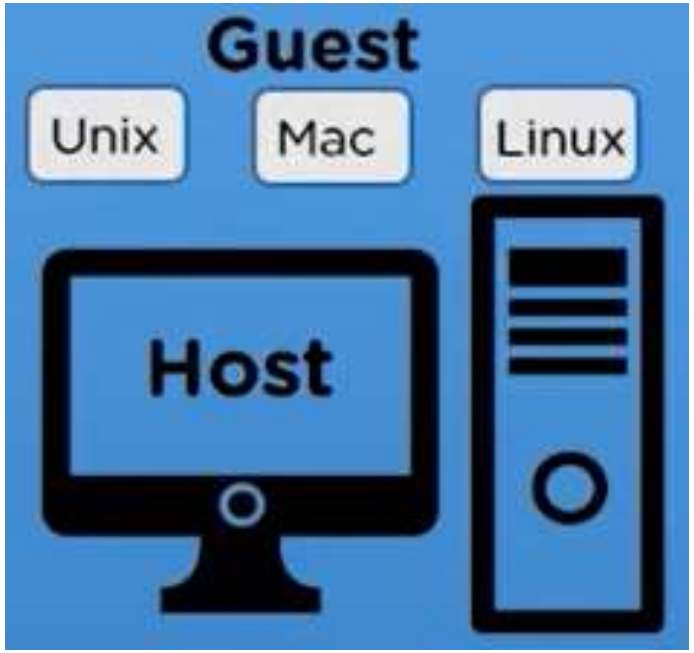
- Virtualization creates virtual layer using hypervisor software which manages resources assigned to virtual instances.
- The newly formed virtual representation is called as virtual machine (VM).
- **Virtual machine** is an emulation or virtual representation of physical system.

