Cloud Computing

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Agenda

- Motivation
- Introduction to cloud
- Building blocks
- Deployment models
- Service models
- Virtualization
- Types of Hypervisors
- Cloud Vendors
- Hands-on experiments on cloud (Amazon AWS)
- Building machine learning models in Azure

Motivation

- Just like water, electricity, mobile and gas, Internet has become a basic necessity in today's society.
- IT industries needs to invest time and budget to scale up their infrastructure, i.e. hardware, software and services.
- This is usually slow, and utilization of these scaled resources may vary.

- Imagine you have developed a small Android chat application like Whatsapp, that will generate huge amount of data each day as it is being used by users extensively.
- So in order to store all the data, you keep increasing your hard disks capacity and pool more number of storage resources every time. Now, Where are you going to place all these storage servers? Lets say, you have somehow managed to get a big space to place your servers. Now, how are you going to maintain these resources?

How many of you know about Big Billion days and Amazon Great Indian sale?

- Flipkarts network traffic is 10 times that of a normal day during the Diwali sale.
- So how do they manage the traffic requests?

ANS: Assume, if they need 1 server to handle requests during normal days, they need to install 10 more such servers to handle the traffic for a Diwali sale.

Is the above answer cost effective and time effective?

What else can they do?

Use Cloud.
Cloud…Megam…Baadhal

- What is this Cloud?
  - This is not something new. Its just a coined, fancy word for Internet or Web.
  - In other words, we can say that Cloud is something, which is present at remote location. Cloud can provide services over public and private networks, i.e., WAN, LAN or VPN.
  - Cloud is a new consumption and delivery model.

How many of you know Amazon Prime video, Netflix, Hotstar etc.?

- Where are they storing all the movies, TV shows, Music etc. which counts to hundreds of Terabytes of data.

What is cloud computing?

- Cloud Computing refers to **manipulating, configuring,** and **accessing** the hardware and software resources remotely. It offers online data storage, infrastructure, and applications.

"I don't care where my servers are, who manages them, where my documents are stored, or where my applications are hosted. I just want them always available and access them from any device connected through Internet. And I am willing to pay for this service for as a long as I need it"

Formal Definition

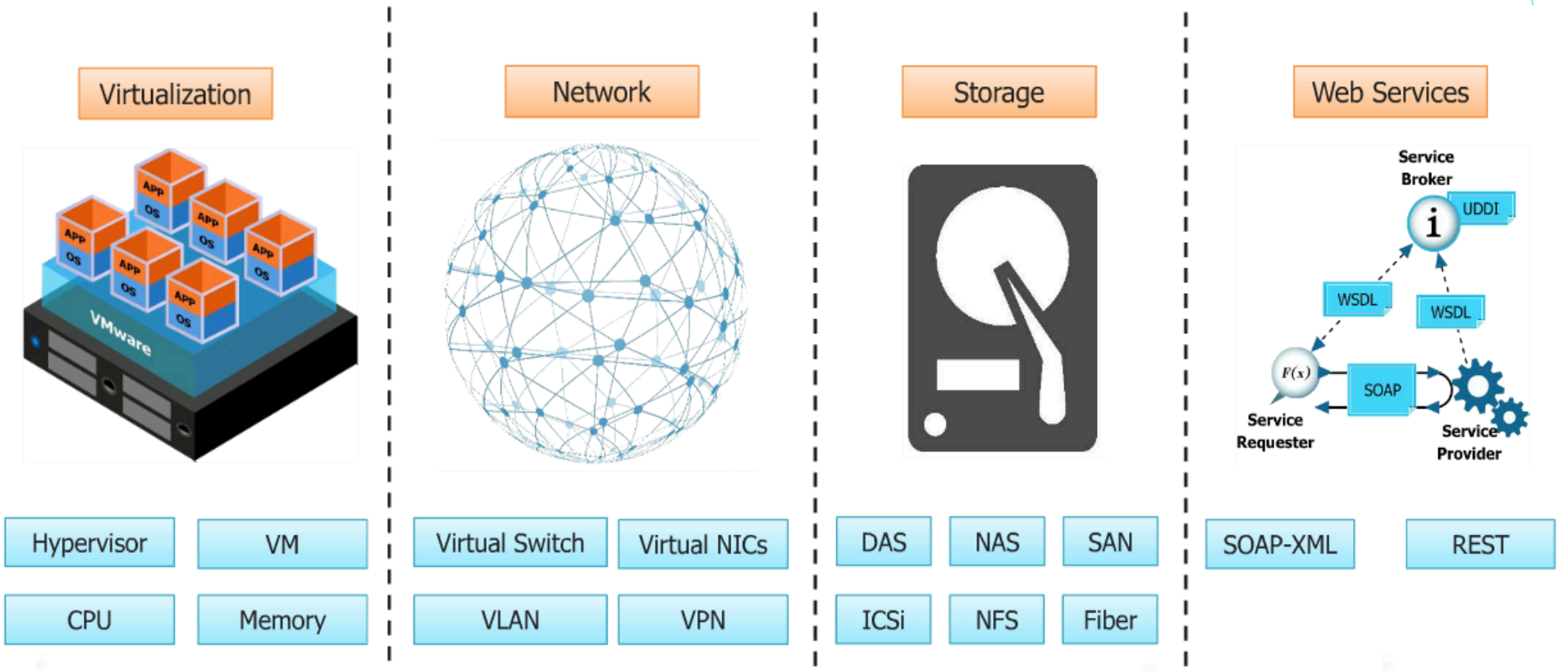
- Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider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

Cloud Addresses:

- cost factor
- scaling
- utilization
- self-service
- IT-agility, flexibility and delivery of value.

Vision of Cloud

Building blocks of cloud computing



Important terms in cloud

- **Content Delivery Network(CDN)**: A distributed system consisting of servers in discrete physical locations, configured in a way that clients can access the server closest to them on the network, thereby improving speeds.
- **Cloud:** A metaphor for a global network, first used in reference to the telephone network and now commonly used to represent the internet.
- **Cloud portability**: The ability to move applications and data from one cloud provider to another.
- **Cloud provider:** A company that provides cloud-based platform, infrastructure, application, or storage services to other organizations and/or individuals, usually for a fee.
- **Cloud sourcing:** Replacing traditional IT operations with lower-cost, outsourced cloud services.
- **Cluster:** A group of linked computers that work together as if they were a single computer, for high availability and/or load balancing.

- **Elastic computing:** The ability to dynamically provision and de-provision computing and storage resources to stretch to the demands of peak usage, without the need to worry about capacity planning and engineering around uneven usage patterns.
- **Tenant:** A group of users / organization that uses the applications running on top of the cloud.
- **Multi-tenancy:** The existence of multiple clients sharing resources (services or applications) on distinct physical hardware. Due to the on-demand nature of cloud, most services are multi tenant.
- **Service migration:** The act of moving from one cloud service or vendor to another.
- **Service level agreement (SLA)**: A contractual agreement by which a service provider defines the level of service, responsibilities, priorities, and guarantees regarding availability, performance, and other aspects of the service.
- **Data Center:** A large group of networked computer servers typically used by organizations for the remote storage, processing, or distribution of large amounts of data.
- **Virtual private cloud (VPC):** A private cloud that exists within a shared or public cloud, e.g., the Amazon VPC that allows Amazon EC2 to connect to legacy infrastructure on an IPsec VPN.

Data center resiliency

- Resiliency is the ability of a server, network, storage system, or an entire data center, to recover quickly and continue operating even when there has been an equipment failure, power outage or other disruption.
- Data center resiliency is often achieved through the use of redundant components, subsystems, systems or facilities.
- When one element fails or experiences a disruption, the redundant element takes over seamlessly and continues to support computing services to the user base.
- Ideally, users of a resilient system never know that a disruption has even occurred.

Cloudlets

- ***Edge computing*** is a new paradigm in which the resources of a small data center are placed at the edge of the Internet, in close proximity to mobile devices, sensors, and end users.
- Cloudlets are these small, edge-located data centers. This paradigm is also called as Fog computing.
- Cloudlet represents the middle tier of a 3-tier hierarchy: mobile or IoT device --- cloudlet --- cloud. A cloudlet can be viewed as a "data center in a box" whose goal is to "bring the cloud closer".
- Apple's Siri, Google Now etc. are some of the example of mobile applications that does intensive calculations on cloud.
- Cloudlets are designed to facilitate and enhance the performance of latency-sensitive mobile applications.