Benefits of Virtualization

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

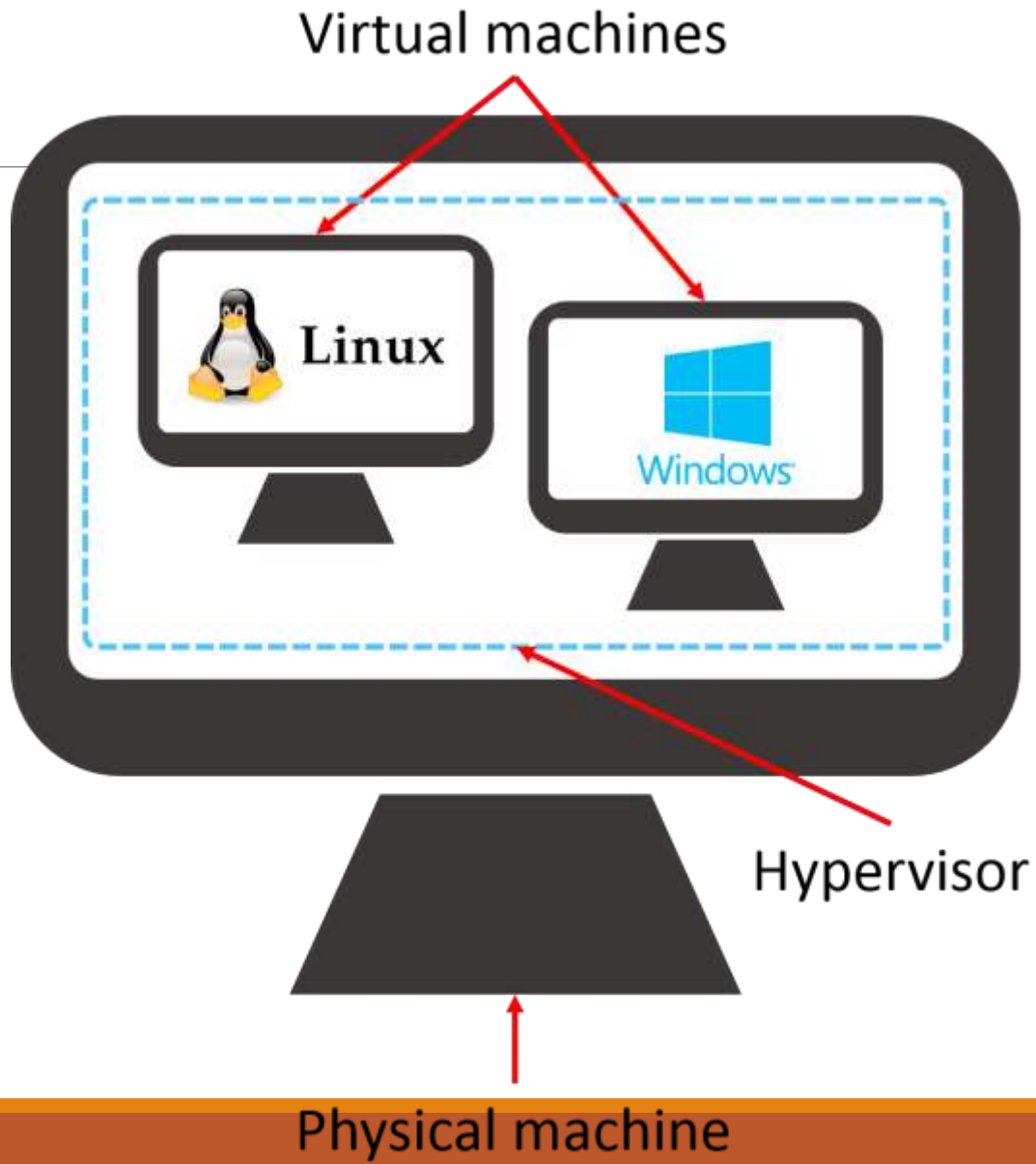
Hypervisor

- The virtual machine is referred as a **guest machine** and physical machine on which the virtual machine is created is known as **host machine**.
- The virtual machine is managed by a software or firmware, which is known as **Hypervisor**.



Hypervisor

Hypervisor is a firmware or low-level program that acts as a Virtual Machine Manager (VMM).