- Imagine every request of Siri or Google Now has to go all the way to cloud servers crossing so many network hops. This is delay the response for a longer time which is not feasible as we expect the Voice Assistants to give the solution within a minimum stipulated time.
- In order to achieve this faster, we place cloudlets in the edge of the internet, closer to the mobile devices thus reducing the latency.
- Cloudlets are the cloud components that are capable of processing the requests made by the mobile devices.

Resource broker / Cloud broker

- The cloud brokers operate on behalf of the consumers and identify the subset of services that match customers' requirements in terms of service profiles and quality of service.
- Brokers perform the same function as they would in the real world: They mediate between coordinators and consumers by acquiring services from the first and subleasing them to the latter.
- Brokers can accept requests from many users. At the same time, users can leverage different brokers.

Benefits / Features of cloud

- Dynamic: on-demand provisioning
- Multi-tenant: shared by multiple tenants/users
- Self-service: As a user, you can use the service you require
- Pay as you use: You will only pay for the amount of service you used per hour
- IP-based architecture: cloud architectures are based on virtualized, internet based technologies.
- Elasticity (scaling up and down)
- Resource / Infrastructure abstraction
- Rapid deployment
- Automation, re-usability
- No CAPEX (capital expenditure), Variable OPEX (operational expenditure)

Deployment models

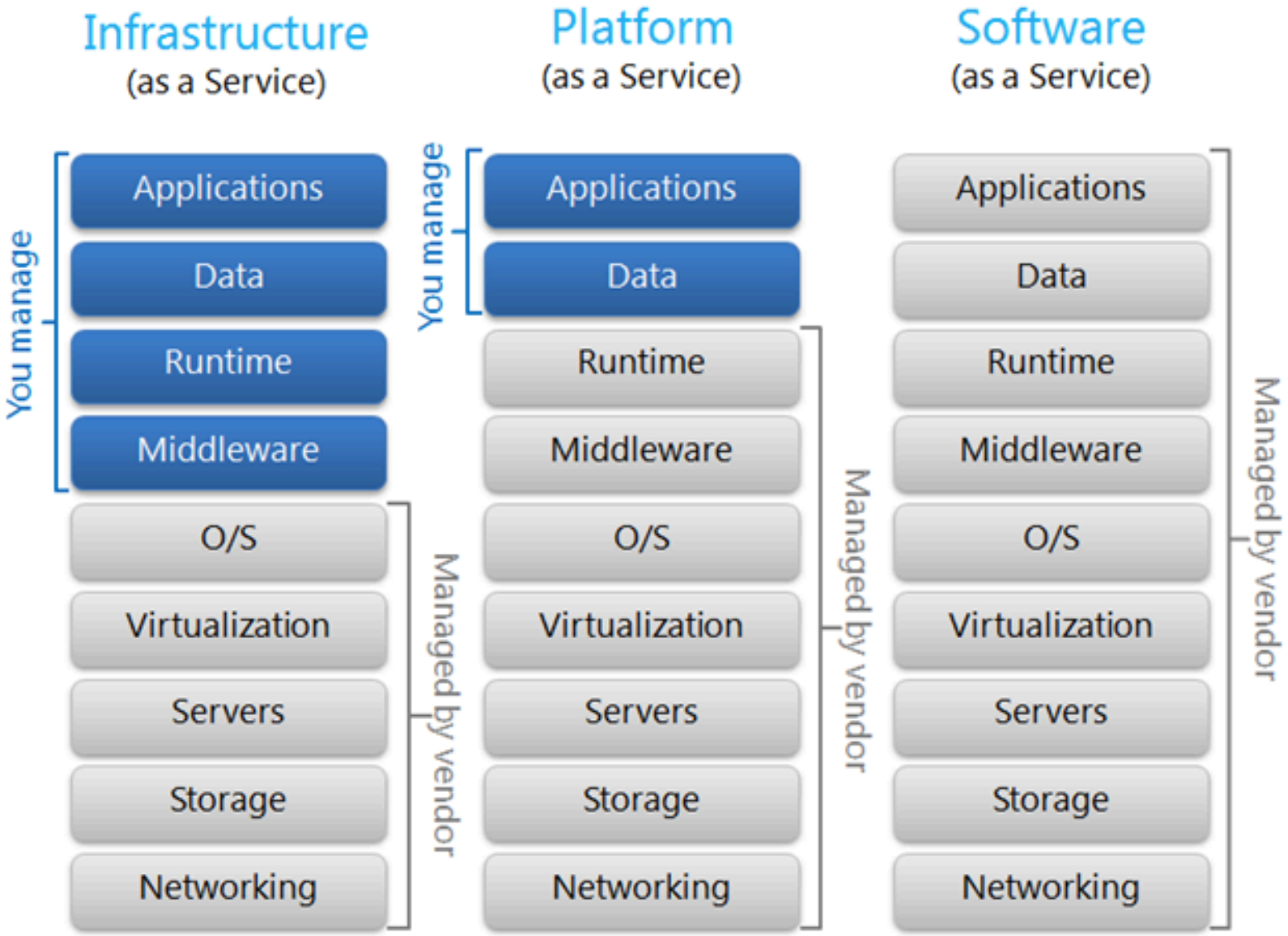
- Private clouds
  - On or off premises cloud infrastructure operated solely for an organization, managed by the organization or a third-party. Examples: Private cloud in Amrita campus.
- Public clouds
  - Available to general public, owned by an organization selling cloud services. Examples: Google drive, Dropbox, Microsoft Azure, IBM Bluemix etc.
- Hybrid clouds
  - Traditional IT and clouds (private and/or public) that remain separate, but are bound together by technology that enables data and application portability. For example, an enterprise can deploy an on-premises private cloud to host sensitive or critical workloads, but use a third-party public cloud provider, such as Google Compute Engine, to host less-critical resources.

Service models / Delivery models

SaaS – CRM, Email, games, virtual desktop.

PaaS – Database, web servers etc.

IaaS – Virtual machines, storage, servers, network etc.


Infrastructure
(as a Service)
Platform
(as a Service)
Software
(as a Service)
You manage
Applications
Data
Runtime
Middleware
O/S
Virtualization
Servers
Storage
Networking
Managed by vendor
You manage
Applications
Data
Runtime
Middleware
O/S
Virtualization
Servers
Storage
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Managed by vendor
Applications
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Software as a Service (SaaS)

- SaaS is very similar to the old thin-client model of software provision, where clients, in this case usually web browsers, provide the point of access to software running on servers.
- Examples: Google Docs, Google Apps, Box, Office 365, Dropbox etc.

Characteristics of SaaS

- Web access to commercial software
- Software is managed from a central location
- Software delivered in a “one to many” model
- Users not required to handle software upgrades and patches
- Application Programming Interfaces (APIs) allow for integration between different pieces of software

When to go for SaaS

- Applications where there is significant interplay between the organization and the outside world. For example, email newsletter campaign software
- Applications that have a significant need for web or mobile access. An example would be mobile sales management software
- Software that is only to be used for a short term need. An example would be collaboration software for a specific project
- Software where demand spikes significantly, for example tax or billing software used once a month

Platform as a Service (PaaS)

- PaaS can be defined as a computing platform that allows the creation of web applications quickly and easily and without the complexity of buying and maintaining the software and infrastructure underneath it.
- PaaS is analogous to SaaS except that, rather than being software delivered over the web, it is a platform for the creation of software, delivered over the web.
- Examples: Google App Engine, Amazon EC2, IBM Bluemix, Microsoft Azure etc.

Characteristics of PaaS

- Services to develop, test, deploy, host and maintain applications in the same integrated development environment. All the varying services needed to fulfil the application development process
- Web based user interface creation tools help to create, modify, test and deploy different UI scenarios
- Multi-tenant architecture where multiple concurrent users utilize the same development application
- Built in scalability of deployed software including load balancing and failover
- Integration with web services and databases via common standards
- Support for development team collaboration – some PaaS solutions include project planning and communication tools
- Tools to handle billing and subscription management

When to go for PaaS

- PaaS is especially useful in any situation where multiple developers will be working on a development project or where other external parties need to interact with the development process.
- Students/Developers can use the services provided by the cloud vendors like Amazon EC2, Bloomix or Azure to run their applications on the cloud provided by them without even actually investing anything in establishing the infrastructure physically.

Infrastructure as a Service (IaaS)

- Infrastructure as a Service (IaaS) is a way of delivering Cloud Computing infrastructure - servers, storage, network and operating systems – as an on-demand service. Rather than purchasing servers, software, data center space or network equipment, clients instead buy those resources as a fully outsourced service on demand.
- It lets you build virtual infrastructure that mimics these resources, which can be created, reconfigured, resized, and removed within moments, as and when a task requires it.
- Examples: Amazon AWS (EC2), Rackspace, Openstack etc.