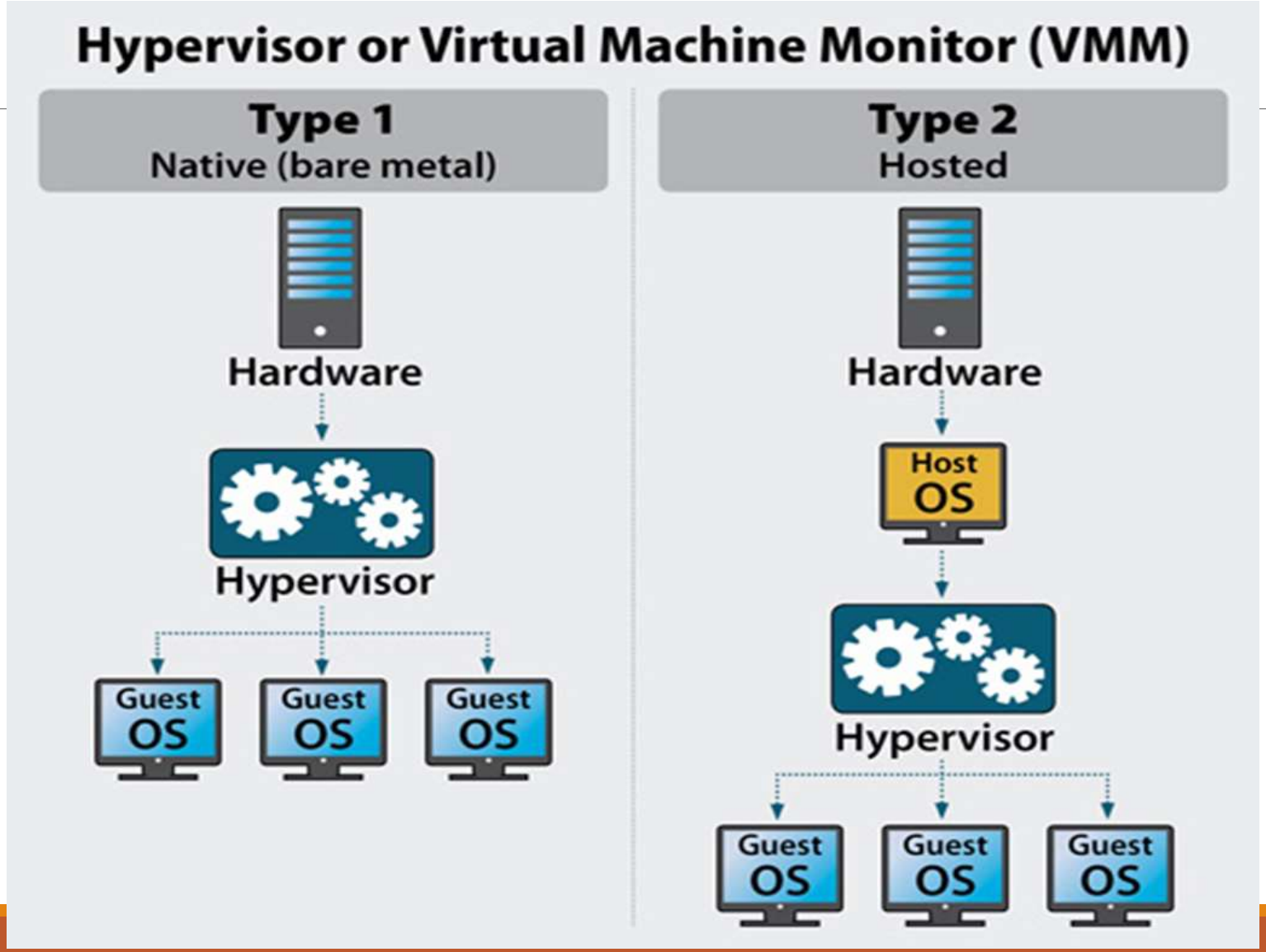


Hypervisor

There are two types of hypervisor:

1. **Type 1 hypervisor** / Native/Bare-Metal Hypervisors
2. **Type 2 hypervisor /** Hosted Hypervisors

Hypervisor


Hypervisor or Virtual Machine Monitor (VMM)
Type 1
Native (bare metal)
Hardware
Hypervisor
Guest OS
Guest OS
Guest OS
Type 2
Hosted
Hardware
Host OS
Hypervisor
Guest OS
Guest OS
Guest OS

1. Type 1 Hypervisor

- They are deployed directly over the host hardware.
- Direct access to the hardware without any underlying OS or device drivers makes such hypervisors highly efficient for enterprise computing.
- VMware ESXi, Microsoft Hyper-V, Oracle VM, and Xen are examples of type 1 hypervisors.

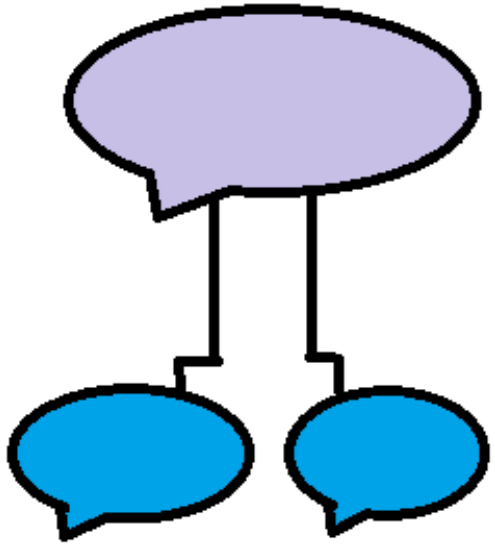
2. Type 2 Hypervisor

- They run as an application over a traditional OS.
- Developers, security professionals, or users who need to access applications only available on select OS versions often rely on type 2 hypervisors for their operations.
- KVM, VMware Server and Workstation, Microsoft Virtual PC, Oracle VM VirtualBox, and QEMU are popular type 2 hypervisors.