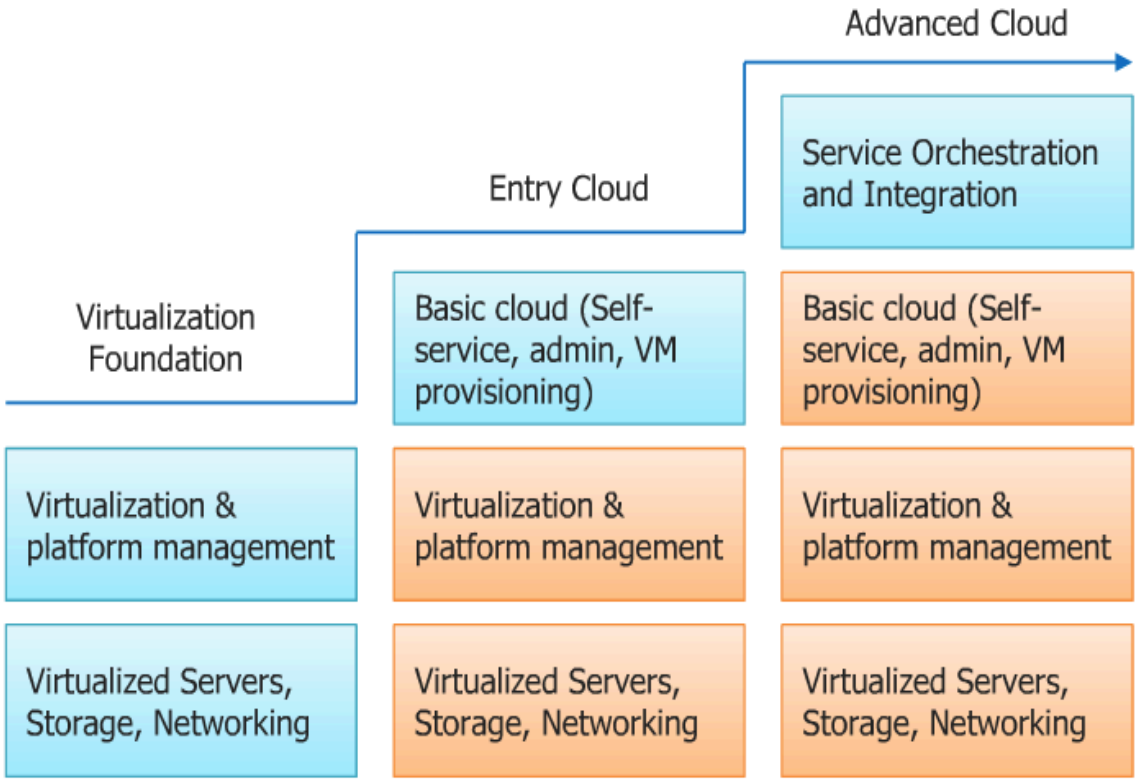
Characteristics of IaaS

- Resources are distributed as a service
- Allows for dynamic scaling
- Has a variable cost, utility pricing model
- Generally includes multiple users on a single piece of hardware

When to go for IaaS

- Where demand is very volatile – any time there are significant spikes and troughs in terms of demand on the infrastructure
- For new organizations without the capital to invest in hardware
- Where the organization is growing rapidly and scaling hardware would be problematic
- Where there is pressure on the organization to limit capital expenditure and to move to operating expenditure
- For specific line of business, trial or temporary infrastructural needs

Cloud = Virtualization + Extras



→This is not always a linear progression. Some begin by optimizing the virtualization foundation for a workload, then gradually move to cloud.

→Some require cloud capabilities from the beginning and may start with advanced cloud or entry cloud solutions.

→Some may be in all of these stages w/ different workloads across the data center.

Virtualization

Heart of the Cloud

What is virtual?

- Not physically existing as such but made by software to appear to do so.
- Examples: Virtual reality.

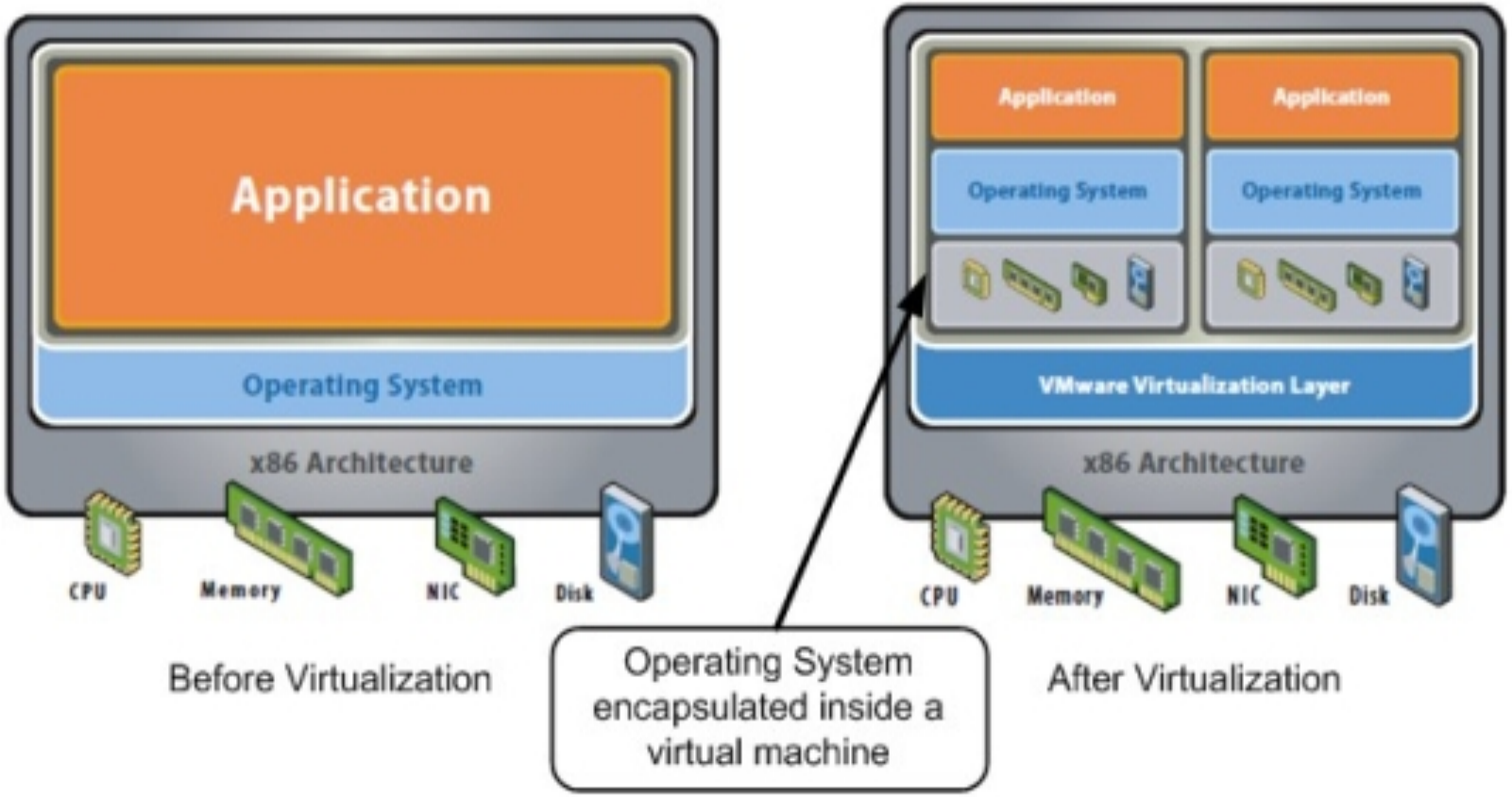
What is Virtualization?

- In computing, virtualization means to create a virtual version of a device or resource, such as a server, storage device, network or even an operating system where the framework divides the resource into one or more execution environments.
- Even something as simple as partitioning a hard drive is considered virtualization because you take one drive and partition it to create two separate hard drives (Example: having a dual boot OS in one machine).

Why do we need Virtualization?

- **Virtualization** reduces the number of physical servers, reducing the energy required to power and cool them.
- It's also much faster to deploy a virtual machine than it is to deploy a new physical server.
- By the term Virtualization people usually are referring to server virtualization, which means partitioning one physical server into several virtual servers, or machines. Each virtual machine can interact independently with other devices, applications, data and users as though it were a separate physical resource.
- Different virtual machines can run different operating systems and multiple applications while sharing the resources of a single physical computer.
- Isolated with each other, therefore one server crash will not effect the other.