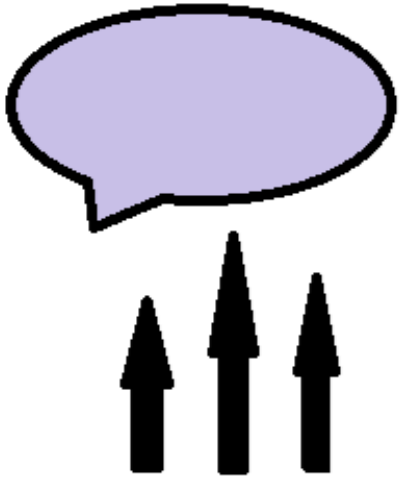
Types of virtualization

DESKTOP
VIRTUALIZATION

APPLICATION
VIRTUALIZATION



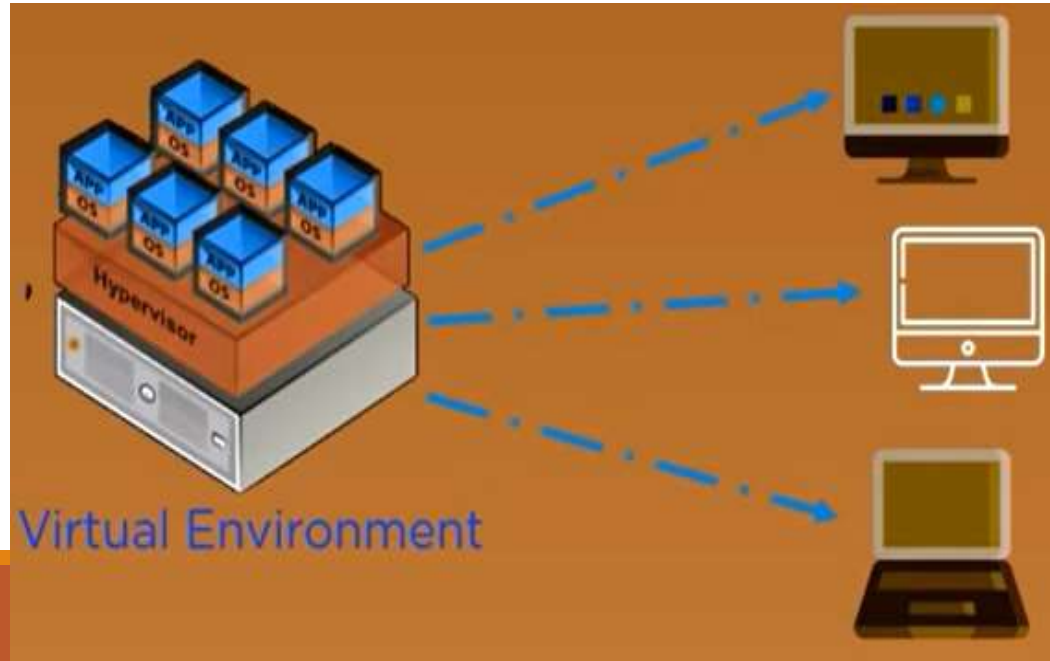
NETWORK
VIRTUALIZATION



STORAGE
VIRTUALIZATION

1. Desktop virtualization

- It allows us to run multiple desktop OS in each VM.
- t allows the user to access their desktop virtually, from any location by a different machine.
- Users who want specific operating systems other than Windows Server will need to have a virtual desktop.
- Main benefits of desktop virtualization are user mobility, portability, easy management of software installation, updates, and patches.



2. Network virtualization

- It basically refers to a system where one can run multiple virtual networks at the same time and each of these networks have a separate control system and data plan.
- It also helps you keep a better track of things on the network and allow for good supervision as well as identification of the data usage.
- Example : firewall

3. Storage virtualization

- Storage virtualization is an array of servers that are managed by a virtual storage system.
- The servers aren’t aware of exactly where their data is stored, and instead function more like worker bees in a hive.

4. Application virtualization

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

Thank You!