Big picture of Virtualization



Before virtualization

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

After Virtualization

- Hardware independence of OS and applications
- VM's can be provisioned to any system
- Can manage OS and application as a single unit by encapsulating them into VM's

SIX areas of Virtualization

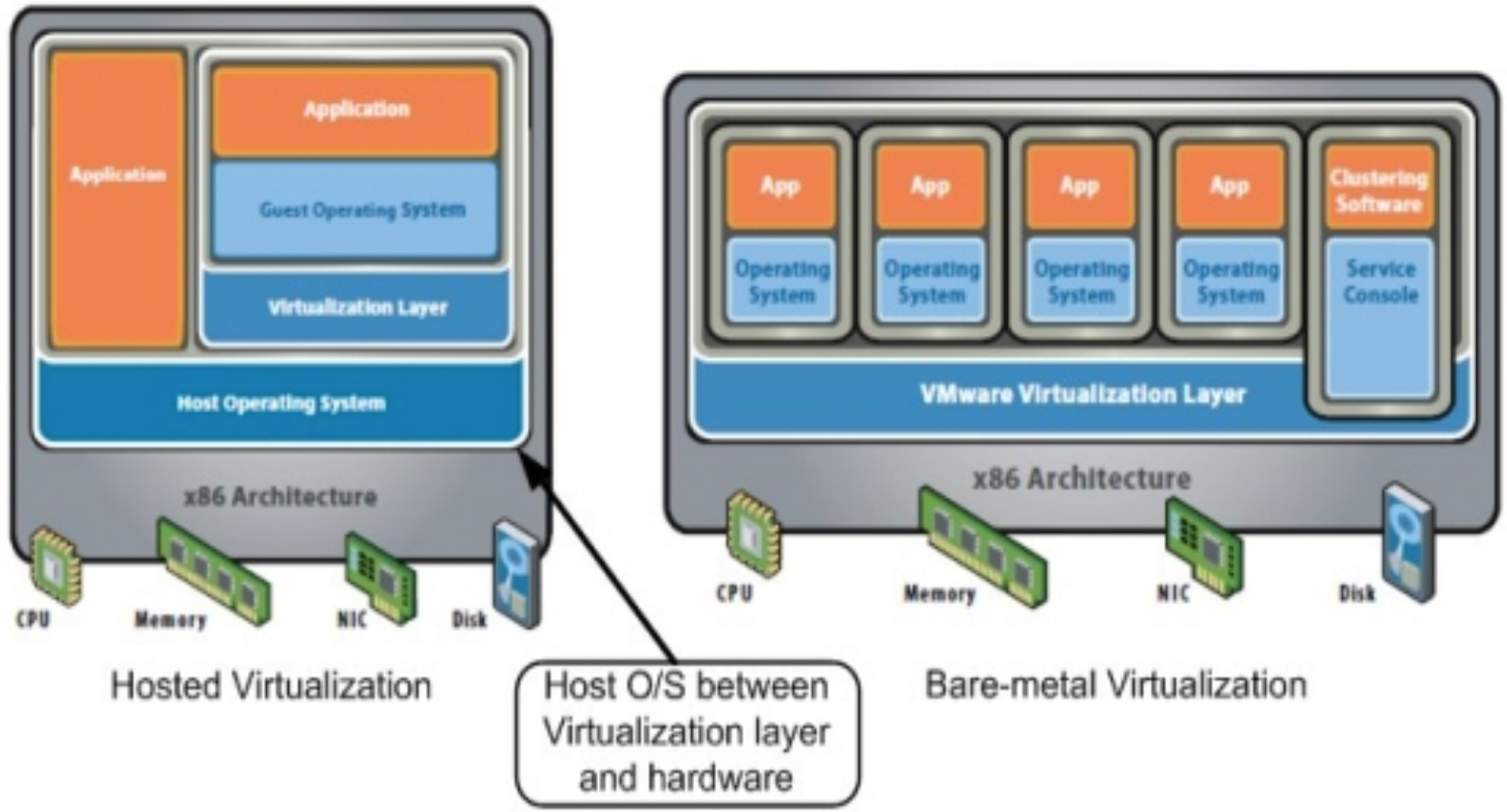
- **Network virtualization** splits available bandwidth in a network into independent channels that can be assigned to specific servers or devices.
- **Application virtualization** separates applications from the hardware and the operating system, putting them in a container that can be relocated without disrupting other systems. This can allow a Windows application to run on Linux and vice versa, in addition to adding a level of isolation. Example: Citrix XenApp, Microsoft App-V, VMWare ThinApp.
- **Desktop virtualization** enables a centralized server to deliver and manage individualized desktops remotely. This gives users a full client experience, but lets IT staff provision, manage, upgrade and patch them virtually, instead of physically. Examples: Citrix XenDesktop, VMWare View, Microsoft VDI

- **Data Virtualization** is abstracting the traditional technical details of data and data management, such as location, performance or format, in favor of broader access and more resiliency tied to business needs.
- **Storage Virtualization** is the pooling of physical storage from multiple network storage devices into what appears to be a single storage device that is managed from a central console. Storage virtualization is commonly used in storage area networks.
- **Server Virtualization** is the masking of server resources -- including the number and identity of individual physical servers, processors and operating systems -- from server users. Examples: Microsoft Hyper-V, Citrix XenServer, VMWare ESX

Virtual Machine Manager / Hypervisor / Virtualization Layer

- Sits between Hardware and OS.
- Hypervisor is a piece of computer software or firmware that creates and runs VM's.
- Computer on which a hypervisor runs one or more virtual machines is called a **host machine**
- Each virtual machine is called a **guest machine**
- Hypervisor presents the guest operating systems with a virtual operating platform and manages the execution of the guest operating systems.

Types of Hypervisors



Type-1 (bare-metal virtualization)

- These type of hypervisors run directly on the hosts hardware taking control of the hardware and the guest OS's. That's the reason they are called Bare-metal hypervisors.

- Examples: Oracle VM server for x86, citrix XENServer, Microsoft Hyper-V and VMware ESX/ESXi.

Type-2 (Hosted virtualization)

- These type of hypervisors runs on the traditional OS just as an another computer program. Guest OS runs as a process on the host. Type-2 hypervisors perform abstraction by hiding the existence of guest OS's from the host OS.

- Examples: VMware workstation, VirtualBox, Parallels Desktop for Mac and QEMU.

Pros and Cons

- Pros
  - Sandbox
  - Hardware independent
  - Fast recovery
  - Cost savings
  - Reduced hardware
  - Run multiple OS simultaneously
  - Use of multicore processors
  - Live backup
- Cons
  - Less efficient
  - Unstable performance
  - Tools lack ability
  - Latency of virtual hard disk
  - Security issues
  - Hardware compatibility issues
  - Maintenance and securing is difficult

Cloud vendors

Vendors

- Amazon AWS
- Google Cloud Platform
- Microsoft Azure
- IBM Bluemix
- Rackspace
- IIT Delhi Baadal
- Etc.

Some Important points before you create a account with any of the vendors

- Most of them provide free 1-year subscription for their free-tier usage policy.
- Free-tier includes, sufficient number of instances with storage, OS images and monthly hours.
- This subscription requires you to give your credit card details. (They don't charge initially, but anything beyond free tier policy is chargeable)
- It is always better to shutdown or remove your instances if you are not using them, as they consume your free-tier bandwidth.

Amazon AWS (Amazon Web Services)

- Amazon Web Services (AWS) is a secure cloud services platform, offering compute power, database storage, content delivery and other functionality to help businesses scale and grow.

Let’s look at different services offered by Amazon AWS and Microsoft Azure.

PRODUCT	aws	Microsoft Azure	Google Cloud Platform
Virtual Servers	Instances	VMs	VM Instances
Platform-as-a-Service	Elastic Beanstalk	Cloud Services	App Engine
Serverless Computing	Lambda	Azure Functions	Cloud Functions
Docker Management	ECS	Container Service	Container Engine
Kubernetes Management	EKS	Kubernetes Service	Kubernetes Engine
Object Storage	S3	Block Blob	Cloud Storage
Archive Storage	Glacier	Archive Storage	Coldline
File Storage	EFS	Azure Files	ZFS / Avere
Global Content Delivery	CloudFront	Delivery Network	Cloud CDN
Managed Data Warehouse	Redshift	SQL Warehouse	Big Query

Source: Cloudhealthtech.com

Thank You ☺

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